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**Transferring Technology from R&D Consortia to Participating
Shareholders : A Study of Canadian Consortia**

by

Aditya Tandon, B. A. Hons. (Economics)
Post Graduate Diploma (International Marketing)

A thesis submitted to
the Faculty of Graduate Studies and Research
in partial fulfillment of
the requirements for the degree of

Master of Management Studies

School of Business
Carleton University
Ottawa, Ontario

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acceptance of the thesis

**Transferring Technology from R&D Consortia to Participating
Shareholders : A Study of Canadian Consortia**

submitted by Aditya Tandon, B.A. (Honours) Economics, PGDIM
in partial fulfilment of the requirements for the degree of
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ABSTRACT

R&D consortia are playing an increasingly important role in maintaining and enhancing the technological competitiveness of firms the world over. Therefore, the ability to transfer the technology developed by such consortias to their shareholders in a timely and efficient fashion assumes great importance. This study presents a model for transferring technology from R&D consortia to the participating shareholder organizations. The model identifies four stages of the transfer process - a technology identification and development stage, a technology flow stage, a ramp-up stage and an integration stage. This model is derived from an in-depth analysis of the technology transfer procedures being followed at eleven Canadian consortia. The study also reports on the strategies and factors that the consortia senior management consider to be important in facilitating the process of transferring technology to their shareholders.

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Chapter 1

INTRODUCTION

Today, technology has evolved to be the most potent force in the world of business. Firms across all sectors are striving to equip themselves with the state of the art. Indeed, this has become a prerequisite for their very survival. Another trend that has become evident in recent years is the shortening of the technology life cycle. Technologies are becoming obsolete at an increasingly faster pace (Evan and Olk, 1992). Given this context, it is not surprising that the R&D function has assumed paramount importance for many firms. However, given the rising costs and the risks associated with advanced research, companies are finding it difficult to conduct their own R&D activities at the required scale. Moreover, the necessity of quick pre-emption strategies and the need to monitor a wide spectrum of technologies in the face of complexities, transsectoral character and the uncertainties of the surrounding technological development (Hagedoorn and Schakenraad, 1994; Hausler, Hohns and Lutz, 1994), has given rise to an increasing trend towards collaborative R&D ventures amongst firms. Such ventures include R&D consortia.

R&D consortia can be broadly defined as an alliance of organizations with similar research and development needs. They are often in the same industry and they band together to create a new organizational entity to fulfill their shared needs. It is a group formed to take an enterprise beyond the resources of any of its members and provide benefits to all of them (Kanter, 1990). The primary functions of R&D consortia are : to

develop new technologies and aid in the development of new products or process improvements from these technologies. Thus, the two critical issues facing a R&D consortium, are the research and development of new technology and the transfer of the same to its shareholders¹ (Evan and Olk, 1992). Research has shown that the second issue is turning out to be “at least as challenging and certainly more controversial than the first” (Smilor and Gibson, 1991). In order to incorporate advanced technology into new and advanced products, not only does the new technology have to be created but it also has to be transferred to the point of manufacturing. Kumar and Magun (1995) have, in fact, identified the successful and expeditious transfer of technology as being the most critical issue facing the consortia management. Difficulties arise in the smooth transition from R&D to operations because researchers and operators are working in very different environments (Lefebvre and Piche, 1997; Sedaitis, 1996). Moreover, consortia shareholders, more often than not, may come from different corporate cultures, present different managerial priorities and procedures and emphasize different, and sometimes even conflicting, objectives. Management thus, faces a variety of organizational, technological, strategic, and cultural barriers to transferring technology expeditiously (Smilor and Gibson, 1992). However, new technology, if allowed to become fallow after development, is of no use. It is therefore, imperative that a thorough understanding of the technology transfer process be developed in order to exploit the benefits of undertaking co-operative research.

¹ Unless explicitly stated otherwise, the term shareholders will refer to the participating shareholders of the consortium.

Therefore, extensive research needs to be done in order to determine the content and the sequence of related activities that constitute the technology transfer process in the consortium-shareholder context. Such research however, remains relatively scarce. Further, there is a great paucity of such studies focused on Canadian consortia. Given the increasing importance of such consortia in maintaining and enhancing the technological competitiveness of Canada's firms, it is crucial that this situation be addressed. Therefore, the first objective of this study was to understand the process of transferring technology from R&D consortia to shareholder organizations. The focus was on studying the technology transfer process from the perspective of Canadian consortia.

Further, in order to transfer the developed technology in an efficient and timely fashion, it is also important that the consortium as well as the shareholders develop the required infrastructure and undertake actions that are supportive of the transfer process (Smilor and Gibson, 1991). Thus, the second objective of the study was to identify various factors and actions that may facilitate the technology transfer process.

Chapter 2

LITERATURE REVIEW

This chapter reviews the literature on technology transfer and consortia and provides a rationale for this study. Several definitions of technology and the technology transfer process can be found in the literature. The first section of this chapter deals with these definitions. The second section deals exclusively with R&D consortia describing in great detail the rationale behind their formation, form, visible trends, benefits derived and challenges posed by this new organizational entity. The third section presents the different models that have been used to describe the transfer process. The integrative model of the transfer process to be used for this study is also developed in this section. The final section examines the various factors which may facilitate the transfer of technology between the consortia and the shareholder organizations.

2.1 Technology and Technology Transfer

In order to develop an understanding of the transfer process, it is essential that one becomes familiar with the concept of technology. The term itself is broad-based and complex and has received widespread attention. Zander and Kogut (1995) describe technology as consisting of the principles by which individual skill and competence are gained and used, and by which work among people is organized and coordinated.

Technology has also been described as referring to the practical knowledge, know-how, skills, and artifacts that can be used to develop a new product or service and/or a new production or delivery system (Al-Ghailani and Moor, 1995). Autio and Laamanen (1995) define technology as comprising the ability to recognize technical problems, the ability to develop new concepts and tangible solutions to technical problems, the concepts and tangibles developed to solve technical problems, the ability to exploit the concepts and tangibles in an effective manner. Al-Ali (1995) identified, from a review of the literature, three broad streams of such definitions: those that viewed technology as involving changes in physical objects and artifacts; those that included labor and managerial skills in addition to the physical objects and finally those that treated technology as a socio-technological phenomenon; that is besides involving material and artifact improvements, technology is considered to incorporate a cultural, social and psychological process as well. For this study, using the definition by Al-Ghailani and Moor, technology was defined as the practical knowledge, know-how, skills and artifacts that can be used to develop a new product or service and/or a new production or delivery system.

Thus, given the variety of ways in which technology has been defined, it follows that the transfer of technology has also been defined in different ways. Al-Ghailani and Moor (1995) define technology transfer as consisting of two separate processes; one the measurable product transfer such as that embodied in the transfer of machinery, equipment and processes and the other know-how transfer that is much more difficult to measure or quantify. Al-Ali (1995) points out that over the years the term has come to be

used as a blanket term to cover a wide range of activities. These activities include the shift of knowledge from production-oriented to application oriented institutions, from laboratories to the various departments of the firm, from the developed countries to the developing, or the process by which science and technology are diffused throughout human activity. However, notwithstanding this broad span of use, technology transfer usually encompasses three basic functions: first the technology must have a source, secondly, the technology must be produced or manufactured and finally, the technology must be applied in some economically or socially profitable way. Autio and Laamanen (1995) add a further element to the definition by treating it as an active process. Many researchers do not take time into account while talking of technology transfer. Technology often, changes during the course of the transfer process itself. Moreover, the transfer process is not an once-for-all process; rather it should be regarded as a continuum of interrelated processes that begins even before the formal research and continues after the technology has been formally transferred (Al-Ali, 1995; Cusumano and Elenkov, 1994; Rhea, 1991). For the purposes of this study, using the definitions by Al-Ghailani and Moor, Al-Ali, Laamanen, Rhea and Cusumano *et al.*, technology transfer was defined as a continuum of interrelated active processes encompassing the product and knowledge transfers occurring between the consortium and the member organizations during their interactions that begins even before the formal research and continues after the technology has been formally transferred.

2.2 Consortia : A New Era for Cooperative Research

Spurred on by increasing international competition, the rising costs of advanced research, the need to leverage scarce scientific and technical talent, and the desire to share the risks associated with technology generation and commercialization, technology companies are banding together in research and development consortia and innovative strategic alliances (Smilor and Gibson, 1992; Bidault and Cummings, 1994; Niosi, 1993). Kumar and Magun, (1995) and Smilor and Gibson (1991) have described a R&D consortium as being composed of companies that seek co-operative research of common benefit while remaining competitors in the market place. Lee and Lee (1992) have expanded this definition by including universities, and government agencies in it. Other factors driving consortia formation include the need to set standards for new technologies, to protect “leaky knowledge” from being appropriated by companies not a part of the research effort (Evan and Olk, 1990), and to reduce the duplication of research activities being carried out in an industry (Torpey, 1994).

The 1980s saw a tremendous increase in the number of consortia. In 1989, MERIT-CATI Data Bank counted about 4,600 technical co-operative agreements in all three core technologies in the world; information technologies, biotechnologies and new materials technologies (Hagedoorn and Schakenraad, 1990). 90% of these co-operative agreements took place during the 1980s (Kumar and Magun, 1995). Moreover, over 90% of worldwide technical co-operative agreements in core technologies have taken place

between companies from and within the US, EC and Japan (Hagedoorn and Schakenraad, 1990). Firms in the industrially advanced nations have not had any choice but to pursue aggressively R&D aimed not only at new products and services but at productivity improvements. So long as the world economy remains relatively open with vast pools of low cost labor in the developing nations, high technology products and high productivity production processes will be needed to maintain competitive industries. Collaborative efforts aimed at both product and process technologies can help create counterweights to relatively high labor costs for the firms in the developed world (Alic, 1990).

Consortia can also be distinguished from other forms of co-operative research. They differ from such weak alliances as trade associations which organizations form for producing generalized or abstract benefits for the industry as a whole in that the consortia are expected to produce specific benefits for particular firms (Kumar and Magun, 1995). Moreover, a consortia can also be distinguished from a joint venture in that it usually includes direct competitors, while most joint ventures do not. An R&D consortium tends to have a less focused goal because its potential output is uncertain and also the equity and other inputs invested by each member firm tends to be less than those invested by each member of a joint venture (Evan and Olk, 1990). Moreover, consortia also differ from the industry and university co-operative research centers as most of these centers are initiated by universities who have a substantial say in setting the agenda for this forum. Furthermore, their initial funding may be from the government (Kumar and Magun, 1995).

Consortia can be classified into the following two types based on their structure : the first is the free-standing consortium in which research is conducted in-house in the consortia's own facilities which are distinct from member facilities. The second type of consortium serves as an administrative body that coordinates research either at universities or at member-company sites (Evan and Olk, 1990). Consortia can also be classified as precompetitive consortia, product development consortia and standard-setting consortia based on their technology emphasis (Kumar and Magun, 1995). In a precompetitive consortium, firms pool resources and their knowledge in particular areas to conduct basic research. The focus of the joint research efforts in such consortia is on generic technologies and not related to specific products. Product development consortia, on the other hand, focus their efforts on producing new products, adding new features or customizing products according to the requirements of their member firms. Standard - setting consortia are formed by firms to create alternate standards in the industry in order to challenge the standards set by a few dominant firms. It should be noted that this study will not focus on any particular type of consortia as the objective is to understand the process of transferring technology from consortia in general and not with reference to any specific subgroup of the same.

Further, with regards to the classification of the consortia's members, Dove (1992) has identified the following two broad classes : the first are the participating shareholder organizations which include the firms that actually contribute resources, personnel etc.

towards the setting up of the consortia. The second class consists of the associate or affiliate members who may fund a few selected projects, but are by and large concerned only with monitoring the research at a nonproprietary level or who may buy into the technology that has been developed by the consortium provided the shareholders decide to diffuse the technology freely into the public domain.

Consortia are typically organized into specialized units to handle the R&D and the communications activities. For example, SEMATECH, the American semiconductor industry consortium, has established a technical communications core distinct from the R&D core which is primarily responsible for liaising with and transferring technology to the shareholders (Novak,1992). Consortium personnel responsible for both these activities may either be recruited from the shareholder organizations or be directly hired into the consortium. A distinct management set-up is also put into place in order to provide strategic direction to the consortium. Again, individuals belonging to the consortium management may come from either the shareholder companies or be hired directly by the consortia. However, in as much as the consortium is a distinct organizational entity, it is possible to differentiate the consortium management and personnel from their counterparts in the member firms in spite of the high degree of interactivity between them.

The strategic objectives that firms wish to achieve through the formation of such R&D consortia include horizontal diversification into new product lines, vertical integration

both backward and forward as well as leap-frogging competition within existing product lines. Link (1990) in a study aimed at establishing the relative importance of these strategies, showed that extensive differences exist between industries in the importance given to each of these strategies. Factors such as foreign competition, profits, industry competition and market share were reported to be responsible for the same.

There can be no doubt that the R&D consortia are increasing both in numbers as well as in importance. Hakanson (1993) points out that there is wide-spread agreement that a very high proportion of cooperative R&D ventures fail to meet expectations. Despite the difficulties that many such ventures have faced in the past, research indicates that their importance will continue to grow within the R&D function of firms (McArthur and Schill, 1995). Being a new type of organizational form, they do pose certain unique management challenges which need to be addressed (Smilor and Gibson, 1991). Unmanaged challenges may be the reason for the rather lackluster performance of some of the consortia. For example, of the four large electronics-related consortia Semiconductor Research Corp. Microelectronics and Computer Technology Corp. (MCC), Sematech and Bellcore, only the last has been an outright success (Leibowitz, 1990). Issues such as obtaining resources, recruiting personnel, workforce integration, tackling the competition-cooperation paradox, the protection of proprietary knowledge, decision making, legal issues including those of intellectual property rights etc. are all areas which require careful handling on the part of the managers of these units (Evan and Olk, 1990; Farr and Fischer, 1992). However, it is the expeditious transfer of technology that has been identified as *the*

major issue facing the consortium management (Kumar and Magun, 1995). Indeed, establishing efficient technology transfer mechanisms is a major concern. Thus, the transfer process needs to be studied in great depth in the consortium-shareholder context. The following section describes some relevant technology transfer models which inculcate a greater understanding of the technology transfer process thus providing a basis for further research into the process of transferring technology from consortia to the shareholders.

2.3 Technology Transfer Models

The process of technology transfer has been studied in a variety of contexts. Consequently, a number of models for the transfer process have been developed. The three models presented here have been chosen because they address the concept of technology transfer in an “organizational” context providing a strong foundation for the development of the integrative model to be used in the present study.

2.3.1 Szulanski’s Model for the Transfer Process

Szulanski (1996) has developed a generic conceptual framework in order to describe the various stages involved in any transfer process including the transfer of technology. As shown in Figure 1, these stages include :

1. Initiation This stage would include all activities that lead to the decision to transfer. A transfer begins when both a need and the knowledge to meet the need coexist. The *raison d'être* for consortia is the generation of new leading edge knowledge either to strengthen further the technological competitiveness of their shareholders in the long run or solve their product problems in the short run. However, once the knowledge to meet either of these objectives has been generated it is imperative that it be transferred to the shareholders in order that they may be able to utilize it to further improve the efficacy of their operations. Thus, the stage is set for the transfer once the discovery of knowledge has been made.

2. Implementation - This stage begins with the decision to proceed. During this stage, resources flow between the recipient and the source. Transfer-specific social ties are established. The transferred technology is often adapted to suit the anticipated needs of the recipient or to preempt any problems that the recipient firms might face in adopting the new technology.

3. Ramp-up - The ramp-up stage begins when the recipient starts using the transferred technology. During this stage, the recipient is predominantly concerned with identifying and resolving unexpected problems that might hamper its ability to optimize the gains be had from the transferred technology. The recipient is likely to use the new knowledge ineffectively at first but gradually improves performance, ramping-up toward a satisfactory level.

4. **Integration** - The integration stage begins after the recipient achieves satisfactory results with the transferred knowledge and the use of the transferred technology becomes routine in the operation of the firm.

FIGURE 1 : SZULANSKI'S MODEL FOR THE TRANSFER PROCESS

(adapted from Szulanski, 1996)

2.3.2 Innovation Process View of Technology Transfer

Another way of looking at the technology transfer process is by studying it with reference to the innovation process (Autio and Laamanen, 1995; Ambrosio, 1995). The innovation process view of technology transfer investigates the flow of technology in the transfer process as a movement of knowledge required to facilitate the onset of the next stage of innovation. As shown in Figure 2, idea transfers, prototype transfers and product transfers are seen as the buffers between the Idea Initiation and the Prototype Development stages; the Prototype Development and the Commercialization stages and the Commercialization and the Market Diffusion stages of the innovation process respectively. This scheme of classification of the various types of transfers has great significance for the present work as it provides an invaluable tool to describe the nature of the technology flows occurring between and within the different stages of the technology transfer process from R&D consortia to participating organizations. One point worth mentioning is that the innovation process view of technology transfer essentially looks at the vertical movement of technology from one phase to another. However, horizontal transfer of technology within a phase might also occur.

FIGURE 2 : INNOVATION PROCESS VIEW OF TECHNOLOGY TRANSFER

(adapted from Autio and Laamanen, 1995)

2.3.3 A Player-based Model of Technology Transfer

Novak (1992) has offered a technology transfer model focused on consortia. This model is derived from the technology transfer procedures followed at SEMATECH, the American semiconductor industry consortium. Given the fact that Novak's study describes the technology transfer process in the consortium-shareholder context, it assumes great relevance for the present work.

The establishment of a communications structure that facilitates close interaction and collective goal setting is a crucial part of any technology transfer effort. To that end, SEMATECH has set up "focus technical advisory boards" (focus TAB) to correspond to each of its technology focus areas. All shareholders are represented on each one of these focus technical advisory boards. This greatly enhances the interaction between the various shareholders. These boards provide advise to both the consortium in general as well as to the "executive technical advisory board" (ETAB) which is composed of the senior personnel at the consortium. The ETAB takes input from the various focus technical advisory boards and provides technical advise directly to the consortium's Board of Directors who then set the strategic direction for the consortium (Browning, Beye and Shetler, 1995). The new technology once developed is examined by the Board again before the final transfer is effected. As shown in Figure 3, the flow of knowledge from consortium to the shareholders takes several different routes. The focus technical advisory boards play a crucial role in this transfer process. Knowledge from the consortium can be

directly transferred to these boards for onward transfer to the shareholders. Another group of personnel critical to the success of the transfer process is the technology transfer managers. It is their responsibility to ensure the smooth transfer of technology into their respective organizations. As respected senior personnel from the shareholder organizations, they often advise the consortium on different matters; especially on those related to technical communications. A major part of the transfer equation, however, involves the member-company (shareholder) full-time assignee engineers working at the consortium. Their contact is a primary receiver(s) who resides in the parent company. All three technology transfer managers, the focus technical advisory boards and the primary receiver(s) then target the appropriate base of end users in the shareholder organization to culminate the transfer process. However, the traces of linearity of movement suggested in this model may not necessarily be true. The whole process of transferring technology is very interactive, with individuals both within the firms and the consortium interacting with each other at every stage.

FIGURE 3 : A PLAYER-BASED MODEL OF TECHNOLOGY TRANSFER

(adapted from Novak, 1992)

2.3.4 An Integrative Model

The model presented here (Figure 4) is an attempt to delineate the process of transferring technology from a R&D consortium to the shareholder organizations based on the models presented in the preceding sections as well as from the insights gained from an extensive review of the technology transfer literature. The basic premise behind this model is that the process of transferring technology should be seen as a sequence of interrelated activities in a non-strict order that begin even before the formal research and continue after the technology has been formally transferred. (Rhea, 1991; Al-Ali, 1995; Cusumano and Elenkov, 1994). The model also recognizes the highly interactive nature of the technology transfer process. It recognizes the fact that, not only do personnel from both the consortium and the shareholder organizations exhibit significant levels of interaction with each other at every stage of the transfer process, but also that the different stages of the transfer process themselves are linked together by iterative loops.

In order to validate the model presented in this section, a probe will be developed based on information culled from the following description about four distinct sets of variables : task variables², activity variables³, interaction variables⁴ and actor variables⁵. This

² Task variables refer to the characteristics of the tasks that need to be carried out as part of the transfer process

³ Activity variables refer to the characteristics of the activities that need to be carried out in order to accomplish these tasks

⁴ Interaction variables refer to the characteristics of the interaction between the various activities that are carried out as part of the process

⁵ Actor variables refer to the characteristics of the individuals involved in carrying out these activities

approach parallels Craven's (1970) study of the process of individual information processing in which data about the above mentioned variables were collected and used in order to validate the conceptual model that had been developed.

Figure 4 : THE INTEGRATIVE MODEL

Key for the Links in the Model :

- **Idea (Information) transfer**
- _____ **Prototype transfer**
- _____ **Product (Technology) transfer**

The following is a detailed description of the model (Figure 4) presented above :

Idea Generation and Technology Development Stage The first stage in the technology transfer process is the initiation stage. Both the consortium and the shareholders try either to identify specific needs to be targeted or identify promising areas where further research could result in the development of newer, more sophisticated technologies which would provide the consortium shareholders with a competitive advantage. In order to carry out successfully such an “identification”, the managements at both organizations need to continuously analyze and monitor both their external and internal environments. Key personnel at both the consortium and the shareholder organizations can be rich sources of such information. Ideas for research can also originate outside the involved organizations. Such sources in the external environment would include universities, conferences, technical symposia, customers etc. It then falls upon the top management of the consortium to set, in conjunction with the shareholder organizations management, the priorities for the research to be conducted. Thus, a screening of the ideas flowing into the consortium is carried out and a smaller subset is chosen to focus on.

