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Report
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DESIGN OF AN EXPERIMENTAL PROGRAM TO TRANSFER TECHNOLOGY TO AND WITHIN CANADA

BY

ABT ASSOCIATES INC.
Cambridge, Massachusetts
May 15, 1973

Technological Forecasting
and Strategy Branch
Office of Science and Technology
Department of Industry, Trade and Commerce
Ottawa, Canada

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EXECUTIVE SUMMARY

An experiment is suggested to test the effectiveness of a technology transfer mechanism which is both functionally and structurally more complete than existing efforts. Technology transfer, as that would be defined for this test, is the process of commercializing existing external technology. Experimental data would be collected to weigh the effectiveness of technology transfer for achieving specified socio-economic objectives for Canada, both in the short- and the long-run.

The experiment would involve the creation of a temporary program to coordinate the required activities. This program would be built around existing Canadian capabilities. The success of future technology transfer efforts depends largely on utilization of the strengths represented by these existing resources. A survey of those capabilities indicates that Canada's major strength is the existence already of many of the required elements, particularly the necessary scientific and technical skills. The most important capability which Canada currently lacks is the ability to provide the centralized direction required to coordinate these elements into an integrated technology transfer mechanism.

The temporary experimental program would be responsible for five separate areas of activity. These areas are 1) matching an identified industrial problem to a potential technological solution, then screening that match; 2) applications engineering and testing; 3) performing the role of advocate for the entrepreneur; 4) making provision for the funding required by technology transfer projects; and 5) facilitating the placement of technical personnel, particularly for identified industrial requirements. Together these five areas of activity would provide for performance of all functions required for the transfer of technology. In all, sixteen separate functional steps have been identified as necessary to an integral model of technology transfer -- a model which has previously been developed and field-tested in diverse settings. A survey of the Canadian industry sectors suggests that the experiment be initiated in the foods, electronics, materials, and wood sectors.

Through this experimental program the efforts of industry, science, and government would be uniquely bound together by a unifying orientation. This fundamental basis for action dictates that any transfer project should be built on and begin with the identification of market demand

for technology. This program also requires direct advocacy of the technology transfer process: this is an active, people-oriented approach -- in contrast with a more neutral approach oriented principally to the transfer of information -- and is expressly designed to develop commitment in the individuals involved. Such an approach recognizes the importance of capitalizing on technological know-how not written in patents or contained in engineering specifications but existing only in the experience of individuals involved with a particular technology. The process also depends importantly upon a thorough generation of technical alternatives through a systematic search of existing technologies, including particularly foreign scientific and technical developments.

Total annual operating costs of the program are expected to average $3,250,000 (plus a one-time $150,000 studies cost). This includes the services of 60 professional and 31 support, a total of 91, staff. Over its five-year duration the program is expected to generate an average of $1,490,000 annual revenues. To meet costs, $1,760,000 additional annual funding support would be required, on average. However, because there would be a lag between start-up and revenue generation, funding support required in the early years might be substantially closer to the total expected annual operating costs.

Though government support would initiate the program, a basic design characteristic of the experiment is that it represent a partnership effort throughout between the public and private sectors. In fact, the private sector would be expected, over time and to the extent that the experiment demonstrated value for industry, to assume a major share of the funding responsibility.

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Case Study

0.0 Introduction

The Office of Science and Technology in the Department of Industry, Trade and Commerce contracted with Abt Associates, Inc. to design an experiment which would examine methods for transferring technology. This study was conducted by means of, first, a thorough review of the relevant literature, particularly that relating to the role of science and technology in Canada's economy. From this material a questionnaire was developed. That questionnaire was the basis for interviews with 1) government officers concerned with technology and the economy and 2) representative firms from selected industries.

This is the report of that study. In the first part, a model of technology transfer developed by Abt is discussed. The middle section reports the results of a survey which compared existing Canadian capabilities for the transfer of technology with the model of technology transfer described in part one. The final part describes the design of an experiment which would build on these existing capabilities and at the same time develop missing elements. The table of contents represents a detailed outline of the report.

The study was carried out under the direction of Dr. Richard Foster, Director, Technology Management Group, Abt Associates, Inc., Cambridge, Massachusetts. Dr. Foster was assisted by Dr. Jack Baranson, formerly Visiting Lecturer at the Harvard Business School and economist at the World Bank; Mr. David Allen; and Mr. John Zysman. Mr. Dalton Cross and Dr. Alan Vanterpool of the Office of Science and Technology were the project officers for the contract. The conclusions drawn from the results of the investigation and analysis are the responsibility of the authors, Dr. Foster and Mr. Allen.

Part I

TECHNOLOGY TRANSFER:

BACKGROUND

1.0 Technology Transfer: Background

1.1 Introduction

Socio-economic research has found it difficult to assess, with any satisfaction, the impact of science and technology on social and economic progress. Studies, at least those at the aggregate level, find little or no correlation between the two.