Once the *agenda for the research* to be conducted at the consortium has been established, it is conveyed to the technical core of the consortium. It is important to emphasize that this is an on-going process. The management constantly interacts with the environment and if need be either refocuses the efforts of the consortiums technical core or further

diversifies its research activities. This phase, primarily consists of *idea/information transfers*.

The focus, then shifts to carrying out actual research and developing a *prototype/experiment* to demonstrate the new technology. The management must estimate during the initiation stage, the goodness of the technology being developed, with respect to its superiority over the existing technologies and with its fit with the shareholders' needs and abilities. In order to ensure this, the *prototype developed is evaluated* by both the consortium top management as well as the key end users in the shareholder organizations. This interaction between the technical cores of the consortium and the shareholder organizations can be carried out through either formal channels of communication (i.e. through the shareholder assignees at the consortium) or through the informal networks which may exist between the two groups of personnel. The feedback given to the consortiums technical core is then used to make the required modifications to the developed technology. A decision to terminate the project might also be made at this phase. This phase of the initiation stage is marked primarily by *prototype transfers*. Once the technology (product) is finally ready to be transferred to the shareholder organization, it requires *final approval* from the consortium management. Though this final transfer is a transfer of the new technology product ("*product transfer*") that has been developed by the consortium, it still is a part of the initiation stage as it marks the final phase of the "goodness" evaluation exercise.

Technology Flow Stage - Once the goodness of the new technology has been established, it enters the implementation stage. It is in this stage that the resources flow between the consortium and the shareholder organizations and that the transfer specific ties are activated. *Goals and verifiable standards* are established in order to measure the success of the flow of technology between the two organizational entities. The consortium's *communications* core takes over and starts interacting actively with the various member-company personnel/bodies responsible for conducting the transfer. These include the member-company (shareholder) assignees, technology transfer managers, etc. It is through them that the developed technology is finally transferred to the key end users in the shareholder organizations. The transfer at this stage consist entirely of "*product*" *transfers*.

Ramp-up Stage - The third stage of the transfer process begins when the key end users actually *first begin using* the technology that has been developed. This stage is called the ramp-up stage. The effectiveness of use of the new technology during the initial phases of the ramp-up stage is not optimal as the recipient is still trying to understand fully the technology's potential but it improves with time and use, gradually ramping-up towards a satisfactory level. An *evaluative mechanism(control system)* is also set up to monitor the success of the transfer of technology process (Madu, 1989). An example of such a mechanism might be an administrative body or individual(s) charged with overseeing and monitoring the progress of the transfer efforts according to certain pre-specified targets. The information about the transfer process is passed onto the mechanism as an

information transfer and is then reviewed. If it indicates a failure in transferring the technology due to a *faulty implementation procedure*, the “*product*” being transferred is looped back to the implementation stage and the process is re-started. The mechanism might also identify a need for further assistance from the consortium personnel in order to aid the shareholder(s) in adopting the new technology. In such a scenario there is direct interaction between the R&D core of the consortium and the key end users at the shareholder(s) which is characterized by information transfers. However, if the mechanism detects a more fundamental discord between the characteristics of the technology that has been developed and the needs of the shareholder organizations that it is stated to satisfy, the technology might be shelved. The process would then be looped back to the initiation phase in the form of an *idea/information transfer for a redefining of the needs and goals*. However, if the evaluative mechanism indicates success, the transfer process progresses to the next stage.

Integration Stage - The fourth and final stage of the transfer process is called the integration phase. At this stage, the technology *spreads* from just the key end users *to the entire organization* and its use becomes routine within the shareholders operations. Again, an *evaluative mechanism* is used to measure the effectiveness of the transfer process at this stage. A failure at this stage would result in the process looping back to the ramp-up stage. Success however, would result in the completion of the technology transfer process.

2.4 Factors Facilitating the Transfer Process

Given the complexity of the technology transfer process, it is not surprising that a variety of factors have been identified that affect its success. The following categorization is an adaptation of Smilor and Gibson's (1991) broad classification of these factors :

1. Mode of Communication Communication is perhaps, the most obvious factor which might impact on the success of transfer of knowledge or technology. Moon and Bretschneider (1997) highlight the importance of communication by stating that the transfer and adoption of technology is essentially the outcome of a communication process.

Communication between technology transmitters and receptors involves both passive and active links. Passive links include research reports, journal articles, computer and video tapes. Such media are best for rapidly communicating the same message at the same time to a widely dispersed audience at a relatively low cost. However, with such attempts, the transmitter is often unaware of whether and how the receptors receive and utilize the transferred technology. Very often information goes out from the consortium but no feedback returns from the shareholders. The hope is that in selected instances the media-based message will hit the right receptor at the right time, and the receptor will be motivated enough to take the time and resources to pursue a more active linkage with the consortium in order to fully exploit the potential of the new technology.

Active links on the other hand, are direct, person-to-person interactions. Such links include teleconferences, board meetings, ad hoc teams, employee visits and transfers. Research (Evan and Olk, 1992; Kenney and Florida, 1994) has shown that greater the personal element and direct interaction in the mechanism being used, the greater is the success achieved at transferring technology. The benefits of active links center on the fact that they encourage interpersonal communication in terms of fast, focused feedback. Though such communication is more costly in terms of time, personnel and resource commitment, it greatly increases the chances of a successful technology transfer. Moreover, with recent advances in information technologies, researchers predict that the ease of engaging in active communications would increase manifold and, thereby, greatly increase the chances of success in the transfer process by allowing for constant monitoring (Okko and Gunasekaran, 1996; Howells, 1995).

Sedaitis (1996) further points out that the communication processes associated with successful transfer attempts are characterized by feedback loops at each stage in order to monitor and if need be, refine the direction of the process. In order to do so, a flexible communications organization needs to be developed that would more readily support such an iterative approach to the process.

2. Geographical and Cultural Distance The distance, both geographically and culturally, between the consortium and the shareholders also exerts a significant impact on the consortia's ability to transfer the developed technology. Geographical distance

between the consortium and the shareholder companies involves the physical proximity of those engaged in research activities. This distance can be lessened by co-locating and promoting active and direct communication links between technology transmitters and receptors by various ad hoc and formal means.

Cultural differences between the consortium and the shareholders, however looms as a more important dimension of the distance variable. Each shareholder brings his or her own values, attitudes, priorities, and the way of doing things to the consortium and thus, giving rise to the possibility of great conflict within the consortium organization. It is essential that the personnel at the consortium collectively understand the values and the attitudes of doing things at each of the shareholder companies in order to successfully implement the technology transfer. Moreover, one must also be cognizant of the fact that the consortium is itself a distinct entity hence, there exists a strong likelihood of it developing its own unique culture over time which might be in conflict with the culture(s) of its shareholders. It is imperative that mechanisms be developed in order to instill a mutual appreciation of the respective cultures in both, the consortium and the shareholder personnel in order to enhance the chances of successfully transferring the technology (Green, Brupbacher and Goldheim, 1991; Szulanski, 1996; Browning, Beyer and Shetler, 1995).

3. Nature of Technology The nature of the technology being transferred also affects the ability to transfer the technology successfully. If the technology being transferred is

high on concreteness, i.e., it is fairly easy to understand, demonstrable and unambiguous, it is easier to transfer. Moreover, such a technology conveys very similar meanings to different individuals. Thus, the lower the equivocality of technology, the easier it is to educate prospective users on the value/ applications of that technology. Furthermore, research has identified the codifiability of the technology to be transferred as an important factor. Even if the technology is not easy to understand or teach, the extent to which it can be encoded goes a long way towards facilitating its transfer (Zander and Kogut, 1995 ; Bonaccorsi and Piccaluga, 1994).

Another dimension to be considered has to do with how radical the technical advancement is. Is the new technology merely an improvement on a technology that is already well understood, an accepted process or technique or is it a “revolutionary” change? Substantial efforts are needed in order to evaluate and utilize technologies falling in the latter category. Szulanski (1996) points out that it is much easier to transfer knowledge with a proven track record. It is much harder to induce the recipients to engage in the transfer if the technology does not have such a record.

4. Motivation, Capability and Commitment The process of transferring technology can never be successful if the individuals involved are not motivated towards ensuring its success. Motivation for participating in technology transfer depends on the importance of the transfer function in the culture of an organization, the criteria by which the individual is evaluated, and the rewards established for those who engage in

technology transfer activities. The greater the variety of incentives, rewards and recognition, the higher the motivation for those engaged in the process.

At the organizational level too, both the consortium and the receptor firms need to show a willingness to promote and the commitment to support the transfer process. Lin (1997) points out that the organizations involved need to have a certain level of “technology capability” in order to transfer the technology effectively. Technology capability is defined to include the extent of experience that the organizations have had in transferring technology, the percentage of technical staff to the total staff, the financial resources made available for the transfer activities, the compatibility of the technology already in use with the technology being transferred, the capability of the personnel involved and the quality of management. Indeed, it is essential that adequate resources in terms of personnel, finances, time etc. are made available in order to facilitate the transfer process, especially if the technology capability of the involved organizations needs to be upgraded. Researchers have pointed out that it is the skills and training issues from amongst the other attributes of technology capability that are very often forgotten or misjudged by companies (Foley and Watts, 1994). Indeed, the shareholder organizations need to ensure that their personnel possess the requisite skills to be able to adopt the technology being transferred (Okko and Gunasekaran, 1996; Jones and Tang, 1996). If not, care must be taken to impart the necessary training to them.

Further, it can be argued that though the transmitter's willingness helps, it is the receptor's motivation that is crucial to the transfer process. The recipient may have to make changes to its procedures, work organization, training etc. in order to exploit fully the potential of the transferred technology (Seaton and Cordey-Hayes, 1993). Thus, the receiver must be convinced about the latent profitability of the new technology to be an enthusiastic participant in the process. Without such enthusiasm, even an aggressive proactive approach on the part of the consortium to transfer technology is liable to flounder.

5. Role of Management Shareholders and consortium management play a critical role in building an infrastructure that is both supportive and conducive to technology transfer. Shareholder management should clearly identify the individual(s) in the company responsible for monitoring, receiving and disseminating a technology at the shareholder organization. They should also assign a "liaison" or a "boundary spanner", someone who is highly visible and respected in the shareholder company, to the consortium (Morgan and Crawford, 1996; Lang, 1996). These boundary spanners would perform a number of functions including overseeing the relationships of their respective firms with the consortium, communicating policies with regards to technology transfer and acting as filters of knowledge.

To reap the benefits of investing in the consortium, shareholder management should try to change the organizational culture of their firms in order to minimize the impact of the "not invented here" syndrome (Smilor and Gibson, 1992; Szulanski, 1996). Expectations and

usability criteria for the consortium technology should be explicitly stated so that the consortium personnel have a clear understanding of what the shareholders expect from them. The consortium management should also set up a technology transfer office to monitor, document, and publicize technology transfer activities. People/programs at the consortium should be encouraged to have explicit technology transfer objectives. For example, they may be encouraged to commit to a date by which key end users at the shareholder organizations would begin to use the technology developed. Consortium researchers should be encouraged to set up on-site demonstrations of their technologies in order to make it more understandable to its potential users. Management at both the shareholder organizations as well as the consortium should encourage greater formal and informal interactions between their personnel including lecture series, workshops and social outings etc. This would foster a better understanding of each others values and attitudes (Smilor and Gibson, 1991). Consortium personnel could also be set up as technology champions in order to facilitate interaction with a range of personnel at the shareholder companies (Bidault and Cummings, 1994). Finally, management should also strive to design incentive systems which recognize and reward successful attempts at transferring technologies. These may include the traditional financial incentives in the form of pay raises or bonuses or royalty arrangements for transferred technology as well as due recognition of the individuals/groups involved in technology transfer through features in newsletters, through documentation of transfer success stories etc. (Smilor and Gibson, 1991).

6. Size and Type of Industry

Researchers have also identified other factors that fall outside the purview of Smilor and Gibson's framework. The importance of firm **size** is often mentioned in the technology transfer context (Moon and Bretschneider, 1997; Sedaitis, 1996; Stock, Greis and Dibner, 1996). However, the influence that the size of the involved organizational entities exerts on the success of the transfer process is indirect in that the larger organizations have more resources and personnel and thus, are better able to manage the relationship of the aforementioned factors with the success of the transfer process. However, it should also be noted that though this availability of greater amounts of resources may be an enabling factor in the successful transfer of technology, the scale at which the technology transfer to a large organization needs to be implemented greatly increases the complexity of the process. Another factor thought to play an important role is the **type of industry** to which the consortia and the shareholder organizations belong (Moon and Bretschneider, 1997). Again, the type of industry would affect factors like the nature of technology being transferred and thus, exert an indirect influence on the transfer process.

Chapter 3

RESEARCH OBJECTIVES

The main purpose of this study was to develop a better understanding of the complex process of technology transfer from R&D consortia to the shareholders. The study focused on:

1. Identifying and confirming the various stages involved in the technology transfer process.
2. Identifying the various facilitators of the transfer process.

Chapter 4

RESEARCH METHODOLOGY

This section describes the steps undertaken to conduct this research study. Section 4.1 discusses the research design and strategy that was adopted for this study. Section 4.2 describes the sample selection procedure adopted. Section 4.3 provides a detailed account of the data collection method used. Finally, Section 4.4 details the analysis performed on the data that was collected.

4.1 Research Design and Strategy

The research design used in this study was an **Ex Post Facto Design** wherein the researcher made no attempt to control or manipulate the independent variables under study. The study was a field study in the respondents' environment. It was also **exploratory** in nature with the primary focus being on the technology transfer process from the perspective of the consortia. An exploratory study was selected as much research has not been done in the proposed area in the Canadian context. The study involved personal interviews with senior personnel in the consortia responsible for transferring technology. Using the results from the study, a model for transferring technology from the consortium to the shareholders was developed and the factors that facilitate the transfer process were identified.

4.2 Sample Size and Selection

A total of eleven consortia across Canada were considered for the purpose of the study. Given that this was an exploratory study, the sample size was considered to be adequate. Two subjects were interviewed in one consortium, and one each in the remaining ten. Consortia in Ontario and Quebec were given preference. This made it easier to conduct in person interviews and thus gain a better insight into the transfer process. However, a sufficiently large sample was not obtained from the defined geographic area and thus it became necessary to include consortia outside of the two provinces. The sampling unit in the study was senior management staff at the various consortia included in the study. These respondents were not asked for information about specific projects; rather they were encouraged to provide the researcher with a generic view of the transfer process being followed at their respective consortia.

4.3 Data Collection

A **primary data collection** method was used for the purpose of this study wherein interviews were conducted with senior consortium management. In order to keep the discussion about the transfer process in focus, an integrative model of the process was developed. Also, the factors that influence the success of the transfer process were identified through an extensive literature search. These were then used to develop an interview probe in order to determine the various stages of the transfer process as well as

to obtain information on factors which impact on the success potential of the transfer process. Open-ended questions were used on the probe. The probe is shown as a part of Appendix B.

Once the consortia to be included in the study had been identified, the appropriate contact person(s) in each was identified through phone calls to the selected units. The individuals were then approached and briefed about the study. Subsequently, an appropriate time and date for the interview was fixed. Prior to the interview, a letter from the thesis supervisor explaining the purpose of the study and ensuring confidentiality of the information provided was presented to the respondent. In cases where it was not feasible to conduct interviews in person, arrangements were made to conduct the interview over the phone. The respondents were told that the results would be reported in an aggregate form and no individuals would be named in the results. Each interview lasted for approximately 60 minutes. Further, during the interviews, any prompting of the interviewees was kept to a minimum. This was done to ensure that no interviewer bias was introduced in their responses. All the interviews were recorded with the interviewees consent. A request was also made for annual reports and web site addresses in order to obtain additional information about the various consortia studied. Moreover, the findings of this study were made available to the participating consortia if they so desired.

The probe was pre-tested on one consortium. The pre-test did not result in any significant improvement in the data collection instrument. This pretest as well as an extensive

literature review were used to establish the reliability and the validity of the probe. However, given that this is an exploratory study with a small sample size, the generalizability of the results might not be very extensive but this study could form the basis for further research.

4.4 Data Analysis

The analysis conducted for this study was qualitative in nature. The interviews conducted were transcribed. To represent the qualitative data obtained through the interview probe, the approach that was adopted is based on the principles of content analysis. The lengthy verbal responses obtained were reduced to essentials and then grouped into well-defined categories. The responses thus categorized were used to develop a model for technology transfer from consortia to the shareholder organizations to gain an insight into what factors are considered important for the success of the transfer process. These responses were also used to prepare extensive case studies of each of the consortia. These case studies have been included in Appendix C.

Chapter 5

RESULTS

The results of this study are presented in two sections. The first objective of this study was to study the various stages and the sequence of related activities comprising the technology transfer process in the consortium-participating shareholder context. Thus, the first section will describe in detail the technology transfer process being followed by the various Canadian R&D consortia included in this study. The second objective of the study was to identify the factors which may facilitate the transfer process in the given context. The second section will include a discussion of the factors that the respondents perceived to be important in ensuring the success of technology transfer.

The analysis of the data obtained from the interviews with senior consortium personnel was facilitated by the insights obtained from the works of Patton (1980) and Wolcott (1994) on qualitative data analysis and this will be incorporated in the discussion.

Before proceeding with the discussion of the results, however, it is worth noting that the consortia included in this study can be differentiated along a number of dimensions especially the number and type of shareholders, the organizational structure especially in terms of the status of the end users and sector of operation etc. (Table 1) These differences

resulted in several variations in the transfer process being followed at the different consortia which have been highlighted in the following discussions.

Table 1 : Some Characteristics of the Consortia included in this study⁶

	Number and Type of Shareholders	Organizational Structure	Sector/Area of Operation
Organization 1	36 shareholders including 35 companies and 1 university	Free standing body: located at one particular shareholder site	Seismology
Organization 2	Over 150 shareholders including companies and government agencies	Free standing body ⁷ : located at one particular shareholder site	Paper industry
Organization 3	Over 26 shareholders including universities and other organizations in the area of health care research	Free standing body	Software/Information products for health care professionals
Organization 4	8 shareholders including companies and a federal research organization	Free standing body : located at one particular shareholder site	Multiwavelength communication technology
Organization 5	10 shareholders including companies and a federal research organization	Primarily an administrative body though consortium facilities are used for technology evaluation	Optoelectronics
Organization 6	Over 55 shareholders including various companies and universities	Primarily an administrative body	Microelectronics
Organization 7	4 companies ⁸	Administrative body; End users acquire shareholder status on a project to project basis	GIS, Remote Sensing
Organization 8	Over 300 industrial partners	Administrative body; Trade Association Structure	Various
Organization 9	32 shareholders including companies, research institutions and universities	Administrative body	Artificial intelligence technology
Organization 10	26 shareholders including manufacturers, service providers, research institutions and universities	Administrative body	Rehabilitation technology
Organization 11	18 shareholders ⁹ including a number of universities and research institutions	Administrative body	Bacterial diseases

⁶ The consortia included in this study were located in the following cities/regions : Toronto, Vancouver, the Ottawa Valley, Kingston, Calgary, Edmonton, and Hamilton.

⁷ The free-standing consortium is one in which research is conducted in-house in the consortia's own facilities which are distinct from member facilities. An administrative consortium, on the other hand, coordinates research at shareholder sites.

⁸ Does not include end users.

⁹ Does not include end users.

5.1 The Technology Transfer Process

Idea Generation and Technology Development Stage The process of technology transfer begins with the identification of the technology areas to be pursued by the consortia. Different sources are used by the consortia included in this study for generating ideas and identifying promising directions for research. In as many as ten of the eleven consortia studied, the specific short-term and long-term needs of the shareholders provided the bulk of the ideas. The reasoning behind such a strategy is that it ensures greater commitment on the part of the shareholder for the transfer process. However, of these ten, nine consortia, also exhibit varying degrees of proactivity in the technology identification phase. In the case of these consortia, even though the needs of the shareholders remains a major area of focus, this is further supplemented by various other sources for ideas. These sources include the consortium management and personnel, the external research environment (universities, research organizations, conferences etc.), discussion forums and technical symposia and advice from non-member sources of funding like government agencies. One particular consortium has set up a rather unique mechanism for identifying potential research areas. The consortium actively surveys the final consumers of the products produced by its shareholders in order to identify areas in which to focus its R&D efforts.

The last consortium in the sample is further along on the spectrum of proactivity. The mandate of this consortium is to further basic research in the field of seismology. Thus,

the consortium very rarely focuses on any short-term specific issues facing the shareholders; concentrating instead on the discovery of more generic knowledge.

Given the variety of sources used for generating ideas, it is not surprising to find that, except for one, all other consortia had set-up fairly stringent mechanisms for the evaluation of these ideas. These mechanisms mostly take the form of administrative bodies that are established in order to review thoroughly the proposed research ideas for their technical merit as well as for their commercial potential.