However, formulating research in these terms may not be the best approach to the question. When elements operate only as parts of an interlocking system of several elements, assessing the impact of any single element on the performance of the overall system is always difficult, at best. An everyday example is the question of what contribution a valve -- or a piston or any other single part -- makes to the horsepower output of the whole automobile engine. The system will perform only through the successful interaction of all the elements together.

If it were the case that science and technology does in fact contribute to the furtherance of socio-economic objectives, such as employment and the generation of capital, it seems likely to occur only as science is harnessed together with other elements, such as timely financing, coordination through government policies, and management from industry. Assessing the impact of science and technology would seem to depend importantly upon accounting for the context in which science and technology operate.

Regardless, however, of the difficulties in assessing technology's impact, what is clear is the immediate need to improve Canada's manufacturing industries. The Science Council in its Report No. 15 described the "deterioration [that] has taken place in Canadian manufacturing over the last four years" and pointed out that "this deterioration places many of [Canada's] recent investments...in jeopardy."[1] Arthur Cordell, in the Science Council Special Study No. 22, puts this problem in its broader context when he states that Canada would like "to decrease [its] absolute or relative degree of dependence [on those powers that now hold a technological sovereignty]."[2] Pierre Bourgault, in his conclusion to the Science Council Special Study No. 23, suggests what may be at least a part of the necessary remedy: he emphasized the need "for Canada to develop and exercise product engineering and design capability" (emphasis deleted from original).[3]

In fact, recent studies support the conclusion that technical innovation can and does contribute to one form of the economic improvement desired in Canada: the commercialization of new products -- but this occurs, the studies indicate, only when innovation is set in an appropriate context of other necessary elements. In 1969 in a broad study of 567 different innovations, Myers and Marquis reported that, of the successful innovations from the total sample, a large percentage, 75 percent, apparently depended for their success upon being in a particular setting: the innovations in this largest group of the total successes were each a direct response to a recognized need in the marketplace.[4] We have called the essential element in this setting -- that is, placing the focus of the innovation process initially on need in the marketplace -- a "market (or demand) orientation." Myers and Marquis' experimental conclusion has been supported in studies by Wright[5] and by Chakrabarti and Rubinstein.[6] Adoption of a technical innovation depends, these studies argue, upon its being in the context of a demand orientation.

This is in contrast with a "supply orientation" which takes as its starting point the counterpart to market demand for a technology: the starting point for a supply orientation is the creation of technology (vs. its market use). In this supply orientation, ideas are generated from, say, basic research, pass through a development phase, are engineered into product form and finally emerge, seeking demand, into the market. The studies cited above argue that, by far, the largest number of innovations that reach the market place do not come by this path. They follow a route that begins with the other end of the sequence of events just spelled out. Innovations that are successfully introduced to the marketplace, these studies argue, begin with a focus, not on the creation of technology, but on the market and what it demands.

The above sequence of the chain of idea development -- research (R) -> development (D) -> engineering (E) -> marketing (M) -- apparently is reversed in most cases of the successful introduction of technical innovations. Engineering is done only in response to a demonstrated demand in the market, development is undertaken only when the attempt at engineering identifies a need for further development, and research is employed only if that development effort should require it.

This, of course, does not in any way preclude basic research for its own sake. What it does address is the question of how to get results from technology: such results require a demand orientation. It also makes suggestions, as will be seen, about how this same orientation is part of a process to build, ultimately, an indigenous industrial research and development capability.

1.1.1 The M->E->D->R Model

In assignments to develop technology management programs over the last four years, and based on the above ideas and research findings, Abt Associates has developed a model of the demand-oriented process. The basic formulation underlying this model is that demand for a technology is established before the supply of that technology is sought. The sequence described earlier is reversed, as explained there, into:

M -> E -> D -> R

Only after the market has signalled the need for a technical innovation is that technology pursued, then starting with engineering and only proceeding if required to development or research.

This is thought to introduce an efficiency into the development and commercialization process. The E -> D -> R process is focused only on that which the market (M) is seeking. Since any investment in this engineering, development or research is more likely to bear marketable fruit, that investment should be more efficient. Either less investment should be required or, for a fixed amount of investment, the return should be higher. In particular, this may be the situation if, in equating time with money, investment is viewed as time lapse between development and commercialization.

Further, management of technology by this model may, as described below, lead to development of an industrial design and engineering infrastructure and perhaps even an industrial research capability.

In the early years of a demand-oriented program, the technologies that are sought as a result of the demand orientation typify, understandably, the first steps of the E -> D -> R sequence -- that is, improvements in engineering or, even, design. (As an example, industrial design may itself be the source, that is, supply, for technology to meet an identified market demand for new designs of plastic kitchenware.) As improvements in engineering and design, the innovations during this period are largely incremental steps forward in technology.