For the proposals that are selected, most interviewees referred to undertaking an extensive goal setting exercise for establishing major project milestones. This is passed on to the technology development team as an information flow at the time of project commencement. The only consortium that did not exhibit this kind of a set-up was the one in which the shareholders have given complete freedom to the researchers to set their research directions. This eliminates the need to establish any upfront procedures for evaluation. The review process in this case is rather indirect. The shareholders renew their association with the consortium on a yearly basis. Any shareholder who does not feel that the work being done is of any relevance to their organization withdraws from the consortium at the end of the year.

Once the projects have been selected, the actual development of the technology begins. As far as the organization of the actual development work is concerned, the consortia studied

exhibited wide differences. In four of the consortia, the development work is carried out in the consortium facilities themselves. In two of these, teams consisting of consortium personnel as well as personnel from various shareholders work on the projects. However, in the other two, the development work is carried out by the consortium personnel alone with little involvement from the shareholders. The remaining seven consortia are administrative in nature and thus, the development work is carried out at shareholder sites. In two of these consortia, the development work is carried out in parallel at multiple shareholder sites with the different elements of the technology product being integrated into the final “product” at a later stage. In five other consortia, the development work is carried out at one particular shareholder site. However, in only one of these, does the project team consist of personnel from the other shareholders. In the remaining four, though multi-institutional development occurs sometimes, in most cases the project teams consist only of personnel from the shareholder charged with developing the technology.

These differences notwithstanding, prototyping is an integral part of the technology development phase. Only two of the eleven interviewees observed that the development of the prototype was not an important activity. Both these consortia do highly knowledge intensive work. Thus, the very nature of their work mitigates the need for an explicit prototyping stage. However, one of these two consortia is involved in the development of specialized software for its shareholders. In such cases, even this consortium releases beta versions of the software product.

Moreover, it was clear that both the consortium and shareholder personnel are involved in the evaluation of the prototypes. In one of the consortia, the prototypes are even evaluated by the final consumers of the products being produced/used by the consortium's shareholders. Furthermore, one interviewee also stated that the project might be terminated at this stage if this evaluation yields unsatisfactory results. This phase of activities is marked by prototype transfers

It is also important to evaluate the management involvement during the technology development phase of the initiation stage. Such involvement might be needed in order to ensure that the project remains on track and also to refine the development efforts if required. The consortia exhibited varying degrees of management involvement during the technology development phase. In as many as seven consortia, management interaction with the technical personnel during the development phase ranged from being low to being non-existent. One of the interviewees observed that the management develops a fairly good idea of the progress being made by the development teams by informally monitoring the requests for technical assistance that the teams put in while working on developing the technology. Only in four consortia have mechanisms been established by the management personnel in charge of the operations of the consortium to keep abreast of the progress status of all projects. These mechanisms include setting up frequent formal meetings with the project team leaders and team members as well as requiring them to submit regular reports.

Another aspect of management involvement during the initiation stage is the need for final approval from the management before the technology flow to the recipients can begin. In as many as eight consortia, no formal procedures have been established for management approval in order to initiate the technology flow. In some cases, such approval is not required as the management is actively involved throughout the development process. In other cases, the absence of such procedures is due to a desire to reduce the level of bureaucracy in the transfer process. In most cases, it is left to the project managers/team leaders to do a final review of the project and inform the management that the technology is ready for the transfer to the recipients. One respondent noted that an extensive approval process is normally used only when the technology that has been developed is radically new.

In three consortia however, elaborate mechanisms have been set up for a final review of the technology by the management before the transfer of technology to the recipients commences. In two of these, the final recipients of the technology acquire shareholder status only on a project to project basis. These members do not share in the collective intellectual property rights for all R&D work done under the aegis of the consortium. Thus, in these consortia a final clearance by the management has been made mandatory before the technology flow can be initiated.

The results for the idea generation and technology development stage have been summarized in Table 2.

Table 2 : Summary of Results¹⁰ : Idea Generation and Technology Development Stage

- **Technology Identification and Project Selection**
 - Focus on shareholders specific needs for generating ideas for technology development (10)
 - Some degree of proactivity in generating ideas for technology development (10)
 - Elaborate mechanisms for evaluating the ideas for technology development (10)
- **Technology Development**
 - Technology developed at consortium by teams of personnel from the consortium and shareholders (2)
 - Technology developed at consortium by consortium alone (2)
 - Technology developed at multiple shareholder sites (2)
 - Technology developed at one shareholder site by that particular shareholder's personnel (4)
 - Technology developed at one shareholder site by a team consisting of personnel from many shareholders (1)
 - Prototyping is an integral part of technology development (9)
- **Management Involvement**
 - Management involvement in the technology development phase low (7)

Technology Flow Stage Most interviewees agreed that the establishment of transfer specific ties to facilitate the flow of technology from the source to the recipient is a crucial stage in the transfer process. As discussed above, the technology may be developed at the consortium or at single or multiple shareholder sites. It then flows from the development site to other shareholders. However, sometimes this flow is not an isolated and distinct activity but occurs in parallel with the development process. In one particular consortium,

¹⁰ The number in parenthesis represents that number of consortia that exhibit the particular characteristic.

the technology is always developed at the recipient site itself and is transferred as it is being developed. This can be seen in some other consortia as well where the developer of the technology is also amongst the users/final recipients of the technology. Another point to note is that in most cases due to the presence of personnel from the recipient shareholder(s) on the development team, some amount of transfer occurs during the development process itself through informal information flows.

Interviewees identified a number of means of communication that are used for transferring technology. These include direct means for technology transfer such as onsite visits, workshops, “annual days”, technology demonstrations, seminars and personnel transfer as well as indirect means such as research/technical reports, technology bulletins and newsletters. In one particular consortium, an annual conference is organized in order to achieve broader dissemination of the non-proprietary elements of their R&D work in the public domain.

Further, in all consortia the responsibility for initiating and managing the flow of technology from the development site falls on the development team leader and members. In cases where shareholder personnel effect the transfer of technology by moving back to the parent organizations, a separate team for receiving the technology is not set up. However, in shareholders that do not have personnel working on the development team, normally a group of individuals is made responsible for receiving the technology into the organization. At least two interviewees also specifically mentioned the presence of

“transfer/technology champions” in the shareholder organization to ensure that the transfer occurs smoothly.

At least eight interviewees observed that separate goals are seldom established for the technology flow stage. This might be a reflection of the fact that the actual technology flow activity is a dynamic process and it is perhaps, difficult to capture it in terms of goals. In most cases, overall goals for the major project milestones are established before initiating the project. These goals are then used as a benchmark to monitor the technology flow stage. In the case of one particular consortium, it was pointed out that the goal was to establish mechanisms that would support an ongoing outflow of technology from the consortium. Thus, goals were established only with regards to the setting up of these mechanisms and not for the culmination of the technology flow stage.

The results for the technology flow stage have been summarized in Table 3.

Table 3 : Summary of Results : The Technology Flow Stage

<ul style="list-style-type: none">• Technology Flow<ul style="list-style-type: none">• Flow of technology is sometimes not an isolated and distinct activity• Personnel on the development teams responsible for managing the flow of technology from the development site (11)• Shareholders set up a team of personnel to receive the technology¹¹ (8)• Separate goals are seldom established for the technology flow stage (8)• Means of Communications<ul style="list-style-type: none">• Direct means include onsite visits, workshops, “annual days”, seminars, and personnel transfer• Indirect means of transferring technology include research/technical reports, technology bulletins and newsletters.

Ramp-up and Integration Stages The shareholders in all of the consortia studied, exhibited a phased process of adopting the incoming technology. In at least three consortia, shareholder personnel were involved in the actual development of the technology. As mentioned above these individuals are responsible both for bringing the technology into their respective organizations and for its subsequent organization-wide adoption. In these cases, the ramp-up stage is not as significant as the primary carriers of the technology into the shareholders already have extensive understanding of the capabilities of the technology by virtue of being involved with the development team. However, in the case of the other consortia, teams of shareholder personnel are set up in order to receive the technology into their organizations. These personnel are charged with

¹¹ In the case of the remaining three consortia, the shareholder personnel working on the development teams assume responsibility for bringing the technology into their respective organizations and thereby, eliminate the need for setting up a separate team of personnel to receive the technology.

developing an extensive understanding of the capabilities of the incoming technology and ensuring a smooth integration of the technology with the operations of the organization.

Further, one interviewee noted that the nature of the adoption process exhibited by a particular shareholder depends on its size. The larger shareholders adopt a more structured and phased adoption process while the smaller organizations show a much more ad hoc process. However, another respondent observed that in the case of many smaller shareholders the technology being transferred is normally crucial to their very existence. These organizations set up fairly stringent monitoring mechanisms to ensure the successful integration of the technology into their operations. It was also pointed out that the nature and complexity of the technology being transferred also exerts an impact on the type of adoption process used. If the technology being transferred is highly complex, normally a phased process of adoption is seen where a small group of technically skilled individuals develop a thorough understanding of the capabilities of the technology (ramp-up) and then disseminate the technology through the rest of the organization. If, however, the technology being transferred is not as complex it might be put to more general use straight away.

Moreover, most of the consortia studied are not involved in monitoring the adoption of the technology by the shareholders. In most cases, the shareholders use their own internal control systems to keep track of the process. The general consensus amongst the interviewees was that once the shareholders have started using the technology, monitoring

the adoption becomes the shareholder's internal decision and the consortium has no role to play at that stage. However, in the case of one particular consortium, the shareholders are required to submit regular reports about the adoption of the technology. This allows the consortium to monitor actively the adoption process. Another interviewee commented that in some cases goals are established by the consortium for the commercialization of the technology by the shareholder. The establishment of such milestones allows the consortium to exert some influence over the adoption and use of the technology by the shareholder.

The results for the ramp-up and integration stages have been summarized in Table 4.

Table 4 : Summary of Results : Ramp-up and Integration Stages

<ul style="list-style-type: none"> • Technology Adoption <ul style="list-style-type: none"> • Phased process of technology adoption (11) • Consortia monitoring the adoption of technology by the shareholders (2) • The size of the recipient organization impacts on adoption process exhibited by a particular shareholder (1) • The complexity of the technology being transferred impacts on adoption process exhibited by a particular shareholder (2)

Loops in the Transfer Process At least ten interviewees stated that if needed, technical assistance is provided to the shareholders in adopting and using the technology. Only in the case of one consortium did the interviewee observe that the consortium did not have the ability to provide their shareholders with technical assistance. This assistance is normally characterized by an information flow. However, it was pointed out by a

respondent that at times the technology product might also be sent back to the consortium so as to “iron out the glitches” in the technology.

Moreover, interviewees also noted that there is rarely a mismatch between the needs of the shareholders and the actual technology product. This is possibly due to the fact that in most cases the end users are actively involved in the needs analysis and goal defining activities as well as in evaluating the technology during its development. In the rare case that this does happen, the shareholders are more likely to shelve the technology rather than reinitiate the entire process. It was also pointed out that at times the technology might be shelved due to a change in the strategic focus of the shareholder. One interviewee also stated that the technology might be shelved during the prototyping stage itself if the evaluation of the prototype does not yield satisfactory results.

Though none of the interviewees mentioned the technology flow stage and the integration stage failures identified in the integrative model, the researcher feels that the existence of these loops is implied by their responses. The technology flow stage failure is concerned with improper management of the technology flow activities. This results in an inability on the part of the primary receivers at the shareholder organizations to fully understanding the capabilities of the technology. In this context, it is worth noting that the interviewees did mention that the shareholders are provided with assistance for successfully adopting the technology. This implies that the necessary steps will be taken to rectify the situation described above including the reinitiation of the technology flow stage, if needed.

The integration stage failure refers to a situation where the shareholder has been unsuccessful in routinizing the technology in its operations. Interviewees mentioned that in most cases the adoption of the technology is closely monitored by the shareholders through their internal control systems. If these control systems detect a problem at any stage of the technology adoption process, steps are taken to rectify it. These would include looping the technology product back to the earlier stages of the adoption process, if required.

The results for this section are summarized in Table 5.

Table 5 : Summary of Results : Loops in the transfer process

• Ongoing assistance provided in order to help the shareholders adopt the technology (11) • The process re-initiated if a mismatch occurs between the technology's capabilities and the shareholder requirement¹² (0) • Continuous evaluation during the prototyping phase (9)

Based on the preceding description, a model for transferring technology from R&D consortia to the participating shareholder organizations was developed (Figure 5). The model presents a detailed and comprehensive view of the technology transfer process in the given context. It should be noted that this model does not endeavour to capture the specific differences that were observed in the technology transfer procedures being followed at the various consortia studied. The mandate in terms of model development

¹² Apparently, a mismatch is extremely rare.

was to focus on the commonalties in the process much more than the differences. However, these differences have been covered in the above discussions. These differences were a result of the variations which existed amongst the consortia studied including differences in terms of their organizational structure (free standing vs. administrative) and research focus (basic knowledge oriented vs. specific product or process oreinted). The specific technology transfer procedures being followed at the various consortia have also been covered in great detail in the case studies included in Appendix D.

Figure 5 : Model for Transferring Technology from R&D Consortia to Participating Shareholders

Key for the Links/Flows in the Model :

- **Idea (Information) transfer**
- _____ **Prototype transfer**
- _____ **Product (Technology) transfer**

Characteristics of the transfer process A wide variety of responses were obtained when the interviewees were queried about what activities are the most crucial, most complex and most time consuming part of the technology transfer process. An explicit needs analysis and goal setting exercise at the beginning of the project emerged as perhaps the most crucial part of the technology transfer process. At least five interviewees felt that the establishment of an explicit agenda at the very outset is a must to ensure that the downstream efforts remain focused. Another four interviewees observed that as technology transfer was a highly people based process, managing the relationship between the individuals involved is in many cases, the most complex and time consuming part of the entire technology transfer process. Some other activities that were also mentioned in this context are the actual development of the technology, setting up and managing the means of transferring technology and clearly identifying individuals responsible for managing the transfer process. Another point to be noted is that in the consortia where the end users acquire shareholder status on a project to project basis, the negotiations related to intellectual property rights was identified as an extremely important issue.

The results for this section are summarized in Table 6

Table 6 : Summary of Results : Characteristics of the Transfer Process¹³

Activity	Most Crucial (Count)	Most Complex (Count)	Most Time Consuming (Count)
Goal setting and needs analysis	5		1
Managing relationships between individuals involved in the process	1	4	4
Establishing and managing the means of transferring technology	1	2	3
Technology development	1	1	
Ensuring compatibility of the incoming technology and the embedded technology at the shareholders		1	1
Intellectual property rights negotiations	1	1	1
Clearly identifying people responsible for the transfer process	1		

5.2 Respondent Perceptions about Success Factors for Technology Transfer

Means of Communication Literature states that direct face to face means of transferring technology are superior to indirect means such as research reports etc. irrespective of the stage of the transfer process (Evan and Olk, 1991; Kenney and Florida, 1993). Most interviewees tended to support this view point. Two interviewees in fact, went as far as saying that “direct means of transferring technology are vastly superior as

¹³ Count represents the number of interviewees who classified a particular activity as being the most complex, the most crucial or the most time consuming part of the technology transfer process. Further, these responses were unsolicited, i.e., the interviewer did not prompt the respondents to rate the importance of previously identified characteristics.

no one has the time to read lengthy technical reports.” However, at least four interviewees observed that although direct means are the most efficient means of transferring technology, it is important to supplement them with adequate documentation. It was pointed out that doing so greatly accelerates the learning curve of the recipients of the technology.

Although there was wide spread support for the use of the direct means of transfer, it was observed that sometimes the use of such means of transfer can be time consuming and economically unviable. Direct means also pose a problem if the consortium is interested in increasing the breadth of dissemination of the technology. For achieving this, the use of indirect means of transfer is, in fact, recommended. There is at least one consortium amongst those studied that does not use the direct means of transfer for precisely these reasons. This consortium has taken advantage of the advances in information technology and uses the internet, email and FTP as the primary modes of technology transfer. For most other respondents such advances are a positive development as they facilitate the interaction between the various individual involved in the transfer process. However, at the present time most respondents remain skeptical about the ability of these advances to present a viable alternative to the direct means of technology transfer.

Three other respondents stated that it is extremely difficult to rank the different means of transferring technology. They observed that the suitability of a particular mode of transfer depended entirely on the particular circumstances and technology. If the technology to be

transferred is tangible and easy to codify and package, then indirect means might prove to be more beneficial. However, if the technology is more knowledge intensive and abstract, then direct means might be appropriate.

One interviewee noted that the consortias and the shareholders can no longer afford “ the luxury of treating technology transfer as a linear process.” This is in line with the view expressed by Sediatis (1996). Mechanisms should be established so that the transfer of technology can occur in parallel with technology development. Care should be taken to get feedback from the recipients of the technology about the effectiveness of the particular mode of transfer used. Alterations to the means of transfer adopted should be made based on this feedback.

The results for this section have been summarized in Table 7.

Table 7: Summary of Results : Means of Communications

- The appropriateness of a particular mode of technology transfer depends on the the nature of technology being transferred.
- Direct means for transferring technology are better than indirect means (7)
- Direct means of transfer are especially appropriate if the technology is more knowledge intensive and abstract
- Information technologies such as email, FTP, the internet etc. has a significant impact on technology transfer specifically breadth in dissemination of technology (4)
- Advances in information technology have had a significant impact on technology transfer (1)

Distance Research has stated that the smaller the geographical distance between the consortium and the shareholders the easier it is to transfer technology (Smilor and Gibson,

1991). As many as nine of the interviewees subscribe to this viewpoint. The reasoning behind this being that if the shareholders and the consortium are located close to each other, direct face to face interaction becomes easier and this exerts a positive impact on the transfer process. However, at least two interviewees stated that the significance of physical distance as a factor impacting on technology transfer might be a bit overrated. They noted that they had often successfully transferred technology to shareholders located far away from their respective consortia. One of these two interviewees also observed that the use of such tools as the internet and the email has further reduced the significance of this factor.

Moreover, one of the interviewees stated that the impact of physical distance is moderated by the product type. The influence of physical proximity on the transfer process might be less important in the case of a software product than in the case of something more tangible such as a piece of machinery. Another interviewee noted that the impact of distance might be inversely related to the age of the consortia. As mentioned before, technology transfer is considered to be a very people-based process thus, the relationships between the individuals involved are crucial for its success. Early on in the life of the consortium, these relationships are still being formed therefore the need for face to face interaction is tremendous. However, once these relationships have been established the need for direct interaction might not be as great. Thus, the importance of physical distance as a factor might also diminish.

There was unanimity amongst the interviewees that organizational culture is an extremely important factor as far as the process of transferring technology is concerned. All the respondents pointed out that it is difficult to transfer technology if there are significant differences in the values and attitudes of the recipient(s) and the source. This makes establishing the relationships between the different individuals involved in the transfer process extremely difficult and thus, poses a grave threat to the possibility of executing a successful transfer. Interviewees highlighted different examples of how the organizational culture influences the transfer process. One respondent pointed out that a consortium's culture is highly research oriented. Thus, this makes it easier to transfer technology to a shareholder who shares a similar research focus. Further, the culture at some shareholders might be more open to accepting new and outside technologies and these shareholders would also adopt the technology much faster than others. Another respondent pointed out that in large shareholders the organizational culture is typified by the entrenched bureaucracy. This particular aspect of their culture often proves to be a major hurdle in the path of successfully transferring technology.

The results for this section have been summarized in Table 8.

Table 8 : Summary of Results: Distance

- **Physical Distance**
 - Physical proximity greatly facilitates the transfer process (9)
 - The impact of physical distance on the technology transfer process is moderated by the technology product type and the age of the consortium (1)
- **Cultural Distance**
 - Differences in the organizational cultures of the consortium and the shareholders are a barrier to effective technology transfer (11)

Motivation, Capability and Commitment Most interviewees noted that it is important that due emphasis be placed on the transfer function. This can be done by making technology transfer a part of the job description of the individuals working on the development project or by identifying it as a high priority area in the project description. Further, the interviewees also observed that the shareholders often underestimate the commitment in terms of resources that is required in order to execute a successful transfer. At least eight interviewees felt that it is crucial that adequate resources, especially in terms of personnel and time be set aside for the transfer process.

In terms of incompatibility of the incoming technology with the embedded technology, at least three interviewees noted that this was an important issue. It is important that the shareholders have the appropriate technical infrastructure in place to successfully adopt the technology. However, two of these three interviewees pointed out that as projects are usually initiated at the request of the shareholders, it is highly unlikely that a shareholder

would put in such a request if it does not have the capability of absorbing that technology. Further, if a shareholder does realize that it does not have the needed capability, it either does not participate in the project or acquires the necessary infrastructure to adopt the technology. Four interviewees also noted that training of the recipient personnel, especially in cases where the personnel have not been actively involved with the development of the technology, is an important issue. They stated that such training is normally provided by the shareholder organizations.

Interviewees also observed that there is a learning curve associated with the transfer process. Thus, the more experience one has with technology transfer the better one gets at completing the process. The reasoning behind this being that with experience the individuals are in a better position to identify the potential pitfalls inherent to the process and are able to take timely action in order to avoid the same. Two interviewees also stated that it helps even more if one has engaged in transferring technology with the same group of individuals in the past. The reason being that technology transfer is essentially a people-based process, i.e., the relationships between the different individuals involved are crucial for its success. If one is working with the same group of individuals, these relationships have already been established and this can go a long way towards ensuring the success of the transfer.