The call from the market for making these changes in engineering and design encourages industry to establish the nucleus for a design and engineering capability. As there is growth in the number of innovations sought in the market, this nucleus can grow. In time, demand uncovers requirements which only research -- and the more basic breakthroughs sought in development or, ultimately, research -- might meet. Thus demand-pull may encourage, finally, an industrial research and development infrastructure. That is, industry's capability for absorbing technology may be enhanced by the demand-oriented approach.

In summary, a technology policy which seeks out demand for technology before its supply should result in more successful attempts at innovation. Further, such a program may be useful as a "start-up" mechanism to get industry moving toward its own research and development infrastructure.

1.1.2 A Definition of Technology Transfer

In terms of its implications for the source, or supply, of technology, this demand-oriented approach indicates that, in the early stages of a demand-oriented program, technology will be purchased wherever it already exists. As an in-house design and engineering capability grows, more of the technical advances utilized will be generated internally. Toward the end of the process, internal operations may be sufficient to supply most of the technology required. Thus, at the beginning the focus is on purchasing the technology; later the focus shifts to internal development.

The purchase, then commercialization, of technology results in the transfer of technology. Purchasable technology exists both within Canada and abroad. This study has placed its major emphasis on the possibilities for and problems of Canadian industry's use of external technology; a lower priority was placed on internal sources. Thus, technology transfer as that term is used here is the process of commercializing existing external (and internal) technology.

The general objectives of technology transfer are explained by the earlier discussion of the M->E->D->R model: technology transfer is intended to move new ideas into the marketplace in a more efficient way, as well as, encourage the development of an indigenous industrial design and engineering capability. Technology transfer is in fact only one of several strategies available for these purposes. This study looks just at technology transfer. To reach objectives, it will probably be necessary to consider implementing several complementary strategies at once.

1.2 Objectives for a Canadian Technology Transfer Program

For a Canadian technology transfer program, these purposes can be stated in terms of the following specific objectives. These objectives are in terms of both a) intended immediate output and b) broader, longer-range impact.

Immediate objectives include:

1 - The enhancement of smaller, Canadian firms in secondary, manufacturing industries, particularly the improvement of their production efficiency.

2 - Reduced dependence on technology acquired by the direct-investment route through multi-national corporations.

The broader objectives are:

3 - An efficient, internationally competitive industry.

4 - An increase in employment.

5 - Social justice, including income redistribution and regional development.

6 - Protection and improvement of the physical and social environment.

1.3 A Sixteen-Step Functional Process

The operational form of the M->E->D->R model is a market-oriented program to transfer technology. Over the course of several technology management assignments, Abt has experimentally field-tested and confirmed such a program in both the United States and other countries. This program identifies sixteen individual functions, grouped into four separate phases, whose performance is necessary for the successful transfer of technology.

1.3.1 General Characteristics

The sixteen functions taken as a group have several overall characteristics which are essential to the success of a technology transfer program:

First, and fundamentally, such a program is market- or demand-oriented as that has been defined above. Identifying what the market is demanding and then bringing technology to meet that market demand lies at the center of a successful technology transfer program.

Second, this demand-orientation calls for soliciting firm declarations of demand from potential users in the marketplace, then seeking out the requisite technology. This requires an active -- as contrasted with passive, or even neutral -- approach to technology transfer. Thus, such a program must be a strong advocate of its own activities.

Third, this advocacy can only be accomplished if the program strongly emphasizes personal involvement throughout. New ideas are adopted only when there is a high level of commitment from those who effect and are affected by those ideas. The commitment of company top managements is essential; similarly, when an innovation is moved from its place of origination, the personal involvement of the inventor or developer with his store of unwritten know-how can be a key factor.

Thus successful technology transfer requires advocacy and is people-oriented. Pertinent to the requirement for these two general characteristics are information services which make science-related information available to industry -- for instance, computerized information-retrieval systems supplying technical information on request. These services are important for successful technology transfer, particularly in searching for a supply of demanded technology. But, by themselves such services are relatively neutral and information-oriented. For successful technology transfer, these services must be fitted into a larger, people-oriented program which acts as advocate for the process.

Fourth, direction of a successful technology transfer program requires centralized coordination to insure the interrelated performance of the several phases and each of their functions. Also, only such a focused effort can articulate the advocacy necessary for results.

Fifth, once a demand has been pinpointed in the market, the program must have the capability to search systematically those existing supplies of technologies, both at home and abroad, which might potentially meet the demand. Only such a search can provide a thorough generation of the technical options available.

1.3.2 The Four Phases

There are four general phases to the technology transfer program. (See Exhibit 1, page 10.) During the first, or "demand," phase, the potential market for technology is established. This includes identifying problems which represent potential uses for technology and checking that these problems are sufficiently widespread to warrant seeking their solution. During the "supply" phase, alternative technical solutions to these problems are proposed and existing technology is systematically searched to find those alternatives which may be currently available. If these two phases are completed, supply will be matched to an established demand.