Moreover, eight interviewees also thought that both the consortium and the shareholders need to be committed towards the transfer process. As one respondent stated, “both the

consortium and the shareholders together need to undertake steps for executing the transfer.” However, it was pointed out that in reality, one rarely sees equal commitment from both the organizations. In some instances the consortium is more motivated as the technology is their “baby” whereas in other instances the shareholder might be more motivated as the technology might be aimed at solving a specific problem at their organization. Three other respondents however, disagreed and stated that though the consortium commitment is important, it is the pull aspect of the transfer process that is more crucial. If the shareholders are not committed to the transfer, then the “ technology will not go anywhere.”

Lastly, none of the consortia studied offered any rewards to either the consortium or the shareholder personnel involved in transferring technology for exemplary transfer efforts. Moreover, only one consortium recognized technology transfer efforts through its newsletter. However, most interviewees felt that instituting such rewards might be an effective way of motivating the involved personnel to engage in more efficient transfer of technology. These rewards could include bonuses, pay raises, royalty arrangements for the transferred technology etc.

The results for this section are summarized in Table 9.

Table 9: Summary of Results: Motivation, Capability and Commitment

- Emphasizing the importance of the transfer function (8)
- Shareholder commitment to the success of the transfer process more important than the consortium's commitment (3)
- The consortium and the shareholder organizations should provide adequate resources for the transfer process (8)
- Recognizing and rewarding transfer efforts (7)
- Though most respondents agreed that rewarding transfer efforts might be an important motivating factor, none of the consortia studied had any mechanisms for doing so
- The consortium and the shareholder organizations have previous experience in transferring technology (9)
- Incompatibility of the new technology is an important factor. (3)

Role of Management All the interviewees agreed that the management at both the consortium and the shareholder organizations can do a lot in order to facilitate the transfer process. Management should be explicit about their commitment towards technology transfer. The transfer function should be identified as a high priority activity by the management and should be made a part of the job description of the individuals involved in the project. One interviewee also suggested that the management should try to establish standards which could be used to evaluate the technology transfer performance of the various employees.

It is extremely important for a successful transfer that both the shareholder and consortium management identify the personnel responsible for technology transfer. Two interviewees also pointed out that appointing an overall technology transfer champion can prove to be beneficial as far as the transfer process is concerned. It was also suggested that

the management should encourage greater interaction between all organizations and individuals involved by organizing such events as internal show and tell days.

The management at both the consortium and the shareholder organizations should free up adequate resources especially in terms of personnel and time. Steps should also be taken to ensure that no infrastructural bottlenecks are present which might obstruct the smooth adoption of the technology by the shareholders. The shareholder management should also provide training to the personnel who would be responsible for receiving the technology and implementing it in the organization. Interviewees further noted that an environment receptive to research done at external sites, needs to be created at the shareholder organizations. The reference was quite obviously to the “not invented here” (NIH) syndrome. One possible step that the shareholder management could take to minimize the impact of the NIH syndrome is to advertise extensively to the companies employees the extent of the companies involvement in the development of the technology.

The results of this section are summarized in Table 10.

Table 10 : Summary of Results : Role of Management (Consortium Management as well as the Shareholder Management)¹⁴

- **Management Action**

- Management should explicitly recognize the importance of the transfer process and be committed to its success (7)
- Management should explicitly include the transfer function in the job/project description (4)
- Management should establish explicit goals for the entire transfer process (1)
- Management should clearly identify the individuals responsible for the transfer process including technology transfer champions, if any. (6)
- Management should free up adequate resources for the transfer process (11)¹⁵
- Management should set up explicit criteria to evaluate personnel performance on technology transfer (1)
- Management should ensure that the environment at the shareholder organization is conducive to accepting technology developed at external sites (1)
- Management should encourage interaction between the personnel of the consortium and the various shareholders (1)
- Management should institute mechanisms for rewarding transfer efforts¹⁶ (7)

Size of the involved organizations There does not seem to be any agreement amongst the interviewees about the impact of size of the involved organizations on the transfer process. Four of the interviewees stated that size is an important factor as far as technology transfer is concerned. However, amongst these four, two claimed that it is easier to transfer technology to larger organizations due to their larger resource base while

¹⁴ The number in parentheses represents the number of respondents who identified the particular management action as being crucial for the transfer process.

¹⁵ A count of eleven may be a manifestation of an interviewer bias that might have been introduced during the interview inspite of the researchers best efforts to minimize the same.

¹⁶ Though most respondents did not mention this as an important management action; however, it is safe to assume from the previous table (Table 9) that it is important. In that table ,7 interviewees had clearly stated that instituting such rewards might prove to be critical for ensuring the success of the transfer process.

the other two claimed that it is easier to transfer to smaller organizations as they tend to be more focused and less bureaucratic. Five interviewees claimed that size is not a factor at all. However, amongst these as well, three went on to say that most large organizations work through smaller, more focused groups and thereby effectively sidestepping the problems associated with large size. Two other respondents did not take a stand on the issue at all and stated that though size is a factor, it is difficult to articulate its impact on the transfer process. One interviewee mentioned that irrespective of the size of the organization, what is really crucial for the transfer process is that individuals responsible for technology transfer be clearly identified.

The results for this section are summarized in Table 11.

Table 11 : Summary of Results : Size of the involved organizations

<ul style="list-style-type: none"> • Impact of Size <ul style="list-style-type: none"> • Size exerts a significant impact on the transfer process (4) <ul style="list-style-type: none"> • It is easier to transfer to larger organizations (2) • It is easier to transfer to smaller organizations (2) • Size is not a factor as far as the transfer process is concerned (5¹⁷)

Nature of Technology and Type of Industry There was some confusion evident in the responses obtained regarding the impact of the sector in which the consortium and the shareholders operate (e.g., the paper industry vs. the remote sensing industry). Five

¹⁷ However, of these 5, 3 stated that size is not an issue as most large organizations sidestep the problems associated with size by operating through smaller, more focused groups. Thus, it would be safe to assume that for these 3 interviewees, size would have been a significant factor if this was not the case.

interviewees noted that by being in a particular sector, the organizations deal with particular kinds of technologies and are influenced by the sector's culture in terms of receptiveness to new technology, openness to technologies developed outside the organization etc. Factors like these, can exert a significant influence over the transfer process. However, other interviewees pointed out that the sector per se did not exert any influence as there are early innovators and adopters in all sectors and that there are commonalities in the transfer process which remain valid irrespective of the sector in which these organizations work.

Except for one, all interviewees agreed that the nature of the technology itself is an important factor as far as technology transfer is concerned. The easier a technology is to explain, demonstrate and codify, the easier it is to transfer. The respondents identified the ease of demonstrability and use of the technology as perhaps, its more important characteristics as far as technology transfer is concerned. Further, codifiability of the technology is also important but is not as significant as the ease of use or understanding. Interviewees observed that even if clear steps could be put down, it would be up to the shareholder personnel to interpret them and they may not be able to grasp the technologies' full capabilities. Another interviewee noted that it is difficult to rank the various characteristics of technology as such. What characteristics are important, depends upon the particular circumstances in which the technology is being transferred. In certain conditions codifiability of the technology might be crucial and in others, the ease of demonstrability might be the most important. One respondent also mentioned that it is

more difficult to transfer a technology that is radically new. In the case of such a technology, there are extremely stringent approval mechanisms that are established. This considerably slows down the transfer process. The researcher also feels that in the case of a radically new technology, the users of the technology will find it more difficult to fully come to grips with the functionality of the technology. This would further reduce the probability of executing a successful transfer.

The results for this section are summarized in Table 12.

Table 12: Summary of Results : Nature of Technology and Type of Industry

<ul style="list-style-type: none"> • Type of Industry <ul style="list-style-type: none"> • The sector in which the consortium and the shareholders operate, exerts some impact on the transfer process (e.g., the paper sector vs. the remote sensing sector) (5) • Nature of Technology <ul style="list-style-type: none"> • The nature of the technology being transferred exerts an impact on the transfer (10) • The ease with which the technology can be demonstrated and used is more important than the ease with which it can be codified

Chapter 6

CONCLUSIONS

The final segment of the thesis presents the conclusions related to the two objectives of this study. This section will be followed by the limitations and the contributions of this study.

The integrative model (Figure 4) suggested in this study was used to determine the content and sequence of the various related activities that comprise the technology transfer process in the context of Canadian consortia. The technology transfer procedures being followed at the different consortia lend support to the notion that the transfer process is a sum of an idea generation and technology development stage, a technology flow stage, a ramp-up stage and an integration stage. A thorough review of these procedures revealed some variations from the integrative model and these have been captured in the revised model for transferring technology from R&D consortia to the participating shareholders presented in Figure 5.

In conclusion, some important results need to be re-emphasized. A variety of sources are used by the various consortia in order to identify promising research directions. At least ten consortia exhibit some degree of proactivity and are not hesitant in exploring domains external to the consortium and the shareholder organizations in search of promising

technology areas. Further, as many as five interviewees identified the initial goal setting and needs analysis as the most crucial aspect of technology transfer. This highlights the importance of upfront planning in successfully executing the transfer. Several different models for organizing the actual development of the technology were evident. Moreover, management involvement in the technology development phase was, by and large, found to be low. This helps in reducing the bureaucracy in the process.

As for technology flow activities, it is important to note that the flow of technology is not always an isolated and distinct activity as hypothesized in the integrative model. In many instances, the boundaries of this stage are blurred by the development of the technology at the recipient site, or by recipient shareholder personnel working on the development team, or by informal information flows during the development of the technology. Further, at least eight interviewees stated that explicit goals for the technology flow stage are usually not articulated. This is due to the fact that the actual technology flow activity is a very dynamic process. Thus, it is extremely difficult to capture it in terms of goals.

In all the cases studied the shareholders tended to adopt a phased process for adopting the technology. However, the significance of the ramp-up stage varies, depending upon whether the primary receivers of the technology are involved in its development or not. It should also be noted that size of the organizations and the nature of technology might influence the exact mechanisms established for transferring technology. The relationship between them needs to be explored in greater detail. Further, it was also observed that in

most cases, the consortium did not play any role in monitoring the adoption of the technology by the shareholders. This stands to reason as once the shareholder has received the technology, working out the logistics of its actual use is an internal decision.

As far as the loops in the transfer process are concerned, it was startling to discover that if a mismatch between the technology capabilities and the shareholder requirements occurs, it is more likely that instead of re-initiating the process, the technology will be shelved.

Technology transfer also emerged as a highly people centric process with at least four interviewees identifying the management of relationships between the different individuals involved in the process as the most complex and time consuming part of the transfer efforts.

The interviewee perceptions about the success factors for technology transfer are largely consistent with the work of various scholars as outlined in the literature review. However, some interesting points need to be highlighted.

It was suggested that the preferred direct means of transferring technology should be supplemented by indirect means in order to shorten the learning curve associated with technology adoption. Most interviewees were skeptical about the impact the advances in information technology are having on the technology transfer process. However, they might be underestimating this in that they might be taking the use of such tools as the

email, FTP, the internet etc. for granted. This is an argument which is further supported by the responses obtained on the impact of physical proximity on the transfer process. Many interviewees noted that they had successfully transferred technology to several shareholders located at great distances from them. It is unlikely that these consortia could do so without extensively using IT tools. Another observation that was made was that the impact of physical distance is inversely related to the age of the consortium. This assertion needs to be studied further.

It is important to ensure that the personnel involved in the transfer process are motivated and that the consortium and the shareholders are committed and capable of carrying out technology transfer. Several possible management actions for achieving this were identified with the four most important being : freeing up adequate resources in terms of personnel, time etc., instituting rewards for exemplary transfer efforts, explicitly recognizing the importance of the transfer process and clearly identifying the individuals responsible for carrying out the transfer. Though the institution of rewards for technology transfer was identified as an important motivating factor, it should be noted that not one consortia in the sample studied had any such mechanisms in place. Further, it should also be noted that as many as eight interviewees stated that both the consortium and the shareholders should be committed to the transfer process for it to succeed. They disagreed with the statement that the pull aspect in technology transfer is more important than the push aspect.

Moreover, ten interviewees also noted that the nature of the technology exerts a great influence on the transfer process. The ease of demonstrability and use were identified as the most important attributes.

However, there was a lot of disagreement among the respondents as far as the impact of the size and the type of industry is concerned. Some interviewees observed that it was easier to transfer technology to a large organization as it had more resources while others took the opposite view claiming that it is more difficult to transfer to a large organization as it tends to be less focused and more bureaucratic. Similarly, some interviewees claimed that being in a particular sector influenced the transfer process through the sector's distinctive culture and the particular kind of technology that is used while others dismissed this argument by saying that there are commonalities in the transfer process which remain valid irrespective of the sector. Thus, further study needs to be done in order to clearly articulate the relationship of size and the sector in which the organizations operate to the transfer process.

BENEFITS OF THE STUDY

This study provides detailed information about the process of transferring technology from consortia to shareholder organizations in the Canadian context. Thus, it greatly enhances understanding of the technology transfer process in the consortium-shareholder organization context and also provides a foundation for future research in this area.

Indeed, the model presented here is a bird's eye view of the transfer process. It would be interesting to study each stage of the transfer process in greater detail. Also, the study has obtained information about the factors that are crucial for the success of this transfer process. It would be interesting to try and further this research by trying to develop a relative ranking for the various factors identified. It would also be exciting to explore the relationships between the different factors that have been identified by this study.

Further, given the growing importance of consortia for the competitiveness of organizations, it is imperative that they have the ability to transfer technology swiftly. To that end, the study provides the consortium and shareholder managers with guidelines for making the transfer more effective and expeditious. These guidelines include :

- Direct means of transferring technology should be supplemented with adequate documentation in order to accelerate the learning curve of the technology recipients.
- Direct means of transferring technology are especially appropriate if the technology is knowledge intensive and abstract.
- Managers should note that physical proximity between the various organizations involved in technology transfer greatly facilitates the process. Thus, greater resources and commitment would be required to transfer technology to the shareholders located far away from the development site.
- Shareholder management should also keep the impact of physical distance on the transfer process in mind while forming the consortium. It might be worthwhile to

restrict membership to the consortium to organizations located in close vicinity of each other.

- Differences in the organizational cultures may adversely impact on the transfer process. All consortia are highly research oriented. Thus, managers should note that greater resources will be required to transfer technology to a shareholder that is more marketing oriented, for example. Managers should also take cognizance of other aspects of a shareholder organization's culture like the "not invented here" syndrome which might affect the transfer process.
- Management should explicitly include the transfer function in the job descriptions of the various members of the development teams. They should also identify the transfer function as a high priority task in the project description.
- Shareholder management often underestimates the resource requirement for successfully transferring technology. Adequate resources need to be set aside for the transfer process, especially in terms of the time that is allocated for the transfer.
- Management should ensure that the appropriate technical structures are in place at the shareholder organizations to receive the incoming technology. Further, it is also important that the shareholder personnel are provided with the required training in order to use the incoming technology.
- Management should clearly identify the personnel responsible for the technology transfer process.
- Management should institute mechanisms for recognizing and rewarding technology transfer efforts.

- Management should encourage formal and informal interaction between the personnel of the consortium and the various shareholders.

LIMITATIONS OF THE STUDY

The necessary data to carry out this research was collected from a sample of 11 consortia. Such a small sample size is not adequate to ensure generalizability of the results, even though the case study approach was used. Time and budgetary constraints make it unviable to pursue a study with a very large sample. Moreover, given that the respondents would be consortium personnel responsible for technology transfer, there is a possibility that the data collected suffer from a respondent bias towards reporting successful outcomes. There is also a strong likelihood that an interviewer bias might have been introduced in the study. This stems from the fact that the researcher was required to interpret the responses obtained from the interviewees. Also, in some cases the researcher may have unknowingly prompted the respondents into giving certain answers.

The transfer of technology from consortia to the member firms; especially in the Canadian context, is a topic that has largely been neglected in the literature, thereby any attempt to model the process is by definition, exploratory in nature. Though the reliability of the study was tested through a rigorous literature review and a pretest, it is possible that additional factors exist that are important to the transfer process but have not been captured by the research

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APPENDIX A

REQUEST LETTER GIVEN TO RESPONDENTS PRIOR TO THE INTERVIEW

School of Business,
Carleton University,
Ottawa, ON, K1S 5B6

[Consortia Name]

[Consortia Address]

Dear [Contact Person],

Re: Research on Technology Transfer from Consortia to Participants

One of our graduate students, Aditya Tandon, is conducting research on the technology transfer process from consortia to shareholder organizations to fulfill his master's thesis requirement under my supervision. This study has two objectives: the first is to identify the various stages involved in the technology transfer process; the second is to identify the various facilitators of the transfer process. As your organization is one of the leading consortia in Canada, your participation in this study would be greatly appreciated.

We are seeking an interview which will last about an hour and a half. This session will include open ended questions where you will be asked to describe the technology transfer process for one of the recent projects (last 2-3 years) for which you were responsible. A further set of open ended questions will be asked in order to obtain information about the factors that are important in ensuring the success of the technology transfer process in general.

Information gathered from the interviews will be aggregated and no information on individual organizations will be divulged. If desired, a summary report will be made available to you.

I appreciate your assistance as your help is essential to conduct this study.

Yours Sincerely,

Dr. Uma Kumar

Professor,

School of Business, Carleton University.

Phone : 613 - 520 - 2600 (Ext. 4463)

APPENDIX B

INTERVIEW PROBE CONTAINING OPEN ENDED QUESTIONS FOR THE TWO RESEARCH OBJECTIVES

QUESTIONNAIRE A:

Conventions used in this interview schedule are:

- 1 Questions to be asked by the interviewer are in Lower Case
- 2 Probes are in Bold
- 3 Interviewer notes are in Upper Case

Background Information

Q-1 The Consortium -----

Q-2 Respondent's Name -----

Q-3 Respondent's Designation -----

Q-4 Contact Information -----

Q-5 The objective of this interview is to determine the content and the sequence of related activities that constitute the technology transfer process in the consortium-shareholder context and also to identify the factors that impact on the success of the said transfer process.

Could you please describe the technology transfer process followed for a project undertaken in the last 2-3 years for which you were responsible ? (**what kind of decisions, major events are involved**).

PROBES TO BE USED

INITIATION STAGE:

a) How was the project initiated (idea came from the consortium, shareholder or others)? Was there an explicit needs analysis and goals defining phase in the process? If not, what was the starting point?

b) Were the management and the personnel of both the consortium and the shareholder organizations involved during this phase?

c) Once the objectives of the project have been established, did the management continue to interact with the technical personnel in order to refine or if need be, refocus their research efforts? If such interaction indeed, existed was it limited only to the consortium management?

d) Did you have an explicit prototype development and evaluation stage?

e) What kind of personnel from the consortium and the shareholder organizations were involved in the prototype development and evaluation (management, technical, others)? If the shareholder personnel were involved, through what mechanisms did they communicate with the consortium?

f) Was a final approval from the consortium top management required before the flow of the technology to the shareholders could be initiated?

IMPLEMENTATION STAGE:

g) Was there a stage devoted entirely to communication activities?

h) Once the flow of technology between the consortium and the shareholders begins, what channels of communication are used to manage the flow? Were there individuals or groups of individuals in both the consortium and the shareholders specially designated to manage this flow?

i) Were goals and verifiable standards set in order to measure the success of the flow of technology between the consortium and the shareholders? Were the shareholder management and personnel involved with the setting of these goals and standards?

RAMP-UP STAGE:

j) How many end users in the shareholder companies made the first use of the technology ? Were the consortium personnel involved in helping the end users in the shareholder organizations to understand the technology transferred?

k) Was a mechanism set up to evaluate the success of the transfer process at this stage? Were the consortium personnel involved in the development and the operation of such a mechanism?

INTEGRATION STAGE:

l) Was the first use of the technology by the recipient organizations limited only to key end users?

m) Once the technology had been absorbed by the key end users, was there an explicit effort to diffuse the technology throughout the recipient organization? Were the consortium personnel involved in facilitating the spread of the technology to the entire organization?

n) Was a mechanism set up to evaluate the success of such efforts? Were the consortium personnel involved in the development and the operation of such a mechanism?

DURING THE COURSE OF THE INTERVIEW IF A STAGE IS MENTIONED BY THE RESPONDENT WHICH IS NOT A PART OF THE MODEL DEVELOPED, ADDITIONAL DETAILS ABOUT IT WILL BE SOUGHT. IF THE RESPONSES INDICATE AN ADDITION/DELETION IN THE STAGES OF THE PRESENT A PRIORI MODEL, THEN MODIFICATIONS WILL BE MADE TO THE MODEL.

IN ORDER TO OBTAIN ADDITIONAL INFORMATION ABOUT THE ABOVE MENTIONED STAGES/ACTIVITIES, THE FOLLOWING QUESTIONS WILL BE ASKED:

PROBES TO BE USED

A) What task(s) and/or activity(ies) that were a part of the technology transfer process would you identify as being the most crucial towards ensuring the success of the transfer process?

B) What task(s) and/or activity(ies) that were a part of the technology transfer process would you describe as being the most complex?

C) What task(s) and/or activity(ies) that were a part of the technology transfer process would you describe as being the most time consuming?

FURTHER, TO INVESTIGATE THE EXISTENCE AND NATURE OF THE LINKS BETWEEN THE VARIOUS STAGES OF THE MODEL, THE FOLLOWING QUESTIONS WILL BE ASKED:

PROBES TO BE USED

Was there a link between

A) Defining goals and needs and the research and development activities (including prototype development and evaluation)? Was the flow of technology represented by the link characterized by the transfer of idea(s)/prototype/product (technology)?

B) Prototype development and prototype evaluation? Was the flow of technology represented by the link characterized by the transfer of idea(s)/prototype/product (technology)?

C) Research and development activities and the final decision that the technology was ready and suitable for transfer? Was the flow of technology represented by the link characterized by the transfer of idea(s)/prototype/product (technology)?

D) Final decision that the technology was ready and suitable for transfer and communication activities (including setting verifiable goals to measure the transfer process)? Was the flow of technology represented by the link characterized by the transfer of idea(s)/prototype/product (technology)?

E) Communication activities and the technology adoption at the recipient organization by the designated key end users? Was the flow of technology represented by the link characterized by the transfer of idea(s)/prototype/product (technology)?

F) Technology being adopted by the key end users and a control system to evaluate the technology adoption by the key end users? Was the flow of technology represented by the link characterized by the transfer of idea(s)/prototype/product (technology)?

G) Technology being adopted by the designated key end users at the recipient organization and the technology being adopted throughout the shareholder organization? Was the flow of technology represented by the link characterized by the transfer of idea(s)/prototype/product (technology)?

H) Technology being absorbed into the entire recipient organization and a control system to evaluate the technology absorption by the organization? Was the flow of technology represented by the link characterized by the transfer of idea(s)/prototype/product (technology)?

Besides the above mentioned links, were there any other links in the process?

IN ORDER TO DETERMINE THE FEEDBACKS THAT WERE PRESENT IN THE TECHNOLOGY TRANSFER PROCESS FOLLOWED, THE FOLLOWING QUESTIONS WILL BE ASKED:

PROBES TO BE USED

Was there feedback between

A) The initial adoption of the technology by designated key end users in the recipient organization and communication activities (implementation failure)? Was the flow of technology represented by the link characterized by the transfer of idea(s)/prototype/product (technology)?

B) The initial adoption of the technology by designated key end users in the recipient organization and the research and development activities (technical help needed for adoption)? Was the flow of technology represented by the link characterized by the transfer of idea(s)/prototype/product (technology)?

C) The initial adoption of the technology by designated key end users in the recipient organization and the research and defining goals and needs (objectives not achieved, redefine goals and needs)? Was the flow of technology represented by the link characterized by the transfer of idea(s)/prototype/product (technology)?

D) The absorption of the technology by the entire recipient organization and the initial adoption of the technology by designated key end users in the recipient organization? Was the flow of technology represented by the link characterized by the transfer of idea(s)/prototype/product (technology)?

Besides the above mentioned loops, were there any other feedback loops in the process?

Qs. 8 What are the factors that impact in a significant fashion on the success of the technology transfer process in the consortium-shareholder context?

IN ORDER TO IDENTIFY THE FACTORS IMPORTANT TO THE TRANSFER PROCESS, THE FOLLOWING QUESTIONS WILL BE ASKED :

PROBES TO BE USED

MEANS OF COMMUNICATION:

A) Are passive communication means such as research reports, news letters, journal articles, computer or video tapes effective in transferring technology? How do active communication links such as teleconferences, board meetings, ad hoc teams, employee visits rate as means of transferring technology? Have the advances in information technology made the use of such active links easier?

B) How important is the level of direct interaction between consortium and shareholder employees to the success of the transfer process? Does establishing

technology transfer as a highly interactive process instead of viewing it as a one shot exchange aid in the successful transfer of technology?

C) Are certain means of communications better suited to certain stages of the transfer process?

DISTANCE:

A) Is it easier to transfer technology to a shareholder who is located closer (physically) to the consortium's resources and facilities?

B) How important is it to the success of the transfer process that the consortium and the shareholder employees understand and appreciate the values, attitudes and the way of doing things at the each other's organizations?

MOTIVATION, CAPABILITY AND COMMITMENT

A) In order to ensure the success of the transfer process, is it important that due emphasis is placed on the importance of technology transfer both at the consortium and the shareholders?

B) Does the fact that the involved organizations have previous experience in transferring technology enhance the probability of a successful transfer? What if the previous experience is in transferring a different kind or genre of technology?

C) How important is to recognize and reward technology transfer efforts in order to ensure the success of the transfer?

D) Does providing support to the transfer process in terms of finances and qualified personnel significantly enhance the probability of it's success? How important is it to the success of the transfer process to provide the necessary training to the shareholder personnel to aid in the adoption of the technology being transferred?

E) How does the fact that the technology being transferred is incompatible with the technology already in use at the shareholders impact on the possibility of executing a successful transfer?

F) Is shareholder commitment to the transfer process more important to its success than the consortium's commitment?

ROLE OF MANAGEMENT:

A) Does the fact that the consortium management is committed to the transfer process enhance the probability of its success? What are some of the actions that the consortium management can undertake in order to facilitate the transfer process?

B) In your opinion, how important to the success of the technology transfer process is the fact that the shareholder management is committed to the transfer process? What are some of the actions that the shareholder management can undertake in order to facilitate the transfer process?

NATURE OF TECHNOLOGY:

A) Does the nature of the technology being transferred exert an impact on the probability of success of its transfer ? (RESPONDENTS WILL BE ASKED TO COMMENT ON HOW THE FOLLOWING CHARACTERISTICS OF THE TECHNOLOGY BEING TRANSFERRED IMPACT ON THE POSSIBILITY OF ITS SUCCESSFUL TRANSFER : 1) THE TECHNOLOGY IS EASY TO UNDERSTAND; 2) THE TECHNOLOGY IS EASY TO CODIFY; 3) THE TECHNOLOGY IS EASY TO DEMONSTRATE; 4) THE TECHNOLOGY IS UNAMBIGUOUS.)

B) Is it more difficult to transfer a technology that is a radical advance over existing technologies?

SIZE OF THE CONSORTIUM AND THE SHAREHOLDER ORGANIZATIONS :

A) In your opinion, would you expect the size of the consortium and the shareholder organizations to exert a significant impact on their ability to successfully transfer technology? If yes, how or through what ways would you expect the size of the organizations to impact on the transfer process?

TYPE OF INDUSTRY :

A) In your opinion, would you expect the type of industry to which the shareholder belongs to exert a significant impact on the technology transfer process? If yes, how or through what ways would you expect it to impact on the transfer process?

Besides the above mentioned factors, are there any other factors that you feel might exert a significant impact on the success of the transfer process?

Q-9 Would you like a summary of the results?

- 1. Yes**
- 2. No**

Thank you very much for your time for the interview.

Appendix C

List of Consortia Included in the Study

List of Consortia

1. Precarn Associates Inc.
2. CMC (sister concern of the Strategic Microelectronics Consortium)
3. Solid State Optoelectronics Consortium
4. Canadian Biodiversity Informatics Consortium
5. The Consortium for Research in Elastic Wave Exploration Seismology
6. The Cochrane Centre
7. The Canadian Bacterial Diseases Network
8. Optical Processing & Computing Consortium of Canada
9. BC Advanced Systems Institute
10. Ontario Rehab Technology Consortium
11. Alberta Research Council and Forintek Canada Consortium

Appendix D

Case Studies

Case Study 1

Organization 1 is an administrative consortium with over 300 industrial partners/shareholders. The consortium actively liaisons and establishes partnerships with researchers at various universities and other research institutions. The consortium does not focus on any one specific sector or technology. Most of the research and development is done at the shareholder sites. This consortium functions almost like a trade association. The shareholders, through the consortium, are able to enhance the quality of their R&D resources in that the consortium actively scans the environment for promising technologies as well as facilitates the access to such technologies for its shareholders. However, the shareholders do not necessarily share their R&D resources.

The Technology Transfer Process

Idea Generation and Technology Development Stage The consortium does not proactively scan the environment in order to identify promising technologies. Most projects are initiated when the shareholders approach the consortium with specific technical needs and requirements. The underlying logic behind this strategy is that if the company management themselves do the needs analysis and goals defining then they will be more committed towards ensuring that the project is completed successfully. The project is then reviewed by the consortium's management. Once the project is accepted, the consortium scans the research horizon in order to identify the researchers with the necessary expertise to solve the needs of their industrial partner and establishes a partnership with these researchers. The next step in the process is the actual development of technology. Researchers normally work at the company site in order to ensure greater interaction with the shareholder technical personnel. In some projects, the initial development may occur at the researcher's institution but that work would then be transferred to the shareholder site and developed further. This also facilitates a continuous evaluation of the technology by the shareholder technical personnel. All projects taken up by this consortium normally

have an explicit prototype development phase. The involvement of both the member and consortium management is minimal during this phase and limited to ensuring that the project is staying on track through quarterly reports that are submitted by the personnel involved in the project. Final approval from the consortium management to begin the transfer process is not needed as the technology is usually developed at the receptor site itself. The shareholder and consortium management are notified once the technology is ready for use.

Technology Flow Stage The transfer procedures being followed at this consortium do not exhibit an explicit stage devoted solely to communication activities. The technology flows into the receptor as it is being developed through the direct interaction between the researcher and the shareholder personnel who work on the project together. Goals for achieving the major project milestones that are established at the beginning of the project by the shareholder management in consultation with the consortium management, also provide a framework for measuring if this transfer process is on track.

Ramp - up and Integration Stages There is a phased adoption of the technology by the shareholders of this consortium. By virtue of being involved in the project from its very outset, the shareholder personnel develop a thorough understanding of the capabilities of the technology being developed. It is this group of personnel which is then responsible for disseminating the technology through the rest of the organization. The researcher or the consortium personnel are not normally involved in facilitating this adoption process. Most shareholder organizations have their own internal mechanisms in place in order to monitor the adoption and/ or commercialization of the technology being developed. The consortium personnel or the researcher play no part in setting up these mechanisms.

Characteristics of the transfer process The interviewee identified the articulation of an explicit agenda for the entire project as the most crucial aspect of the transfer process. The various players involved in the transfer of the technology very often tend to

underestimate what is required of them to effect a successful transfer and this has to be guarded against. The interviewee also observed that the technology very often does not tend to be that complex; however it is the management of the relationship between the various players involved in the process that is perhaps, the most complex and time consuming aspect of technology transfer.

Loops in the Transfer Process The process of transferring technology occurs in parallel with its development at this consortium. Due to the fact that the shareholder personnel work on the development teams, they develop an extensive understanding of the capabilities of the technology. Thus, these personnel are in a good position to provide any technical assistance that might be required during the assimilation of the new technology by the shareholder organization. If any other assistance is needed for adopting and understanding the technology, the consortium ensures that the required expertise is identified and brought in. Given the fact that most projects are initiated by specific needs identified by the shareholder management, it is very rare for a mismatch to occur between the capabilities of the technology and the needs it is supposed to satisfy. However, sometimes the strategic focus of the shareholder organization might change during the course of the project. This might result in the shelving of the technology that has been developed.

Respondent Perceptions about Success Factors for Technology Transfer

Means of Communication The interviewee noted that the direct face to face means for transferring technology are definitely superior to indirect means such as research reports and that most people do not have the time to read lengthy technical documents. The best technology transfer occurs when a personal rapport has been established between the researchers and their technical counterparts in the shareholder organizations. It is for this reason that the consortium encourages the researchers it recruits for the various projects to work with the shareholder personnel at the member site. Further, the respondent emphasized that companies can no longer afford the luxury of treating technology transfer

as a linear process. In fact, the processes of technology development and adoption have to run in parallel as they do in the case of this particular consortium. The advent of such technologies as email, videoconferencing etc. has only had a marginal impact on the way technology is transferred at this consortium. Direct interaction between the different individuals at each and every stage of the transfer process still remains, by far the most efficient means of transferring technology.

Distance Physical distance between the parties involved in transferring technology does exert a significant influence on the transfer process. The interviewee observed that if the organizations, the consortium, the technology source and the recipient are located close together, it facilitates the establishment of trust between them which is crucial for executing a successful transfer. Cultural distance also is an important factor that impacts on the technology transfer process. At this consortium, researchers and the company personnel work together to develop the technology. These individuals usually come from very different environments and therefore, have different values and attitudes. This has often caused problems between the two groups and has adversely impacted on the process of transferring technology.

Motivation, Capability and Commitment The interviewee stated that it is important to give due importance to the technology transfer function and that the transfer function should in fact, be made a part of the job descriptions of the individuals participating in any given project. Further, though rewards to explicitly recognize the technology transfer efforts have never been set up at this consortium, the respondent thought it might be a good idea to do so. In terms of the impact of having previous experience in transferring technology, the interviewee stated that it was not important if the source and the recipient have had any such experience in the past per se. However, if the two individuals or groups of individuals have engaged in the transfer of technology before that does have a positive impact on the probability of executing a successful transfer in the future. Further, the incompatibility of the new technology with the embedded technology at the shareholder is never an issue at this consortium as the

technology is developed at the member company site. Lastly, the respondent observed that it is important that both the technology source and the technology recipient be equally motivated towards ensuring that the technology is successfully transferred. In most cases, as the technology is being developed to meet a specific need of the shareholder, it is quite committed to ensuring the swift transfer and the successful adoption of the technology. However, sometimes the researcher(s) are not as committed towards ensuring a successful transfer and that can lead to serious problems.

Role of Management It is extremely important that the management at both the consortium and the shareholders, ensures that the technical personnel and the researcher(s) involved with the development of the technology realize the importance of transferring the technology. The respondent stated that to do so the management should include the technology transfer function in the job descriptions of the various personnel involved in the project. Further, the management should ensure that adequate resources and especially, enough time is set aside for the transfer process.

Size of the involved Organizations Size is definitely an important factor as far as technology transfer is concerned. The interviewee noted that it is far easier to work with and transfer technology into smaller organizations as they tend to be less bureaucratic and more focused than large organizations.

Nature of Technology and the Type of Industry The respondent observed that operating in a specific sector does not impact on the transfer function as there are simple and complex technologies as well as innovators and early adopters in all sectors. However, the nature of the technology itself does have a profound impact of the technology transfer process. The more complex the technology, the more difficult it is to transfer it.

Case Study 2

Organization 2 is an industry sponsored consortium in the forest products' sector. The consortium is located at a research institution, where most of the development work is carried out.

The Technology Transfer Process

Idea Generation and Technology Development The consortium accepts proposals from both the shareholder companies and the consortium staff, for research. These proposals are reviewed by the consortium's Technical Advisory Committee (TAC). The TAC comprises senior technical personnel deputed by the various shareholders and the consortium management. Based on the recommendations of the TAC, different projects are selected. Though some of these projects try to address specific technical issues the shareholders are facing, a number of them are selected because of the potential of the new technology or process being proposed. Once the projects have been selected, each shareholder is asked if they would like to depute individuals to work on the project. There have even been instances where the consortium members have allowed the participation of personnel from interested non-member companies in order to take advantage of the technical expertise of these companies. Deputed shareholder personnel work with the consortium personnel at the consortium's research facilities in order to develop the new technology. This facilitates greater interaction between the consortium and shareholder personnel and also allows for constant evaluation of the technology being developed. In most projects taken up by this consortium, there is an explicit prototype development stage. This is true even for projects where the technology being developed is more process oriented as opposed to product oriented. The consortium has a pilot facility and can simulate a mill scale environment. Most of the prototypes are tested using this pilot facility. The involvement of the consortium as well as the shareholder management is minimal during this phase. No formal approval process for initiating the flow of the

technology into the shareholder organizations has been set up at the consortium. The interviewee noted that this had been done in order to reduce the bureaucracy in the transfer process. Further, by virtue of the fact that most projects are selected based on the recommendations of the TAC, in most cases, the shareholders and the consortium management have already bought into the technology. Thus, this further reduces the need to have any formal approval processes in place. It is left to the project managers to decide the actual logistics of the project; especially, in terms of when the technology is ready for the actual transfer.

Technology Flow Stage The technology transfer procedures followed by the consortium do exhibit an explicit stage devoted only to communication activities. The technology flows into the receptor organization after having been developed and tested in the consortium's research facilities. On site visits by the consortium personnel and research reports are used for transferring the technology. There are normally no separate individuals designated for the transfer process in the case of the shareholders who have contributed personnel to the project. The consortium and shareholder personnel responsible for the development of the technology are also responsible for transferring it into the shareholder organization. However, for most other shareholders, there usually is a designated contact who is responsible for ensuring that the technology is transferred into the organization smoothly. No separate goals are set up for monitoring the flow of the technology from the consortium to the shareholders.

Ramp-up and Integration Stages There is a phased adoption of the technology by the shareholders of this consortium. Usually, a small group of individuals first receives and understands the technology and then disseminates it through the rest of the organization. However, in cases where the shareholder organization has individuals working on the project, no separate team of personnel is set up to receive the technology. These same individuals transfer the technology when they move back to their respective parent organizations. The consortium personnel are not normally involved in facilitating this adoption process. Most shareholder organizations have their own internal mechanisms in

place in order to monitor the adoption of the new technology. The consortium personnel play no part in setting up these mechanisms.

Characteristics of the transfer process The interviewee identified clearly defining the goals of the project as the most crucial aspect of the transfer process. It is important that this be done at the very beginning of the project so that the individuals involved are clear about what is expected from the project. Further, according to this respondent, the most complex and time consuming aspect of technology transfer is the evaluation of whether the mechanisms used for transferring technology were appropriate and suitable. The interviewee felt that such feedback can ensure that if there is need, the general framework being used for transferring technology can be altered in order to increase the possibility of executing a successful transfer.

Loops in the Transfer Process Due to the fact that technical personnel from some of the shareholder organizations work with the consortium personnel on technology development, they develop an extensive understanding of the capabilities of the technology. Thus, these shareholder personnel are in a good position to provide any technical assistance that might be required during the assimilation of the new technology by their organizations. However, the consortium personnel do provide assistance to the shareholder organizations if at any stage, these organizations run into trouble with the technology. Moreover, sometimes if glitches are discovered in the technology, further work might also be done on it at the consortium's facilities. The respondent observed that there have also been some cases where the technology developed by the consortium was shelved by the shareholders as it turned out to be too new, or radically different from what the shareholders were currently using.

Respondent Perceptions about Success Factors for Technology Transfer

Means of Communication The direct face to face transfer of technology is the preferred medium of transfer at this consortium irrespective of the stage of the transfer process. Most of the technology transfer occurs through on site visits by the consortium personnel. Research reports that are written very often go unread and the emphasis is on site demonstration. Such technologies as videoconferencing, shareware etc. have not been used at the consortium to actually transfer technology. However, the interviewee observed that the use of such technologies might actually facilitate greater interaction between the different individuals involved in the project and therefore, might positively impact on the transfer process.

Distance The respondent noted that it is easier to transfer technology to a shareholder that is located closer to the consortium. Physical proximity allows consortium and shareholder personnel to interact more frequently and also facilitates on site visits by both groups. The interviewee also felt that the organizational culture is an important factor as far as technology transfer is concerned. For example, the forestry industry as a whole is a very conservative industry and this mind set exerts a significant influence on the actual mechanics of the transfer process. Further, more than the organizational culture, it is the mind set of the individuals involved in the project that is crucial for effecting a successful transfer. However, having said that, it is highly unlikely that an individual will survive in an organization if his/her value system is radically different from that prevalent at the organization.

Motivation, Capability and Commitment The respondent felt that it is important that due emphasis be placed on the technology transfer function. The project team members should realize the importance of swiftly transferring the technology that they develop. The interviewee also observed that it is important that both the technology source and the technology recipient be equally motivated towards the transfer. In most cases, the shareholder organization is quite committed towards the adoption of the

technology. In fact, the interviewee stated that there have been instances where the shareholders have wanted to begin using the technology even before the final technology product is ready. The consortium too must show its commitment to the transfer process and free up adequate resources in order to ensure that the technology is successfully transferred. However, the interviewee felt that sometimes the organizations involved are constrained by their other commitments from devoting the required amount of resources; especially manpower, to technology transfer. This can be a very big stumbling block in executing a successful transfer. The respondent noted that rewarding and recognizing technology transfer efforts might have a positive impact on the transfer process. However, the consortium and the shareholders have not done so in the past.

Role of Management It is extremely important that the management at both the consortium and the shareholders place due emphasis on the technology transfer function. The interviewee recommended that the management should try and identify ways to measure the performance on transferring technology, rewarding successful technology transfer efforts and freeing up time for the personnel involved in order for them to transfer technology. The respondent also stated that it is important that the management clearly identify one or more individual(s) responsible for the transfer of technology. The best cases of technology transfer at the consortium, have occurred when the management has done so.

Size of the involved Organizations The respondent observed that size is not a factor at all as far as technology transfer is concerned. What is more important perhaps, is the organizational structure of the shareholder. If the large organization is organized such that it operates through small focused groups, then the largeness of the organization per se does not pose any problems as far as technology transfer is concerned. Irrespective of whether an organization is large or small, what is important is to clearly identify the individuals responsible for technology transfer.

Nature of Technology and the Type of Industry

The respondent noted that the nature of technology and the type of industry can both be important factors. The complexity of the technology being transferred exerts an important influence on the transfer process. Further, the fact that the consortium and the shareholders operate in a particular industry and thereby, deal with particular kinds of technologies can also exert an important influence on the transfer process. The interviewee observed that the codifiability of technology is not a factor at all. It is much more important to be able to demonstrate the capabilities of the technology.