During "screening," the actual prospects for the newly-matched problems and technologies are tested out in further detail. The projects which show promise during screening are selected for "implementation." This is intended to result, finally, in profitable sales of a new product and thus complete the commercialization of a newly-introduced technology.

1.3.3. The Sixteen Functions

The sixteen functions of technology transfer described below, particularly in the latter phases, are not

Exhibit 1

Technology Transfer: Sixteen Functions Grouped into Four Phases

PHASE:	FUNCTION:
Demand	1 - Problem identification and analysis
	2 - Initial demand survey
Supply	3 - Technical alternatives discovery
	4 - Product survey
	5 - Systematic technology search
Screening	6 - Basic criteria test
	7 - Market acceptance
	8 - Technical feasibility
	9 - User commitment
Implementation	10 - Project funding
	11 - Applications engineering
	12 - Testing - Reliability, safety, maintenance - Standards
	13 - Patent and license arrangements
	14 - Test market demonstration
	15 - Full business study
	16 - Assist manufacturing/marketing

necessarily sequential. There is overlap between functions; in some cases, functions will be performed in parallel with each other. Also, some later functions (for instance, a provision for full-scale business studies) are well understood already and thus require little description here.

It is strongly recommended that, as the following description of the sixteen technology transfer functions is read, the case study developed in Part III be followed step-by-step. That case study sets these functions in the perspective and detail of an actual situation and is integral to a full description of the functions. The case study appears in Part III on pages 39, 40, 43, 48, and 55. Also, reference to Exhibit 1 should serve to keep clear the separation between each of the sixteen functional areas.

1.3.3.1. Demand Phase*

The first of the necessary technology transfer functions is the identification and analysis of a problem. Some problems will have a much larger technological component than others. This technological component represents a potential market for the technical solution to the problem. Identifying that market is, of course, the object of a demand-orientation.

Such problems are identified through the participation of companies which have become convinced of the practical value to them of a technology transfer program. Company personnel are involved in the effort to specify the corporate problems whose technological solution might benefit the company. These problems may relate to the reduction of current cost structures and, in general, the improvement of production efficiency. They may also relate to the need for improved or new products to increase market penetration.

Problems must be specified at a level of detail low enough to make it possible to propose solutions. One way to focus on the specifics of a problem is to examine either prior attempts to solve the problem or solutions currently in use which are considered unsatisfactory. The specific points at which these attempts are deemed to fail are important indicators of the detail of the problem.

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*The description of events during the demand phase in the case study begins on page 40 in Part III. The introduction to the case study on page 39 should also be read.

Problems so specified must, of course, be checked to insure that they are problems in fact and not just problems that arise out of a failure to understand the proper procedures for using an existing piece of equipment or other failures of a similar character. The process of identifying and analyzing problems results in a sizeable number of formal problem statements. These problem statements include both the specifications for and constraints impinging upon any solution to the problem.

Once a problem is identified and specified, an initial survey must be made to begin to gauge the overall market size any technical solution to the problem might enjoy. Both the ubiquitousness and magnitude of the problem are checked. Other similar companies are asked to what extent they encounter the same problem: the more widespread the problem, the greater the potential market. The magnitude, or seriousness, of the problem suggests the level of investment a company might make to solve the problem: this of course also determines market size. If the potential market size appears attractive enough, the technology transfer process moves to the next phase.

1.3.3.2. Supply Phase*

With an apparently attractive market identified, the focus switches to finding a supply of the required technology. To begin, the various technical alternatives which might offer a solution must be discovered. A team of scientists who represent a spectrum of disciplines is convened. In a brainstorming session they are asked for suggestions as to promising alternative approaches.

With the resulting list of alternatives in hand, the next step is to survey the existing and locally available products to see if one of the suggested alternatives is already available. It is occasionally the case that such a product has so far been overlooked. In that case the technology transfer process need go no farther. However, a technology transfer effort terminated at this point should still provide a residual benefit: the market for the existing locally available product will be expanded to the extent that new users have been made aware of it.

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*The supply phase of the case study begins on page 43 in Part III.

- If no such product is found, then a systematic search is conducted for technologies which offer possibilities along the lines of the suggested alternate approaches. This includes making informal personal contacts. More formal methods are also used. For instance, technical literature, particularly patent files, are searched in depth; this includes computerized searches of libraries maintained in computer-compatible form. All potential sources of the hoped-for technologies, foreign and domestic, are included.

If such a technology is found and a match thus made between a market for a technology and its supply, the original developer of that technology is involved in the project if possible. The inventor not only brings with him know-how not written in any patent. His longer-term involvement with and commitment to the technology can be one of the key ingredients in successfully conveying that technology from its point of inception to its point of use.

1.3.3.3. Screening Phase*

If a match has been made, the next requirement is for screening: the match must be screened to decide a key investment question. That question is whether to make further investment, beyond the investment required for the program to this point, in an attempt at implementation, that is, an attempt to bring a new product through production into the market place. Screening will test whether the likelihood of success is high and the payoff sufficient.

The new match must be tested against basic criteria. These are criteria relating to the overall goals of the technology transfer program. As such, they will be standards to test for both immediate results and longer-run impact. The proposed technology transfer should, on the one hand, produce within a year to two years, an increase in sales through the creation and/or expansion of a smaller Canadian manufacturing firm. Equally, to be attractive the proposed project should offer a longer-term prospect for the development of Canada's industrial design and engineering capability.

The market's acceptance of this proposed new product must now be researched comprehensively. The first (demand)

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*The screening phase of the case study is described beginning on page 48 in Part III.

phase included an initial market survey. Now the results of that survey must be verified through a more detailed investigation. This will include expected total market size plotted against the life cycle of the product, what market share a new manufacturer might expect and, particularly, how the possession of this new technology will affect competition in this market sector.

Just as the market must be confirmed, the technical feasibility of the project must be investigated in greater detail. When the problem-technology match was made, there was an initial decision that the newfound technology could perform so as to solve the identified problem. Now that decision must be checked since success will depend on whether the technology will in fact be able to perform.

This further test of technical feasibility includes a first projection of itemized costs. The investigation of technical aspects in greater depth will generate a more detailed specification for the proposed new product. With these specifications, an initial estimate of the labor and materials required can be made.

Finally, if the match successfully passes through the first three "screens" in this phase, a firm commitment to buy is sought from the intended users of the new product. If possible, this commitment will specify a minimum purchase and be contingent only upon the actual manufacture of the product to specifications, by some deadline, and at a maximum sales price. The extent to which users will make such a commitment is an important indicator of just how successfully the whole technology transfer process has been oriented toward actual demand. As such, this commitment (in some degree of firmness) will figure importantly in later decisions, taken by a variety of parties to the process, to make further investments in this transfer of technology.

1.3.3.4. Implementation Phase*

Those problem-technology matches which screen as good prospects are candidates for implementation. The object of implementation is, of course, to bring a new product actually into the marketplace. A number of the functions to be performed in this phase are relatively more familiar.

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*Implementation phase for the case study begins on page 55 in Part III.

The project requires funding (funds, that is, beyond those already provided to get the project to its current status). This includes funding for any further engineering or development which is required to make the technology directly applicable to the demand; it also includes start-up funding to get manufacturing underway.

The government should be prepared to provide a part of these funds. Such funding spreads the unavoidable risk of innovation (risks that exist even in a demand-oriented project) over the public at large. With the government as "lead investor" to take risks that any individual corporation might not, private money may be induced to follow and provide a part of the support and, in this way, further commit itself to the project. Because the market orientation has reduced the risks of the project, the chances for gaining this private participation are increased.

Both the supplier and the user of these funds must be prepared to negotiate in realistic terms. These terms include not only the price placed on the capital but also the future plans for production and sales of the new product.

The technology which has been matched with the identified problem will most probably require further detail development before it is in a form which can in fact supply the demand. This requirement for applications engineering provides an incentive (as described earlier) for the creation of design and engineering capabilities in industry.

The finished prototype which emerges from applications engineering must be tested for reliability, safety, and maintenance requirements under all the conditions the product is likely to encounter when sold broadly. When possible, this testing should involve those who will be the end-users of the product. In some cases, this testing step provides a look back to the first step (problem identification) of the technology transfer process: the testing may uncover other problem areas which represent excellent candidates for yet other transfers of technology.

The new product must also be tested against existing standards of manufacture for such products. In some cases standards have yet to be established. This vacuum may represent an opportunity to establish those standards and thus aggregate larger markets than would otherwise exist: if the standards are widely adopted, a single design can serve several different areas at once.

License arrangements may be necessary for the technology that is being transferred. Ideally, there would be initial agreement on the terms for any license at the point in time when a match is first made in the supply phase. At that point the full commercial value, which requires an investment in applications engineering, does not yet exist. That facilitates bargaining for more liberal terms as to market area.

A last market check is made by demonstrating the prototype in test markets. Such demonstrations allow for confirmation of demand for the product in its final, actual form.

To start-up manufacturing, a complete business plan must be prepared. This builds on the market and technical surveys already completed. This business study is the comprehensive plan -- to include marketing, organization, production, and finance -- which is necessary to launch a start-up in a sound fashion.

Once manufacturing is underway and sales are growing, assistance must be available to help straighten out the inevitable kinks of start-up and growth.

Thus, through the performance of sixteen separate functions, technology is transferred and an existing technology commercialized toward the achievement of established objectives.