Case Study 3

Organization 3 is an industrial consortium formed in order to leverage the traditional Canadian strength in such areas as remote sensing, GIS etc. The objective of the consortium is to provide end users with end to end solutions in the area of biodiversity informatics. The shareholders of the consortium, rather than being competitors, bring in complementary technologies to the consortium and thus leverage each others distinct knowledge capabilities during the development of the new technology. End users¹⁸ are not permanent members of the consortium and participate in the alliance on a project to project basis.

The Technology Transfer Process

Idea Generation and Technology Development Stage For the most part, ideas for projects at this consortium come from the “end user” shareholder organizations. These project proposals are thoroughly reviewed by management at both the consortium and the various shareholders. Once a proposal is accepted, the consortium insists that there be an explicit goal defining stage before the project is initiated. Such extensive interaction

¹⁸ In the absence of any “permanent” shareholders from the end user community, all members of the end user community will also be considered participating shareholders in the case of Organization 3. Further , it is also important to note that these end users do not simply buy into the technology developed by the consortium but are extensively involved with the consortium at various stages of the transfer process.

between the various shareholders and the consortium at the very beginning of the project helps in clearly establishing the expectations from the project. Additionally, such a phase ensures that the major mile stones for the project are articulated at the very beginning and this provides the individuals working on the project with a benchmark to evaluate their progress at each stage. Most technology development work is modular. Each of the shareholders develops their own segment of the final technology product separately. Management involvement during the development of the technology is non-existent. Usually, a prototype is not developed for each separate segment of the final technology product. However, once all the separate segments are complete, they are integrated into a final version of the technology product which is evaluated before the actual transfer. Approval from the management at the respective shareholder organizations as well as from the consortium management is required to initiate the final flow of technology into the hands of the end users.

Technology Flow Stage There are two separate communication flows that occur at this consortium. The first one is the flow of the different technology segments from the various “technology developing” shareholders to the consortium. The developers working on the different segments of the technology product come together in order to integrate the different segments. The flow of the technology into the end user “shareholder” organization is managed mainly through on site visits to the consortium by selected groups of end user personnel. These end user personnel become human carriers for the technology into their respective organizations. Goals for achieving the major project milestones that are established at the beginning of the project, are used to monitor the actual flow of technology.

Ramp - up and Integration Stages As far as the technology flow from the “technology developer” shareholders to the consortium is concerned, there is no adoption element at all. The focus is solely on working together in order to integrate the different parts of the technology. However, the end users exhibit a phased adoption of the technology. As mentioned before, the node for entry of the technology into the end user

“shareholder” organization(s) are the personnel working who participate in on site workshops and demonstrations at the consortium. It is this group of personnel which is then responsible for the adoption of the technology by the end user “shareholder” organization. However, in the case of this consortium , the shareholder and consortium personnel are also actively involved in this process. They assist the primary carriers of the technology by organizing joint workshops at the end user “shareholder” site. The consortium personnel even monitors the progress of the adoption of the technology through regular interaction with key end user personnel. This is in addition to the end user “shareholder” organizations own internal mechanisms for monitoring the adoption of the technology.

Characteristics of the transfer process The respondent identified the technology itself as the most crucial aspect of the transfer process. The quality of the final technology product has to be good in order to ensure that the end user shareholders remain motivated throughout the process. The respondent also noted that the most complex and time consuming task in transferring technology is to ensure that the technology product that has been developed, works in the prevalent technical and organizational environment at the end user organizations. Further, in the case of this consortium, the absence of “permanent” shareholders from the end user community rules out the collective ownership of the technology product. Thus, the issues of intellectual property rights also assume significance in this set-up.

Loops in the Transfer Process As mentioned before, the consortium and shareholder personnel provide extensive technical assistance to the end user personnel during the ramp-up and integration stages. This becomes especially important as the end user personnel are not involved during the development of the technology. Further, given the fact that most projects are initiated by specific needs identified by the end users, it is very rare for a mismatch to occur between the capabilities of the technology and needs it is supposed to satisfy. However, there have been cases where the strategic focus of the end user has either shifted away from the technology that has been developed resulting in the

technology being shelved or the technology has just taken too long to develop resulting in a loss of end user interest in the technology.

Respondent Perceptions about Success Factors for Technology Transfer

Means of Communication The transfer of technology at this consortium, for the most part, is carried out through direct interaction between the different individuals concerned. The interviewee noted that the human carrier of the technology is the most efficient means of managing the transfer process though this has to be supplemented by documentation. Again the reason for this perhaps, lies in the fact that the end user personnel are not involved in the development of the technology and therefore, need material for ready referencing. The interviewee also observed that sometimes it is more costly to engage in onsite visits; especially, if the shareholders are located far away. Thus, indirect means are sometimes used for economic reasons. Further, the interviewee also mentioned that if the consortium is motivated and has the right to increase the breadth of dissemination of the technology, it has to rely on such means as research reports and journal articles. The breadth of reach of such indirect means is far greater than that of direct means of transferring technology.

Distance The respondent observed that physical distance is not a significant factor as far as the transfer of technology is concerned. Even though physical proximity does facilitate greater interaction, there have been an enormous number of cases where the consortium has transferred technology to end users that were located at great distances from the consortium. However, according to the respondent, the organizational culture is an extremely important factor. Different organizations, depending upon their culture, will emphasize different aspects of the transfer process or will be more or less receptive to the technology and this can have a tremendous influence on the transfer. An interesting example is that of the prevalent attitude in most public sector organizations. Most such organizations are rather rigid and not willing to adapt or change in order to meet the

demands of different situations. The absence of this flexibility can very often derail the transfer process.

Motivation, Capability and Commitment The interviewee stated that it is important that the transfer of technology be made a high priority task in the project description at the very outset. This instills a feeling of greater commitment towards technology transfer in the personnel involved in the project. Although it is important that both the consortium and the shareholders be committed to the transfer process, the interviewee noted that it is the end user shareholder commitment that is of far greater importance. It is after all, upto the end user to be motivated to accept and adopt the technology being transferred. If the end users loose interest in the transfer process, the technology can never be successfully transferred. The interviewee stated that previous experience in transferring technology also helps. There is almost always a learning curve associated with the technology transfer process. As one gains experience in transferring technology; irrespective of the type of technology, one becomes more careful about avoiding possible pitfalls. Adequate resources must also be set aside for the transfer process in order to ensure its success. It is of great importance that resources be devoted to provide training to the personnel at the end user organizations. It is this group of individuals who will, with the appropriate training, ensure that the technology works to its full capabilities in the new environment. Very often, the incompatibility of the embedded technologies with the new technology has posed a serious threat to the transfer process in the case of this consortium. Resources should be allocated to tackle this hurdle. No mechanisms have been set up to reward and recognize technology transfer efforts at the consortium, though doing so might prove to be greatly beneficial towards ensuring greater commitment for the transfer process.

Role of the Management The respondent identified several different ways in which the management could positively influence the transfer process. The consortium and shareholder management should work into the project plan, goals with regards to transferring technology. This goes a long way in instilling a sense of urgency in the

personnel towards technology transfer. The management themselves should also explicitly show motivation towards and involvement with the transfer process. Furthermore, it is also important that end user management frees up resources for the transfer, especially for providing training to the end users as well as ensuring that the proper infrastructure is in place for accepting the technology. Moreover, the management should also clearly identify the personnel responsible for the transfer.

Size of the involved Organizations The respondent stated that it is difficult to evaluate the impact of size on the transfer process. Larger companies have more resources to devote to the transfer process and that can help in facilitating the process. However, larger organizations also tend to be more bureaucratic and that can be a major obstacle for efficiently transferring the technology.

Nature of Technology and the Type of Industry The interviewee noted that the specific type of industry that the consortium and the shareholders operate in, is very rarely an issue as far as technology transfer is concerned. However, the complexity of the technology itself can become a possible issue; especially in the context of the infrastructure available at the recipient site for accepting the technology into the organization. Codifiability of the technology is important but according to this respondent what is perhaps, more crucial is whether the technology is easy to demonstrate.

Case Study 4

Organization 4 is a consortium of organizations and individuals working in the area of health care research. The focus of the consortium is to develop software and information products to assist health care researchers in leveraging their expertise. An interesting point to note about this consortium is that it is a part of a global network of similar consortia. The transfer of technology occurs from the consortium to the shareholders as well as from the consortium to other consortia who are shareholders in the global network.

The Technology Transfer Process

Idea Generation and Technology Development

The work done at the consortium is dictated to some extent by the directives issued by the global governing body of the international network of consortia that Organization 4 is a part of. Such directives lay broad ground rules for the kind of projects that the consortium can undertake. However, within this broad framework, the consortium has a lot of freedom to pursue its own agenda. Normally, a strategic plan is established at the beginning of each year. This strategic plan is set up with input from the consortium personnel, the shareholders as well as outside funders of the consortium. It is interesting to note that the consortium has non-member entities like various government departments involved in providing funding for the activities of the consortium. Once the strategic plan has been finalized, it is submitted for reviewal to the consortium's Steering Group. It is the Steering group which, in consultation with the Consortium Director, derives a specific agenda or a business plan for the various activities to be pursued during the course of the year. Input is also sought from the consortium personnel in order to determine the feasibility of the various projects under consideration. However, once the more specific plan of action has been developed, management involvement becomes limited to an occasional review of the work being done. Moreover, in most projects that the consortium undertakes, there is an explicit prototype development stage. A beta version of the product is released in order "to test the waters." During the development of the technology there is no involvement of the shareholders. There are also no formal mechanisms in place for approval before the actual dissemination of the technology into the shareholder domain. However, in cases where the technology product is not a radical advance over existing products, formal approval from senior management is required before the transfer can be effected.

Technology Flow Stage

There are two separate communication flows that occur at the consortium. The first one is the flow of the technology from this consortium to the other consortia that are a part of the aforementioned global network of such consortia. The second is the flow of technology from the consortium to its shareholders. The channels

used to manage the flow of technology are essentially email and FTP. A large part of it takes place through the consortium's web site. Given the peculiar means adopted for transferring technology, there are no goals set to complete the transfer. The objective with respect to the transfer is to ensure that the web site is maintained properly so that shareholders can access the technology and also any other information product easily. However, a time line is developed for having the product "up and running" on the web site.

Ramp- up and Integration Stages The adoption of the technology is a process dependent on the individual learning curves of the health care researchers who form the shareholder community for this consortium. However, the transfer of technology from the consortium to its counterparts elsewhere in the world or vice versa has a more defined adoption process. Normally, an individual or a small group of individuals is set up to receive the new product into their organization. Once this individual or group of individuals has\have developed a thorough understanding of the new technology, workshops are conducted in order to spread the technology throughout the organization. There are no formal mechanisms in place to monitor the adoption of the technology. The adoption of the technology is only monitored indirectly through the nature and quantum of problems being identified by the shareholders. Further, the need for evaluating the process of technology adoption is not so great as the shareholders do not aspire to benefit commercially from the technology.

Characteristics of the transfer process For this consortium, the most important and time consuming aspect of technology transfer is the setting up of appropriate means and channels of transferring technology and managing these means effectively.

Loops in the Transfer Process The consortium personnel are actively involved in providing the shareholders with any assistance that they might need in adopting the technology. However, most of this is carried out either through email and phone conversations or by referring them to appropriate workshops in their geographic area. On

rare occasions, the consortium personnel also undertake site visits. It is indeed, very rare to observe major differences between the needs identified at the beginning of the year and the actual technology product. Normally, one does not observe a scenario where the product after having been developed, has “actually slipped back into the process.” In the rare cases that do involve a mismatch between the technology and the needs, the product is maintained for that year but is taken off, once the next yearly cycle of technology identification and development begins.

Respondent Perceptions about Success Factors for Technology Transfer

Means of Communication For the kind of technology development work that is done by the consortium, face to face transfer of technology would be extremely time consuming. Moreover, given that the shareholders of the consortium are essentially scattered individuals, the means adopted by the consortium are perhaps, the most efficient. Indeed, for the consortium, the development of the internet for example, is increasingly rendering face to face transfer as a means of communicating, redundant. Further, given the rapid pace at which information technology is advancing, it is quite likely that soon the need as well as the relative efficacy of face to face transfer would be reduced even further.

Distance The interviewee observed that geographical proximity could be a factor. Indeed, people can interact a lot more if they are located close to each other. However, the experience of the consortium in successfully interacting with a highly scattered shareholder population does seem to indicate that physical distance may not be such a significant factor after all. This conclusion is further bolstered by the hugely successful interaction between the various members of the international network of these consortia. This has been greatly facilitated by such tools as the internet and email. On the other hand, the interviewee noted that organizational culture, or even the mind set of individuals in this case, is an extremely important factor. Some shareholders who have a more open attitude towards change, adopt the new technology faster. There are others however, who resist change. This issue of organizational cultures is further highlighted by the

management of the global network of these consortia. Realizing that the development of indigenous and distinct cultures by the different consortia in the network might prove to be a major obstacle, the management of the global body has laid down a set of extremely stringent rules in order to ensure homogeneity between the different members of the network.

Motivation, Capability and Commitment Even though it is extremely crucial that the importance of the technology transfer function be recognized; the respondent observed that very often the lack of resources do not allow for this. For this consortium, technology transfer is not the primary objective and thus, that leads to the allocation of minimal resources, in terms of time, personnel etc., to the technology transfer function. The low importance accorded to technology transfer is also reflected in the fact that no explicit rewards and recognition mechanisms have been set up by this consortium; though the respondent noted that it might be useful to do so. Further, the respondent also stated that it is important to have both the consortium and the shareholders committed to the transfer process as both need to undertake a series of steps in order to effect a successful transfer. Experience in transferring technology has been a very important factor. Many shareholders of this consortium have through experience become comfortable with the means used for transferring technology and that has made a tremendous difference to the probability of executing a successful transfer.

Role of the Management The interviewee noted that it is extremely important that the management at the consortium explicitly recognizes the importance of the technology transfer function. Further, they must also ensure that adequate resources especially, in terms of time, have been freed up for the transfer process.

Size of the involved Organizations With reference to this consortium, the size has not really made an impact even though the consortium has grown rapidly in the past 5 or 6 years. The reason for this might lie in the peculiar form of transferring technology that the consortium has adopted.

Nature of Technology and the Type of Industry

The fact that this consortium is focused in a particular sector and also that it has to cater to a rather unique shareholder population in terms of composition and geographical spread, has greatly influenced the kind of technology that it develops as well as the means that it uses to transfer the same. The technology itself can have a profound impact on the transfer process. Though the codifiability of the technology is an important factor, the interviewee observed that the ease of use and understanding of the technology are far more important. Even if clear steps could be laid down for the use of the technology, recipients would tend to avoid using it and/or resist learning it if the technology is too complex or difficult to use.

Case Study 5

Organization 5 was an industry sponsored consortium formed in order to pursue pre-competitive research and explore “novel directions in multiwavelength communication technology”. The consortium was based at a central location (in a research institution) with its own research facilities distinct from the shareholders. Most of the development work was carried out here. The consortium had 8 organizations as its members.

The Technology Transfer Process

Idea Generation and Technology Development

The consortium was set up with a broad objective in mind; that of exploring new directions in the field of multiwavelength communication technology. Given this broad goal, the consortium and the shareholders spent a lot of time in establishing more specific strategies and objectives for the consortium. An explicit needs analysis was conducted by the Steering Committee of the consortium comprising of the consortium management and deputed senior shareholder personnel. Once the shareholders had identified some of their major needs, steps were taken to initiate the development of those technologies whose pursuit was deemed to be feasible. The needs analysis phase was considered extremely important and

lasted for almost a full year. Even after the more detailed “plan of action” had been developed, the consortium management and the senior shareholder personnel was actively involved in supervising the projects. Formal monthly meetings were held in order to review the technical aspects of the different projects. Moreover the consortium’s Steering Committee held regular bi-weekly or monthly meetings to ensure that the different projects were on track. Prototype development was an integral part of the various projects that were undertaken by the consortium. Shareholder personnel worked on the development of technology along with the consortium personnel at the consortium’s research facilities. This allowed them to continuously evaluate the technology being developed. As mentioned earlier, there was great management involvement through out the development of the technology. This reduced the need for setting up any kind of rigorous approval processes at the end of the technology development phase though the Steering Committee had to be formally notified before the technology could be formally transferred to the shareholders.

Technology Flow Stage A distinct technology flow stage was discernible in the operations of this consortium. Normally, the shareholder personnel who worked on the projects were the conduits of the technology into their respective companies. Further, monthly reports detailing the developments in the project were also generated and were used as a channel for disseminating information about the technology being developed to the shareholders. Extensive goals and deadlines were set for the transfer of the technology. As mentioned earlier, very detailed overall milestones were established by the consortium management and senior shareholder personnel very early on in the project. These milestones were then translated into more specific goals and it was at this stage that goals were set, for example, for the first use of the technology by the shareholder(s).

Ramp-up and Integration Stages There was a phased adoption of the technology by the shareholders of the consortium. The personnel working at the consortium acted as the node for entry of the technology into their companies. By virtue of the fact that these individuals had been actively involved from the outset, they

developed an extensive understanding of the technology. These individuals, then started working with the new technology at their respective companies and were responsible for the smooth adoption of the technology by other individuals in their organizations. The consortium personnel are not actively involved in facilitating this adoption process. Most shareholder organizations had their own internal mechanisms in place for monitoring the adoption of the new technology. The consortium personnel played no part in setting up these mechanisms.

Characteristics of the transfer process For this consortium, the most crucial and time consuming aspect of the transfer process was conducting a thorough needs analysis and setting up an agenda in order to ensure that the technology development efforts remained focused. The respondent also observed that it was extremely important to have a technology champion at the consortium who understood the importance of the technology transfer function and ensured that the transfer of technology was not being sidelined.

Loops in the Transfer Process The consortium personnel were actively involved in providing the shareholders with technical assistance. Further, there was very rarely a case where the technology that was developed for a particular use was rejected or shelved by the shareholders after its development. This was probably a derivative of the extensive needs analysis stage at the very beginning of the different projects. The few cases which were characterized by such a shelving of the technology were those where the shareholder had changed its business focus and the technology was no longer relevant to their strategic focus.

Respondent Perceptions about Success Factors for Technology Transfer

Means of Communication The interviewee observed that the direct face to face transfer is the best medium for technology transfer; irrespective of the stage of the process ("Technology transfer is about people"). In this consortium shareholder personnel working on the project became the human carriers of the technology into their companies.

However, the accompanying documentation was also extremely crucial. It went a long way in accelerating the learning curve for all individuals concerned. It also served well as a platform for the quick dissemination of the information about the progress of the project to all relevant personnel at the shareholder organizations. Further, it also proved useful for facilitating external reviews of the workings of the consortium.

Distance Physical distance between the consortium and the shareholders is a factor; though in this case not a very significant one as most of the shareholders had personnel working at the consortium. However, in the absence of such a set-up, the interviewee stated that distance could have turned into a major obstacle to the technology transfer function. Further, the interviewee also observed that it was extremely crucial that there was a “meeting of the minds” as far as the individuals working on a project were concerned. If the values and the attitudes that these individuals carry over from their organizations were incompatible, their interaction with each other and consequently, the transfer process would have suffer.

Motivation, Capability and Commitment The interviewee observed that it is extremely important to explicitly recognize the importance of the technology transfer function. The interviewee also noted that it is important that both the technology source and the technology recipient be equally motivated towards ensuring that the technology is successfully transferred. In most cases, the technology source is quite committed towards the transfer, as the technology is “their baby” and they would like to see the technology developed by them being put to use quickly. Commitment on the part of the shareholders is also, however, quite important. This varies from project to project and is influenced by such factors as the importance of the particular technology being transferred to the operations of the company. The lack of shareholder commitment though can pose a big challenge in executing a successful technology transfer and is normally reflected in the amount of resources that they free up towards facilitating the transfer of a particular technology. The interviewee recommended that adequate resources should be freed up by both the consortium and the shareholders in order to facilitate the transfer of technology;

especially in terms of personnel and time. Appropriate infrastructure should be set up in order to ensure the smooth adoption of the technology by the shareholders. If the existing technological systems at the shareholders are incompatible with the incoming technology, the chances of executing a successful transfer are very slim. As far as the importance of previous experience is concerned, the interviewee stated that the learning is limited to being able to quickly identify the potential areas of concern or the possible pitfalls. Thus, for the projects that were taken up further down the road, one could take timely action to avoid the pitfalls that had been identified from previous experiences with transferring technology. Explicit rewards and other forms of recognizing technology transfer efforts were not set up at the consortium though these might have been strong motivators for ensuring commitment to the transfer process.

Role of Management As mentioned earlier, it is extremely important that the management at both the consortium and the shareholder, explicitly recognize the importance of the technology transfer function. The respondent stated that the management should make sure that the personnel involved with the projects clearly understand that the transfer of the technology being developed by them is also a part of their job description. The management should also ensure that adequate resources have been freed up for the transfer process.

Size of the involved Organizations According to the respondent size is not a factor at all as far as technology transfer is concerned. However, the larger firms have a much longer time horizon and well developed integration mechanisms and therefore, can initiate the technology flow from the consortium much earlier than the smaller firms.