Note a characteristic which pervades the overall design of relationships among these sixteen functions. Where there is a sequencing from function to function, that sequencing always operationalizes a demand orientation: investment in search for or further development of technology is made only incrementally and only to the extent that there is increasing commitment from the prospective user of that technology. For instance, "technical feasibility" is further explored only after "market acceptance" has been further verified. Or, again: "user commitment" precedes "project funding" for applications engineering.

1.4 The Structural Requirements for Technology Transfer

A program comprised of these technology transfer functions does not -- and, indeed, cannot -- operate in a vacuum. Schematically, the backdrop against which technology transfer is carried out can be sketched as in Exhibit 2, page 18. In that exhibit, the national setting is portrayed with its government (G), science and technology (S/T), enterprise or industry (E), and financial (F) elements or establishments. Linkages, or at least potential linkages, between each of these establishments are also depicted. Finally, representative foreign national settings are sketched in, particularly the multi-national corporation (MNC) in foreign enterprise establishments.

Clearly, the diagram at its best cannot be used as more than an outline representation for what is a most rich and complex situation. Nonetheless, this diagram provides the necessary basis for describing those requirements for successful technology transfer which are distinctly structural and not functional. A successful technology transfer program requires not just the appropriate functions. It is also necessary that the structural setting for technology transfer have certain minimal attributes.

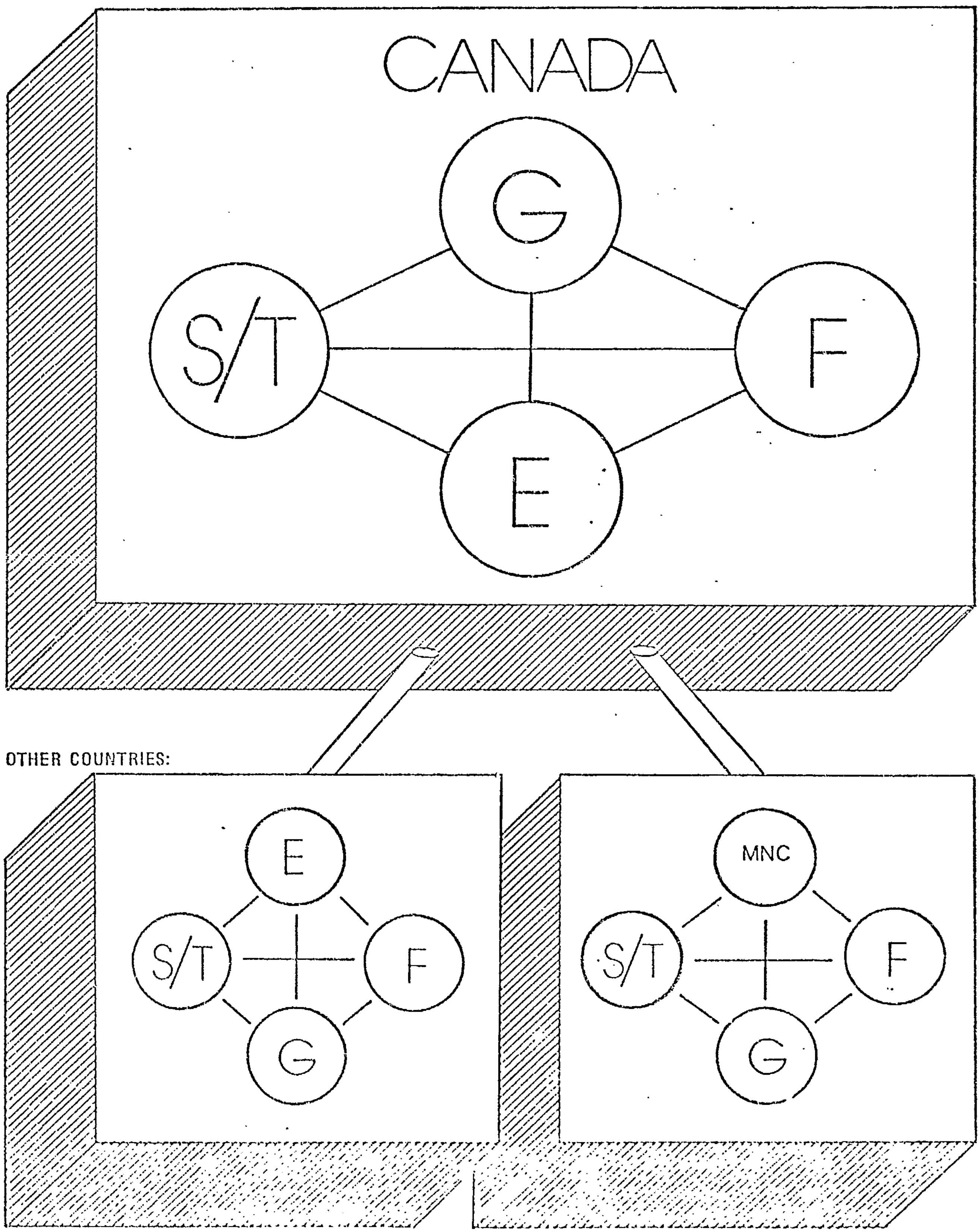
Certainly technology transfer requires of the structural framework that each major element in that framework perform its overall function. Government must be in a position to provide coordination as required, financial institutions must be able to supply funding when appropriate, science and technology must provide people with their ideas, and enterprise is the engine which must be well managed so that it can carry plans into profitable realization in the market. These are essential to the successful technology transfer process detailed in previous sections.