Nature of Technology and the Type of Industry The respondent stated that the type of industry or the sector that the shareholder operates in is of no consequence. The consortium could in fact, not be characterized as belonging to any one sector. That classification could only be made on the basis of the technology area that the consortium was working in; namely multiwavelength communication technologies. Further, the

shareholders of the consortium belonged to different sectors and that did not pose much trouble as far as the transfer function went. Moreover, as far as the technology itself was concerned, its demonstrability was perhaps, the most important factor as far as technology transfer was concerned. Further, the complexity of the technology might also be an issue in the fact that it might take longer for transferring a more complex technology. However, the respondent noted that the codifiability of the technology might be a bit of a “red herring”. Even if the technology has been very meticulously quantified, it is still upto the end user to interpret the codified knowledge. The end user might not be able to fully grasp all the capabilities of the technology.

Case Study 6

Organization 6 is a consortium of 10 different organizations focused on doing research in the area of optoelectronics. The consortium is based at a central location (in a research institution) with its own research facilities. However, most of the development work is carried out at shareholder research facilities. The consortium’s facilities are more focused on evaluating the technologies being developed rather than being involved with the actual development work. The consortium basically functions as an administrative consortium and helps the shareholders in leveraging their capabilities and know how. Most of the technology transfer occurs directly between the shareholders with the consortium acting as the “broker”. Another interesting point to note about this consortium is that there is no collective ownership of the intellectual property rights. However, even though the ownership of the technology rests with the shareholder(s) that develop a particular technology, they have an obligation to sell, lend or allow other shareholders in the consortium to utilize the technology to the extent that they want.

The Technology Transfer Process

Idea Generation and Technology Development

Ideas for the various projects pursued by the consortium mostly come from the shareholders. The shareholders have to

make a technical proposal detailing what they want to do. These proposals are reviewed extensively by the consortium's Technical Director. Based on the recommendations of the Technical Director, the proposals are modified by the shareholders. These proposals are then, submitted for review to the consortium's Technical Review Committee. The Technical Review Committee (TRC) is comprised of the consortium's management as well as senior technical and management personnel from the shareholder organizations. These recommendations then, have to be approved by the consortium's Board of Directors before the projects can be initiated. Even though most of the research is actually carried out at the shareholder sites; the project members still have to submit quarterly reports on the progress of the project to the consortium's Technical Director and the TRC. This facilitates a continuous monitoring and redefining of the actual development of the technology. Most projects do result in the development of a prototype. Even if the focus of the project is on process improvements or it is knowledge intensive; a demonstration is arranged detailing where and how the improvements occur. This prototype is evaluated both at the consortium's research facilities as well as by other members of the consortium at their own research facilities. Once the technology/product has been developed, the TRC needs to be notified before it can be formally transferred to another shareholder.

Technology Flow Stage The actual flow of technology between the shareholders of this consortium occurs through a variety of means. Once the technology product is ready, onsite visits by the other members are arranged in order to facilitate the transfer. These personnel from other shareholders are exposed to the workings of the new technology and then they act as nodes for entry of the technology into their respective organizations. These visits are further supplemented through detailed documentation. Further, other means of disseminating information about the development of the technology amongst the shareholders are also used. The consortium organizes an "annual day" where all the shareholders bring information about the technologies being developed by them and give technical talks as well as demonstrations of the technology in its present stage. As far as the goals for the communication process are concerned, goals are established for the final demonstration of the technology and its availability to the other members of the

consortium, at the beginning of the project. The TRC and the consortium management use these milestones as the benchmark for monitoring the various aspects of the transfer process including the actual flow of the technology.

Ramp-up and Integration Stages Normally an individual or a group of individuals is/are made responsible for the job of developing a thorough understanding of the capabilities of the technology and then routinizing the technology in the operations of their respective organizations. The consortium or the technology developers are not normally involved in monitoring this process. Most recipient organizations have their own internal mechanisms for monitoring the process of adoption and integration and the source or the consortium play no role in setting these up.

Characteristics of the transfer process For this consortium, the most crucial and time consuming aspect of the transfer process is the initial feasibility analysis and goal setting stage. It is extremely important that the efforts of the consortium remain focused and an extensive goals setting exercise be undertaken at the beginning. This can go a long way in ensuring that a successful transfer of technology occurs.

Loops in the Transfer Process Technical assistance is provided to the recipient in adopting the technology by both the consortium as well as the source shareholder. The consortium provides the recipient with help either through its technical director or by providing the shareholder with access to outside experts in the area. Further, as most of the research is done in this case at the shareholder site; the consortium and other members chip in to assist the developer of the technology in case technical assistance is required by that particular shareholder. As most of the projects are initiated by the shareholders themselves, there are very few cases where there is a gross mismatch between the needs identified and the technology developed. Thus, there have been relatively few cases of the shelving of the technology after its development and transfer. However, there have been cases where the recipient has lost interest in the technology due to a shift of focus. In such

cases, the technology adoption process has not been efficient and the technology has invariably been shelved after sometime.

Respondent Perceptions about Success Factors for Technology Transfer

Means of Communications The interviewee noted that the face to face transfer of technology is the most efficient means of transfer. In cases where the technology developed is not something tangible, this transfer should also be supplemented by documentation. However, even in such cases, it is the direct interaction between the individuals involved that is the most crucial to the transfer process. Further, the interviewee observed that the use of communication tools such as the email or videoconferencing are also only supplements to the direct interaction.

Distance The respondent observed that physical distance is an extremely crucial factor as far as the transfer function is concerned. The reason being that physical proximity facilitates greater face to face interaction between the individuals involved in the technology transfer function. Further, the respondent also stated that organizational culture exerts a significant influence on the transfer function. The impact of this factor is reflected in the difficulty of interacting with and transferring technology to a large company. Most large companies are besotted with a bureaucratic culture and this can pose hurdles in executing a successful transfer of technology.

Motivation, Capability and Commitment The respondent noted that previous experience in transferring technology exposes the individuals participating in the process to the areas of potential trouble. Thus, this knowledge allows them to allocate their resources more efficiently and focus more on the riskier aspects of the transfer process. As far as the commitment to the transfer process is concerned, the respondent stated that it is important that both the source and the recipient are committed to the process. However, having said that it has to be remembered that it is the recipient organization that has to make all the adjustments to existing systems in order to properly integrate the incoming

technology into their operations and thus, their commitment has to be greater. It is extremely important that the management of all the involved organizations realize the importance of the transfer function and allocate adequate resources in terms of time, personnel etc. towards ensuring its success.

Role of Management The respondent identified several ways in which the consortium and shareholder management could exert a positive influence on the transfer process. The management should clearly identify the personnel responsible for the transfer efforts. This can go a long way towards ensuring that the transfer of technology occurs “smoothly”. Further as stated above, it is also important that the management allocates adequate resources to the transfer process in terms of personnel, time etc.

Size Size is extremely important as far as the transfer process goes. The respondent stated that it is far easier to transfer technology to smaller companies. Smaller companies are less bureaucratic and more focused as their interest base is less diverse and this can have a tremendous positive impact on the transfer process.

Nature of Technology and Type of Industry The interviewee stated that the technology itself is rarely crucial to the transfer process. It should be remembered that the transfer of technology is a very people oriented process. The fact that the technology being transferred is extremely difficult to demonstrate or codify becomes irrelevant if the personnel involved in transferring the technology are greatly committed to the process. Further, the type of industry does have an impact in that it is easier to effect a transfer of technology if the organizations are all in the same general business. The respondent felt that organizations in the same business have several commonalties amongst them and this can be a major factor in facilitating the transfer process.

Case Study 7

Organization 7 is an administrative consortium with over 55 partners including a large number of universities. The activities of the consortium are focused in the area of microelectronics. Though the consortium has its own R&D facilities, most of the technology development work takes place at the shareholder sites. Most of the technology transfer therefore, occurs between the shareholders with the consortium acting as a “broker”.

The Technology Transfer Process

Idea Generation and Technology Development Stage As far as identifying promising research directions is concerned, the consortium staff conducts an extensive analysis of the needs of the shareholders. This exercise normally results in a plan which is submitted to the consortium’s Technical Advisory Committee and various technology sub-committees. These committees review the plan submitted by the consortium personnel. These committees consist of senior technical personnel from the companies and researchers from the universities and recommend changes to the plan submitted by the consortium personnel. These recommendations are incorporated into the strategic plan for the consortium and a specific plan with goals and deadlines for the different projects is established. Another rather unique feature of the agenda setting exercise at this consortium is that the technology committees are asked to “paint a picture” of the future of the various technologies that are of interest to the consortium and its shareholders. This picture is then used as a base by the consortium staff to determine what are the most likely directions of technology development in the future. The consortium then allocates some of its resources into these areas. After this rigorous agenda setting exercise, there is very little involvement from the consortium management as well as the senior staff at the shareholders as represented by the various committees. The only monitoring that occurs is indirect in the sense that the consortium provides support services as well as technical advise to the developers of the technology. This allows the consortium staff to develop a

fairly good feel for the progress that is being made by the shareholder(s) who is/are developing the technology. Normally, the shareholder developing the technology comes up with a fully functional prototype. At the end of the development phase, a demonstration of this prototype is given and it is evaluated by the consortium personnel as well as staff from other shareholders. Once the technology is ready for the actual flow, the consortium management in consultation with the technical committees extensively evaluates it again and if satisfied gives approval for the flow to begin.

Technology Flow Stage The consortium brokers the flow of the technology from the developer to the other shareholders. The channel used for managing this flow include direct face to face means like extensive on site visits, technical seminars and workshops as well as indirect means such as technical reports. The end of development stage evaluation of the technology also sets up a framework for managing the flow of the technology which establishes major milestones for the remaining part of the process. These are then used to monitor the progress of this stage.

Ramp - up and Integration Stages The kind of adoption process that an organization exhibits depends on the organizations size and maturity. Larger shareholders normally follow a very structured and phased process. Normally, in such organizations point person(s) are appointed in order understand the technology. It then becomes the responsibility of these personnel to ensure the proper integration of the technology into the operations of the firm. In the case of smaller shareholders, this process is very ad hoc. In the case of universities, the recipients of the technology are normally researchers. In this situation, the adoption of the technology depends upon the learning curve of the individuals concerned as well as their attitude towards the use of new technology. The only situation where the adoption process is monitored is in the case of the large shareholders. Most of these organizations have their own control mechanisms in place to evaluate the adoption and the use of the new technology within the organization. The consortium does not play any role in setting up these mechanisms.

Characteristics of the transfer process The process of transferring technology is a very people based process. Thus, the respondent identified the management of the relationship between the various individuals involved in the process as the most crucial and time consuming aspect of the transfer process. Given that the consortium facilitates a tremendous amount of technology transfer between private companies and universities, it is also extremely important that there be an explicit effort to bridge the gap in the attitudes of these two very distinct communities.

Loops in the Transfer Process The consortium provides the shareholders with technical assistance and advise for both the development as well as the adoption of the new technology. During the adoption phase, the developer of the new technology is also available for helping out with the adoption process, if required. There have also been cases where the shareholder has shelved the technology after having successfully received it. This happens most often with the university researchers who often tend to loose interest in the technology after the initial enthusiasm. Further, given the fact that the technology identification strategy at this consortium is fairly proactive in its nature, sometimes even companies who feel excited about a particular technology at the beginning loose interest in it after becoming more familiar with the technology's focus and capabilities .

Respondent Perceptions about Success Factors for Technology Transfer

Means of Communication The respondent observed that it is difficult to compare direct face to face means and indirect means of transferring technology. The consortium uses both kinds of transfer mechanisms. The decision to use one form or the other, really depends upon the kind of technology that is being transferred. If the technology is tangible, the use of direct means of transfer becomes less important. However, if the technology is more knowledge intensive, such direct means would be preferable. However, even in these cases, advances in information technology are beginning to have a tremendous impact. The respondent noted that the option of having

knowledge available on computer networks or setting up on-line tutorials is greatly altering the mechanics of the direct face to face transfers.

Distance Physical distance is not an important factor as far as technology transfer goes. An interesting observation that the respondent made is that physical proximity was of far greater consequence early on in the life of the consortium. As mentioned, the relationship between the individuals involved in the transfer process is an extremely crucial factor. If the individuals are located close to one another, it is easier to cement this relationship. However, once the relationships have been established, the importance of physical distance decreases greatly. Further, the respondent agreed that the values and mind set of the individuals involved with the transfer of technology also has a profound impact on the process. As mentioned earlier, the consortium has two very distinct groups of shareholders; private companies and universities. The individuals coming from these two environments have very distinct value systems and attitudes towards doing different things. These differences can have a major impact on their relationships with each other and therefore, on the transfer process. Further it is in the culture of some organizations to be more amenable to working with new technology. Such shareholders more readily welcome new technologies into their organizations while others prefer to “wait and watch”.

Motivation, Capability and Commitment The respondent stated that the importance of the transfer function should be reinforced by including it in the job description of the individuals working on a particular project. Further, it is also important that technology transfer efforts be recognized and rewarded. This could form an important part of providing motivation and also emphasizing the importance of technology transfer. Such mechanisms do not exist at the consortium at the present time. It is also extremely important that management realizes the importance of allocating sufficient resources for technology transfer. Moreover, the respondent also noted that the more an organization engages in technology transfer, the more adept it becomes at it. There is a learning curve associated with the process and previous experience with the process endows the involved

organizations with the ability to avoid the pitfalls inherent in the process. Further, the pull aspect of the technology transfer process is very important. The recipient, according to the respondent, much more than the source, has to be committed to the transfer of technology if the process has to have any chance at all of succeeding. The source may be committed but if the recipient is not motivated towards accepting the technology into the organizations, then the technology will “not go anywhere”.

Role of Management The respondent stated that the management, or in the case of universities the senior researchers who are incharge, must realize the importance of the technology transfer function and be committed to it. They must take steps to ensure that the personnel feel that the transfer is an integral part of their jobs. The management must also allocate adequate amounts of resources towards ensuring the success of the transfer; especially in terms of allocating time specifically for it. It might also be helpful if the management could set a personnel up as a “technology transfer champion” both at the shareholder organizations, who would oversee the transfer activities and smoothen the possible hurdles in the way of executing a successful transfer.

Size of the involved Organizations Size is a factor as far as technology transfer is concerned. The respondent highlighted the fact that larger shareholders adopt a more structured approach to the transfer process while smaller ones have more ad hoc processes in place to emphasize the point.

Nature of Technology and the Type of Industry The respondent does not feel that the sector in which one operates in makes any difference. However, the nature of the technology itself can have a profound impact of the technology transfer process. It is definitely easier to transfer a technology that is easy to understand and demonstrate. As far as the ease with which the technology lends itself to codification, it is a factor, though sometimes an overrated one. The respondent reiterated that fact that in the end the transfer process depends to a very large extent on the individuals involved in it. Even if a

technology could easily be broken down into a series of steps and stages, two different individuals working with this schema might still produce significantly different results.

Case Study 8

Organization 8 is an industry sponsored consortium with 35 private companies as shareholders focusing on doing basic research in the field of seismology. The consortium is based in a university and has research facilities of its own where most of the technology/knowledge development work is carried out.

The Technology Transfer Process

Idea Generation and Technology Development Stage The consortium adopts a very proactive stance as far as identifying and selecting promising areas of technology/knowledge development is concerned. The researchers at the consortium are given full freedom to explore any research direction that they want to. There is in fact, no formal mechanism in place to review the various research proposals. The reason for this being that the industry shareholders are more interested in basic research rather than product or process specific research. However, the consortium personnel do confer informally with their industry partners and try to take into account their needs too in their yearly research agendas. There is no involvement of the management during the development of the technology. As mentioned before, most researchers pursue their own research interests. Further for the most part, there is very rarely an explicit prototype development stage. However, the consortium is also actively involved in developing software and in these cases a beta version of the product is produced first. Interaction between the technical personnel at the shareholders and the researchers working at the consortium does occur from time to time. The technical personnel at the shareholders may provide solid technical input to the researchers in order to assist with their development of the technology/knowledge. Very rarely, personnel from the shareholders might be directly

involved with some of the projects too. There is no formal approval process before the actual flow of technology can begin.

Technology Flow Stage A distinct stage devoted solely to communication activities is identifiable in the operations of this consortium. The consortium organizes an “annual sponsors day” when its personnel present their work and research to their shareholders in the form of technical papers and an overall research report. If a given shareholder shows interest in a particular project, then they are provided with extensive documentation about the same. If a project has resulted in a specific product, say a software, the shareholders use this opportunity to evaluate it and recommend any changes that could be made to it. The product is then delivered to the shareholders after the recommended changes have been made. No specific goals are established for either the different projects as a whole or for the actual technology flow activity.

Ramp - up and Integration Stages The respondent stated that the adoption process witnessed at the shareholder organizations depends on the nature of the technology or knowledge being transferred. If the knowledge being transferred is highly complex, then it usually goes to a smaller highly skilled research group within the company. However, if the knowledge is not so advanced, then the organization may put it to more general use right away. Usually, however, there is always a point person who evaluates the technology and decides which one of the approaches outlined above would be adopted. The shareholders have their own internal mechanisms of evaluating the adoption of the technology and the consortium plays no role in setting these up.

Characteristics of the transfer process From the perspective of this consortium, the most complex aspect of the transfer process is the development of the technology/knowledge while the most time consuming aspect is the setting up of the mechanisms to be used for transferring that knowledge to the shareholders.

Loops in the Transfer Process The consortium does provide technical assistance to the shareholders in adopting and understanding the technology/knowledge developed by them. If required, the consortium personnel undertake on-site visits in order to assist the shareholders in using the technology/knowledge. As far as the shelving of the technology is concerned, there have been cases where the shareholders have identified a technology as being interesting and have undertaken to use it. However, during the course of adoption of the technology, they have realized that the technology is not quite what they thought it was. In such circumstances, the technology is normally just shelved.

Respondent Perceptions about Success Factors for Technology Transfer

Means of Communication The respondent stated that it would be extremely difficult to rank direct means of transferring technology as being superior to indirect means. The respondent emphasized the fact that these are just alternatives and it is important to have the mechanisms in place to have both kinds of channels of transfer available for use. Another thing that the respondent mentioned is that it is important to get feedback from the shareholders about the different mechanisms being used for transferring technology. The means being used to transfer the technology should then evolve in accordance with this feedback.

Distance The interviewee noted that it is easier to transfer technology to a company that is located close to the consortium. However, having said that, the respondent also pointed out that physical distance is not a determining factor as the consortium has several sponsors from around the world. The organizational culture of the shareholders definitely impacts on the transfer process especially in terms of the adoption of the new technology/knowledge. The respondent observed that more research oriented shareholders adopt the technology faster.

Motivation, Capability and Commitment The respondent stated that adequate resources must be devoted towards ensuring that a successful transfer of technology

happens. Personnel involved in the process must be made to recognize that technology/knowledge development by itself is not sufficient; transferring it to the shareholders is also equally crucial. Further, the consortium as mentioned earlier, evolved its communication mechanisms with time. Thus, the experiences that the consortium has had in transferring technology have definitely helped in the development of superior methods for carrying out the transfer. Normally, the incompatibility of the technology with the existing technical systems at the consortium is not an issue. Given the fact that the shareholders pick and choose from the technologies that are developed by the consortium, it is rare that a technology is picked that is at odds with the existing technologies at their organizations. Further, if such a technology does get picked up and the shareholders are convinced about the potential of the incoming technology, they take steps to ensure that the necessary infrastructure is in place to accept it into the organization. This includes ensuring that their personnel receive the necessary training in order to fully explore the capabilities of the new technology. As far as the relative importance of shareholder commitment and the consortium commitment goes, both are equally important. There are obstacles that both parties face in trying to successfully transfer the technology and these have to be overcome.

Role of Management The respondent identified different means through which management can facilitate the transfer process. The management should be convinced about the importance of transferring technology and allocates adequate resources to the process. Further, they should also designate a person or persons who should have the responsibility to oversee the transfer process. “These individuals should be told clearly that it is one of their priorities to achieve technology transfer.” Also, mechanisms should be set up to ensure that other individuals get to know of the technology that is coming into the organization. Further, the management should also take steps to create an environment that is supportive of ideas coming from outside.

Size of the involved Organizations Size does not seem to be a factor at all. The respondent stated that the same kind of things seem to be involved in transferring technology to small and large organizations.

Nature of Technology and the Type of Industry According to the interviewee, the type of industry or the sector in which the organizations operate in does not normally make any difference. However, the kind of technology does exert an impact in that it is easier to transfer a technology that is easier to explain, demonstrate and codify. The interviewee also suggested that the ease of codifying technology is not necessarily more or less important than the other characteristics of the knowledge of technology.

Case Study 9

Organization 9 is an administrative consortium focusing on the artificial intelligence sector. The consortium does not have any research facilities of its own. Most of the development done under the aegis of the consortium is carried out at shareholder sites.