What is particularly crucial in the structural setting for technology transfer, however, is that the linkages among the four elements be in place and operating. This is essential in order to achieve the coordination necessary for successful transfer. Without those linkages, that coordination becomes very difficult, if not impossible.

It is through these linkages that those in science and technology learn of the opportunities in industry for the application of new ideas. Equally, it is these linkages which help build a technological component in industry -- viz., an industrial research and development capability.

EXHIBIT 2

SCHEMA OF STRUCTURAL SETTING REQUIRED FOR TECHNOLOGY TRANSFER



These same linkages help government and industry cooperate in the development of a rationalized industrial sector policy or help financial institutions and industry negotiate timely financing. These are a few examples.

Key indicators for the existence of such linkages are the flow both ways of people, ideas, and money -- but especially the exchange of people between elements. When researchers are interested in a stint in industry, when industrialists spend a tour in a government post, linkages are being built in the form of the dual competences developing in these individuals who are gaining experience in both of two elements.

Two linkages are especially important to succesful technology transfer. The most important is that between science/technology and industry. Only through an operating flow between these two can the market, on the one hand, and engineering, design, or research, on the other, be brought together. Through this linkage science and technology gain suggestions for fruitful research and industry gains the opportunity to utilize those fruits.

Another key linkage is between government and industry. Such a linkage can promote agreement on both objectives and means. Government is then able to help provide the overall coordination necessary and industry may more effectively convert technology transfer plans into reality.

Several tools exist to facilitate the movement of people between elements and, in general, to build any links which may be lacking. First, institutions can be established which explicitly straddle two elements. Such an institution, if it is to perform its bridging function, must have balancing contacts in both the elements it connects. Second, government policies directed at enhancing connections between two elements can be formulated. Relevant policies which are important to the transfer of technology include those relating to imports and tariffs, business combines, patents and licensing, screening of direct foreign investments, science, finance, education, and employment.

Note that the links between Canadian industry and foreign multi-national corporations may retard the transfer of technology by maintaining the dependence of Canadian operations on foreign-based research units. There also exists the possibility that this link could, on the other hand, be used to promote the transfer of technology: the parent company would in that case, based on new incentives, transfer more integrated operations into Canada, including related research facilities.

Part II

TECHNOLOGY TRANSFER IN CANADA:

AS IT APPEARS TO BE

2.0 Technology Transfer in Canada: As It Appears to Be

In Canada today, a number of groups are engaged in the transfer of technology. These activities are the essential basis for future Canadian technology transfer programs. The first step, then, in designing future programs is to make a clear assessment of those capabilities which are currently available and which might be used to transfer technology.

To assess those capabilities, first a survey was made to identify existing technology transfer activities. Then a comparison was made between these existing activities and the functions required for successful technology transfer, as that term was defined in Part I of this report.

To facilitate this comparison, the sixteen functions were grouped according to the basic capability required for performance of the function. As an example, there are five functions which can be grouped according to a single, basic capability required for the performance of each of the five functions; that capability, stated in summary form, is the ability to "identify markets." The grouping of functions into capabilities required is shown in Exhibit 3, page 23. Grouping the functions according to capability creates a means for describing existing resources and, with that, a standard against which the capabilities of current Canadian technology transfer activities can be directly measured.

In a few cases, the capability which was identified, instead of relating to specific technology transfer functions, related to either a) the five overall characteristics required for a technology transfer program or b) the structural requirements for successful technology transfer.

2.1 Canada's Technology Transfer Capabilities

The survey conducted for this assessment identified the groups in the following sections as having the technology transfer capabilites (in some cases, partial capabilities) indicated.

Exhibit 3

Technology Transfer Functions Classified by the Tasks Required for Performance of the Functions

Summary Description of Tasks Required	Function Number in Exhibit 1	Technology Transfer Function
	1	Problem identification and analysis
Market identification	2	Initial demand survey
	7	Market acceptance
	9	User commitment
	14	Test market demonstration
Apply scientific/technical skills	3	Technical alternatives discovery
	8	Technical feasibility
Product survey	4	Product survey
Search	5	Systematic technology search
Criteria test	6	Basic criteria test
Funding	10	Project funding
Engineering	11	Applications engineering
	12	Testing
Licensing	13	Patent and license arrangements
Management consulting	15	Full business study
	16	Assist manufacturing/marketing

2.1.1 In Government

2.1.1.1 The Department of Industry, Trade and Commerce (IT&C)

The efforts of the Office of Science and Technology strengthen the key linkage between science and industry. Of particular importance are 1) that Office's advocacy of technology transfer and 2) the technical skills of its Science Advisors.