The Technology Transfer Process

Idea Generation and Technology Development The consortium adopts a rather unique strategy as far as identifying and pursuing new technology areas are concerned. It invites or actively encourages companies, both members and non-members, to submit research proposals for review by the consortium's Research Management Committee. The recommendations made by the committee are submitted to the consortium's Board of Directors who also provide input towards setting up the final portfolio of projects to be pursued by the consortium. It is interesting to note that the consortium encourages non-member organizations to participate as well, as that further enhances the R&D capabilities of the member organizations. However, the rights of these non-members are limited. Non-members normally participate in projects in order to be

able to access funds directed through the consortium. Moreover, in every project it is mandatory to have at least two shareholder organizations¹⁹. The consortium also organizes what are called “the technology steering group” meetings. At these meetings different organizations come together and discuss various technical issues. These meetings have often been a fertile ground for ideas. Project managers are assigned to oversee particular projects. It is the responsibility of these individuals to ensure that the projects stay on track. The project managers also communicate with the consortium management and the senior technical personnel from the shareholders about the progress of the projects. The actual development of the technology takes place at a shareholder site. Most projects result in a fully operational prototype. The deemed users of the technology usually have personnel working with the development team. This facilitates a continuous evaluation of the technology as it is being developed. The project managers review the projects before the actual transfer occurs and notify the management and senior technical personnel if the technology is ready for the actual flow.

Technology Flow Stage As mentioned above, at least some of the consortium’s shareholders have their personnel working on the development team. These individuals form the main channel of transferring technology. However, the consortium is very active in disseminating information about the technology that is developed into the general shareholder domain as well. It uses means like technology bulletins, newsletters and workshops to do so. The consortium also organizes an annual conference which provides it with a good forum for disseminating information to a much broader audience about the R&D work occurring under its aegis. No specific deadlines are set for the flow of the technology. Most of the goals that are established are more focused on the development work. The only aspect of the flow process for which an explicit deadline is established is the schedule for the project workshops and the annual conference. These workshops are a mandatory part of each project and are used by the consortium as a platform for disseminating information about the technology to the entire shareholder community.

¹⁹ For the purpose of this study, only the transfer to the shareholders of the consortium will be included.

Ramp - up and Integration Stages Shareholder personnel working on the development teams form the primary node of entry of technology into their respective organizations. They also ensure the smooth integration of the incoming technology into the operations of their organization. Further, it must also be mentioned that the adoption process exhibited by the recipient organization depends on the nature of technology. If the technology is more complex and difficult to understand then it is more likely that a pronounced phased adoption process will be seen. Most organizations have their own internal mechanisms to oversee the adoption process and the consortium or the developer of the technology has no role to play at this stage. A point to be noted is that very often the monitoring of the adoption process is directly related to the how crucial the incoming technology is to the recipient shareholder. If the technology is really crucial as is the case with most of the smaller companies, stringent mechanisms are set up in order to oversee the transfer and adoption process by the recipient.

Characteristics of the transfer process Even though most of the projects are initiated through specific proposals that are put forth by the shareholder, the consortium still spends a fair amount of time in “thrashing out the logistics” of the project. This is extremely important as it helps in providing the project with a well defined focus and “helps refine the whole downstream effort.” The respondent also stated that this activity is also quite important for another reason. It is during this stage that the various shareholders involved in the project start actively interacting with each other. Thus, this is the stage when the relationships between different individuals working on the project are established. These relationships go a long way towards facilitating the transfer process. Thus, this stage is quite crucial from that perspective as well.

Loops in the Transfer Process The consortium does not have the capacity, at the present time to step in and assist the end users of the technology in adopting it. If there are glitches in the technology that has been developed, in most cases, the shareholders have to sort them out for themselves. Although no formal mechanisms exist, informally the

relationship established between personnel on the development teams is often relied upon to obtain technical advice in such situations. There have been some cases although where the recipient shareholder was unable to adopt the technology successfully and as a result the technology was shelved. There are also instances where the technology was shelved due to a shift in the business objectives of the recipient or due to a sudden change in the recipient's resources level.

Respondent Perceptions about Success Factors for Technology Transfer

Means of Communication The respondent stated quite categorically that direct face to face means of transferring technology are better than indirect means of transfer such as research reports etc. However, even though such direct interaction is crucial so is good documentation to follow up. Thus, the respondent noted that both kinds of transfer channels are needed for transferring the technology successfully.

Distance The interviewee observed that physical proximity between the source of the different organizations involved in technology transfer can be an important factor. As mentioned above, direct face to face interaction is a crucial aspect of the transfer process. Physical distance would effect the ability of the involved parties to engage in such interaction and exert an important influence on the probability of transferring the technology successfully. Further, if tremendous differences exist between the organizational cultures of the involved parties and thus, in the mind set and the attitudes of the involved personnel, then the respondent noted that this would most definitely impact significantly on the transfer process. The relationship between the individuals involved is crucial for the transfer process. Radical differences in their attitudes would hinder the establishment of a cordial relationship between them and thus, adversely impact the transfer process.

Motivation, Capability and Commitment To ensure that the technology is successfully transferred, the respondent stated that adequate resources must be allocated to

the transfer process; especially, in terms of qualified personnel. Moreover, it is important that the recipient organizations ensure that the personnel who would be using the technology in fact, have the necessary training for adopting it swiftly. As far as the relative importance of the technology source and recipient goes, both are crucial to the success of the process. However, the respondent noted that very often one encounters situations where the commitment from the two is unequal. Sometimes the source is too busy applying the technology for its own use to focus on transferring it to other shareholders and sometimes the recipient loses interest mid way in the technology as a result of a shift in its strategic focus. This is not a crucial factor as far as this consortium is concerned because being an administrative consortium, technology transfer is the main function of the organization and therefore, there is a strong commitment to it at all times. Further, the respondent mentioned that the consortium highlights the examples of successful transfers in the newsletters and technology bulletins printed by it. However, the consortium has not attempted to gauge what impact this has on the motivation of the personnel involved in the transfer process. Lastly, organizations become more adept at transferring technology with experience as they begin to recognize those areas of the process that have the potential of derailing it and begin to focus more attention on them.

Role of Management The respondent stated that the management of the different organizational entities involved in the transfer process should make technology transfer a part of the “business objective”. It is also important that they allocate adequate amounts of resources to the transfer process to ensure its success.

Size of the involved Organizations The respondent felt that size is definitely a factor as far as transferring technology goes. However, it is not exactly clear how the impact of size plays itself out. Smaller organizations tend to be more focused and committed to the transfer process once the decision of being involved in a certain project has been made. This is in contrast to larger organizations where the mandates keep changing and therefore, the commitment to the transfer process is also quite fluid. On the other hand, sometimes smaller organizations do not have the resources to effect a

successful transfer. Thus, the respondent noted that it is difficult to say outright that it is easier to transfer technology to smaller organizations.

Nature of Technology and the Type of Industry

The type of industry or the sector in which one operates definitely impacts on the transfer process. The respondeent observed that different sectors have different cultures in terms of their receptiveness for new technologies or the willingness to accept technologies from outside sources. Such issues can significantly impact on the ability of organizations to engage in effective transfer of technology. Further, the respondent also stated that the characteristics of the technology itself can exert a significant impact on the transfer process. In particular, if the technology can be easily codified, the probability of being able to transfer it successfully increases immensely.

Case Study 10

Organization 10 is a consortium of different organizations involved with the development of rehabilitation technologies. The consortium has also established permanent links with manufacturers of products and providers of services²⁰ based on these technologies. However, inspite of these strong associations with the consortium, the manufacturers and service providers do not actually participate in the technology development. They act only as advisors for the most part. However, it is these organizations that are the primary recipients of the technologies being developed. The consortium forms multi-organizational teams in order to work on the development of better “technology- based products and services”. Further, the actual development work is carried out at shareholder sites. The consortium is essentially an administrative unit.

²⁰ Though these manufacturers and service providers are not shareholders in the consortium, due to the permanent links most of them have forged with the consortium, they will, for the purpose of this study, be considered participating shareholders in the consortium.

The Technology Transfer Process

Idea Generation and Technology Development Stage

The consortium has set up elaborate mechanisms for identifying promising areas of technology development. Several “Technology Advisory Panels” have been established in order to provide a forum for inflow of ideas into the consortium. The innovation that the consortium has introduced is that not only do these panels have senior personnel from the consortium and the various shareholders as members but also individuals drawn from the manufacturing, general service provider and final consumer communities at large. Thus, the consortium and shareholder personnel are able to identify the needs of the various communities in this sector through their interactions with these individuals. This therefore, becomes a powerful tool for gathering pertinent information which the researchers and developers affiliated to the consortium use to put together proposals for research. Further, the consortium also sponsors several surveys of the final consumer population in order to obtain more information about their needs. The researchers also take the relevant information obtained through these surveys into account while finalizing their research proposals. These proposals are then reviewed by the consortium management as well as the senior personnel from the shareholders. The consortium has also established the “Business Advisory Committee” in order to study the feasibility of the research proposals especially from the point of view of commercial viability. The consortium has also managed to get some eminent businessmen from the local business community to serve on this committee and provide valuable feedback to the consortium and the shareholders about the merits of the various proposals being considered. Once the projects to be pursued have been selected, teams composed of personnel from the various shareholders are set up to work on the development of the technology. Further, there is an explicit prototype development phase in most projects. The “Technology Advisory Panels” which play a lead role at the needs analysis stage are also given the responsibility of not only evaluating the prototype but also monitoring the technology as it is being developed. If need be, these advisory panels will recommend changes to the consortium management and the BAC for redefining the focus of a given project. In a number of cases, these

recommendations are accepted. No formal requirements for seeking approval before the actual flow of the technology have been established; though the team leader is required to relay to the consortium management and the BAC that the technology development is complete.

Technology Flow Stage In most projects undertaken by this consortium, members of the technology recipient community (manufacturers and service providers) are involved in one capacity or the other. Thus, an indirect flow of technology begins even as the technology is being developed. Further, the consortium sets up the team leader as a technology champion to establish a formal channel for the flow of the technology into the shareholder organizations. It then becomes the responsibility of the champion to ensure that the technology flows smoothly into the recipient organizations. Further, the other teams members also make frequent onsite visits and organize training workshops to further facilitate the transfer process. As far as the establishment of goals for the transfer process is concerned, the consortium does not have a formal process for monitoring the actual technology flow activity. Only a rather informal process where the individuals involved are asked to give estimates of their goals, has been established.

Ramp - up and Integration Stages The organizations operating in the rehabilitation sector are very conservative. and thus, most of the consortium's shareholders adopt the technology in a phased manner. The individuals involved in the evaluation of the technology form the primary node for the entry of the technology into the organizations. These individuals interact directly with the technology champion and the rest of the team members in order to develop a thorough understanding of the technology. They then take on the responsibility of ensuring that the technology is successfully integrated with the operations of the rest of the organization. This sequence of events is more relevant to the manufacturing firms to whom the technology is transferred. As far as service providers are concerned, most of the individuals work independently. Thus, in their case the adoption process depends entirely on the persons' own learning capabilities. However, when the entire population of service providers is

considered, a “very stretched out innovation diffusion curve” is observed. It takes a substantial amount of time for the general service provider population to adopt the technology even after the innovators have demonstrated the worth of the new technology or product. Further, the consortium does not really play a role in setting up control systems to monitor the adoption of the technology by the recipients.

Characteristics of the transfer process Given the fact that the recipients in this case are not formal shareholders of the consortium, the issue of ownership of the technology assumes great importance. The negotiations that accompany this issue are perhaps, the most complex part of the technology transfer process in this scenario. However, in order to ensure that the technology can be successfully transferred, it is absolutely imperative that the transfer function be established as a priority area right at the very beginning of every project. The respondent stated that the coaching of the researchers and developers about the importance of swift technology transfer is also perhaps, the most time consuming part of the process. It is also extremely important that the final recipients of the technology be involved during the actual development of the technology in some capacity or the other.

Loops in the Transfer Process The consortium provides the shareholders with technical assistance, if needed. Further, there have also been cases where the projects have been terminated during the technology development phase itself. This has happened when the “Technology Advisory Panels” have not been satisfied with the development work and have recommended that the project be shelved.

Respondent Perceptions about Success Factors for Technology Transfer

Means of Communication The respondent observed direct face to face means of transferring technology are definitely superior to indirect means. Passive means such as research reports are not very effective. In fact, according to the respondent the senior personnel in the recipient organizations seldom read such reports. Further, the advances in

information technology have not had a great impact as far as the process of transferring technology goes, though the respondent pointed out that the impact might be greater in cases where the technology products is a software, for instance. Direct interaction between the individuals involved still remains the most efficient means of transferring technology.

Distance Physical proximity can have a tremendous positive impact on the transfer process. However, the respondent observed that the impact of physical distance is moderated by the product type. If the technology or the product is a software, for instance, physical distance would not effect the process greatly. Such a product could easily be transferred using email for instance. However, if the technology is more tangible, the physical distance between the involved parties would exert a far greater influence on the transfer process. Differences in organizational cultures are also important as far as transferring technology goes. The respondent pointed out that the consortium has very often run into trouble in dealing with some of the larger, more business oriented organizations as their culture is very different from the consortium's highly research oriented culture.

Motivation, Capability and Commitment The respondent noted that it is extremely crucial that the importance of the transfer function be established at the very beginning of any project. Further, adequate resources should also be allocated for the transfer process. The respondent also recommended that the right kind of training be provided to the personnel at the recipient organizations in order that they may be able to successfully adopt the incoming technology. Finally, the respondent observed that it is equally important that both the shareholder (recipient) and the consortium (source) be committed to the success of the transfer process.

Role of Management The respondent recommended several ways for the management to facilitate the transfer process. The management must very explicitly make the transfer function a priority for all individuals involved in the transfer process. The management should also encourage interaction between their personnel by organizing

gatherings like an internal show and tell event for instance. Finally, the management of all the involved organizations should ensure that adequate resources have been allocated for the transfer process.

Size of the involved Organizations Size plays an important role in facilitating the transfer process. The respondent pointed out that the larger shareholders definitely have more resources to allocate to the transfer process and this can have a tremendous positive influence on the transfer process. The respondent also observed that the same thing holds true for the consortium. As the consortium has grown in size, the additional resources have become available. This has allowed the consortium to better manage the transfer process. The respondent noted that sometimes the entrenched bureaucratic culture in some of the large organizations can be a hurdle as far as technology transfer is concerned. However, the positive impact of additional resources more than offsets the adverse influence of a bureaucratic culture.

Nature of Technology and the Type of Industry The respondent stated that the type of industry or the sector to which the consortium and the shareholders belong does make some difference. The respondent also concurred with the statement that the kind of technology being transferred will also influence the transfer process. As mentioned earlier, it is easier to transfer a software based technology even if the recipient is physically located far away from the source. As far as the specific characteristics of the technology are concerned, it would stand to reason that it would be easier to transfer a technology that is easy to explain demonstrate and codify. However, the ease of demonstrability is probably be the most important characteristic of the technology as far as the transfer process is concerned.

Case Study 11

Organization 11 is an administrative consortium formed in order to leverage Canadian expertise in the area of bacterial diseases. The consortium has eighteen shareholders

including a number of universities and research institutions. It is interesting to note that this is essentially a consortium of “technology developers” who have formed the alliance in order to utilize their R&D resources and expertise for mutual benefit. The users of the technology, however are not members²¹ of the consortium. These end user organizations form an alliance (they do not buy the technology outright), and thus acquire “membership” with the consortium, on a project to project basis. The technology development work is carried out at the shareholder site and transferred to the end users at a later stage. Thus, the process of transferring technology in this case would be quite different from that in a more traditional consortium.

The Technology Transfer Process

Idea Generation and Technology Development Stage The consortium has adopted a very proactive strategy as far as identifying potential areas of research is concerned. The shareholder personnel can put in a proposal for pursuing research in any direction that they want. However, these proposals are subjected to a rigorous scrutiny by the consortium’s Scientific Director, the Network Science and Budget Committee and an external Advisory Board. These proposals are reviewed for not only their scientific merit but also for their potential for commercialization. Once the projects have been selected, the researchers are free to do their research. Very often, the actual research is carried out at multiple shareholder sites. Though no formal monitoring mechanisms have been set up, there is a tremendous amount of interaction between the researcher(s) working on different projects and the consortium staff and management. Thus, the consortium personnel keep themselves informed about the progress of the various technology development projects. Normally, no explicit stage of prototype development is seen. For the most part, this is because of the fact that the researchers are conducting basic research and not trying to develop technologies in order to meet specific needs of any organization.

²¹ Given the absence of any permanent shareholders from the end user community, the end user organizations that enter into a partnership with the consortium for the purposes of technology transfer will be considered participating shareholders.

Further, the end users who come in at a later stage pick only those technologies that interest them and quite explicitly have application for their operations. Thus, the need to develop a prototype in order to evaluate the technology in terms of how well it meets the needs of the shareholders is no longer there. More importantly, however most of the research being done is very knowledge intensive. Thus often, the research results in technical papers which carry the results of the project in great detail. It is this knowledge that is used by the end users rather than a product per se. Further, given the fact that the technology is being transferred to organizations that are not permanent members of the consortium approval has to be obtained both from the consortium as well as shareholder management before the flow of technology can actually begin.

Technology Flow Stage In this consortium, in most cases, the channels used for transferring technology would include technical reports as well as onsite visits by the researcher(s) involved in the development of the technology. No specific goals are set up for the technology flow activities per se.

Ramp - up and Integration Stages Normally, the end user organizations involved with this consortium would spend a significant amount of time evaluating and understanding the technology that has been developed. In that sense, one can say that the adoption process is indeed phased. However, the respondent pointed out that this evaluation begins even before the actual flow of the technology is initiated. The organization will develop a some understanding of the technology before entering into an alliance with the consortium. Further, the company will also ensure that as far as downstream efforts go, the end user organizations will normally have personnel familiarize themselves with all aspects of the incoming technology/knowledge before it is fully integrated with the operations of the organization. Further, the respondent also mentioned that the consortium establishes major milestones for the use of the technology for the recipient organizations. This provides the consortium with some capability of monitoring the use of the technology within the end user organization.

Characteristics of the transfer process According to the respondent, the most complex and time consuming aspect of the transfer process is managing the relationships between the various individuals involved in the process.

Loops in the Transfer Process The consortium provides its shareholders with technical assistance, if needed. If the end users run into difficulties using or adopting the technology, the researchers involved with the development of the technology will step in to assist the organization. Further, the respondent observed that there have not really been any cases where the technology has been shelved after having been required by the end user organization. The reason for this is that most organizations do a very thorough appraisal in terms of a particular technology's relevance to their operations before committing themselves to any technology.

Respondent Perceptions about Success Factors for Technology Transfer

Means of Communication The consortium uses both direct as well as indirect means of transferring technology. The respondent observed that it would be unfair to say that direct means of transferring technology are better or worse than indirect means as it entirely depends on the kind of technology being transferred. The consortium has a number of different kinds of technologies. If a certain technology needs a more hands on approach for the transfer, a more direct face to face transfer of technology is effected. On the other hand, if the technology can be easily codified and packaged then indirect means like research reports are used for the transfer.

Distance According to this respondent physical distance between the consortium and the end users has not had any impact on the transfer process. The consortium has quite successfully transferred technology to a number of end users who were located quite far away from the consortium. However, the respondent did mention that the organizational cultures can have a tremendous impact on the transfer process. Most of the shareholders of the consortium come from a research oriented environment and thus, have trouble

interacting with companies. The consortium has given a fair amount of “coaching” to the researchers in order to assist them in their interaction with the end users. This has had a positive influence on the transfer activities.

Motivation, Capability and Commitment The respondent observed that previous experience with technology transfer helps in identifying the areas of the process which require the most attention. Also, if the organizations have had previous experience in transferring technology to each other, then the relationships that are so essential to the success of the transfer process are already in place. This can help tremendously in carrying out a successful transfer. Further, the respondent also stated that it is important that both the consortium (source) and the end user (recipient) be committed to the transfer process if the technology is to be transferred successfully. Adequate resources must be set aside for the transfer process as well. The respondent mentioned that in a number of shareholders, the focus is on technology development and that is reflected in the resources allocation as well. The consortium tries to ensure that this anomaly in the resource allocation is righted. The respondent pointed out that in most cases, the technology being chosen by the end user is extensively evaluated for compatibility with the embedded technical systems. Thus, normally a technology that is at odds with existing technological structures in the end user organization is not chosen. However, if the end user organization is really interested in a technology then it takes steps to ensure that whatever new infrastructural requirements are needed are put into place before the technology enters into the organization.

Role of Management The respondent suggested that the management must ensure that the personnel involved in the development of the technology/knowledge realize the importance of the transfer function as well. Further, the management should also ensure that enough resources have been set aside for carrying out the transfer of technology. The respondent also recommended that the end user management should appoint a technology champion who would take the responsibility of overseeing the inflow of the technology into their organization.

Size of the involved Organizations

The interviewee noted that size is not normally a very important factor as far as technology transfer is concerned. It is not true to say that it takes longer to transfer the technology to a larger organization. If there is a technology champion in a large organization who is committed to the transfer process, things can happen as quickly and smoothly as would happen in the case of a smaller organization.

Nature of Technology and the Type of Industry

The respondent also refuted the statement that the type of industry impacts on the transfer process. Irrespective of which particular sector the consortium and the technology recipients are in, there are commonalities in the transfer process that remain valid. The nature of the technology itself however, can be an important factor. The respondent supported this statement by pointing out that the technology very often dictates the means that will be adopted to transfer it. Further, the respondent observed that it would be difficult to state which particular characteristic of technology is most crucial for the success of the transfer process. In certain circumstances or for certain kinds of technologies, the ease of codifiability might be important while in other cases the ease of demonstrability might be more critical.

IMAGE EVALUATION TEST TARGET (QA-3)

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