Through a variety of activities the Line Branch Officers create and maintain an essential link between government and industry. Also, through their involvement with industry the Line Branch Officers can help identify problems and the market opportunities they represent. This is the basic ingredient in a demand orientation.

The Office of Design, in conjunction with the National Design council, has successfully increased the use of industrial design in Canadian industry. Such a program can be one of the first steps in the development of applications engineering capabilities.

The incentive programs available in IT&C, notably the Program for the Advancement of Industrial Technology (PAIT) and the Industrial Research and Development Incentives Act (IRDIA), can help provide funding for technology transfer.

The "New Products Bulletin" of the Industrial and Trade Enquiries Division provides a product survey; it can also assist in a search for technology.

The Construction Information Program of the Construction Division, through the Building Equipment, Accessories and Materials (BEAM) Program, will provide a comprehensive survey of products for the construction industry.

The Market Development Group which is involved in developing exports may provide assistance with (foreign) market identification.

The Counselling Assistance to Small Enterprises (CASE) Program is actively providing the kind of consultation on business problems which is required near the completion of the technology transfer process.

2.1.1.2 The National Research Council (NRC)

The National Research Council's Technical Information Service, in association with the National Science Library, provides three different services in support of the transfer of technology:

The Technical Enquiries Section provides consultation and, particularly, in-depth literature searches which are essential for a thorough search of available technologies; it also represents some of the necessary technical capabilites. The Technological Developments Section makes a product survey; this survey can also assist with searches for technology. The Industrial Engineering Section is staffed to help provide the scarce personnel resources required for both engineering and consulting.

The National Science Library's central resource, its store of scientific and technical information, is a basic source of supply in a search for technology.

The incentive programs available at NRC, notably the Industrial Research Assistance Program (IRAP), are also available to supply funding.

Canadian Patents and Developments Limited has substantial experience in arranging licenses for patents in the private sector as well as know-how developed in the public sector.

The government's several research laboratories -- and this includes the activities of the Provincial Research Councils -- provide a range of engineering facilities and technical skills that are basic requirements in a program to transfer technology. These laboratories are also sources of supply in the search for technology.

NRC has three programs to encourage the movement of university scientists into industry. These are the Deferred Scholarships, Industrial Postdoctoral Fellowships, and Senior Industrial Fellowships.

2.1.1.3 Other Government Activities

The Ministry of State for Science and Technology is responsible for developing science policy.

The Department of Consumer and Corporate Affairs, through its Patent Office, actively makes Canadian patents available for searches. It also recommends government patent policies.

In the Department of External Affairs, the Science Counsellors abroad are one element necessary for a search capability.

The Department of Regional Economic Expansion is funding regional development programs. The Defence Research Board provides funding through its program for defence-related problems. Programs for industrial development conducted by the Provinces are also funding a variety of projects.

Finally, the scientific and technical publications and the research laboratories of other government departments represent potential sources of supply in a search for technology.

2.1.2 In Universities and Community Colleges

IT&C has sponsored the establishment of Industrial Research Institutes and Centers for Advanced Technology within universities. Through these, scientific capabilities of the universities and community colleges, both personnel and laboratories, are made more readily available to industry. These, of course, include both technical skills and engineering facilities.

Business schools with programs for the study and training of entrepreneurs are developing the managerial skills necessary to build companies which can bring new products to the market.

2.1.3 In Finance

A recent survey found 317 Canadian sources of equity capital for ventures.[7] In addition, the Canada Development Corporation is prepared to provide equity for larger ventures as well as to invest in and develop the Canadian venture capital industry.

The chartered banks are the first source for debt funds to support manufacturing operations. The Industrial Development Bank has available debt funds for sound ventures which do not fit standards set in the commercial banking system.

2.1.4 In Industry

Several selected, smaller Canadian manufacturing firms were interviewed during the course of the work performed under this contract. Among these, there were firms with a strong capacity to absorb technology. One firm quickly and easily identified problem areas as well as the technical aspects of those problems in specific detail; that firm encouraged the introduction of a technology transfer mechanism to assist in finding and implementing technical solutions for the identified problems. Another, larger firm is already engaged in licensing external tecnnology to meet identified needs.

The industry research association idea -- of which the Pulp and Paper Research Institute of Canada is an example -- is being pursued. This could provide both technical skills and engineering facilities as well as be a potential source of supply in a technological search.

Commercial consulting and engineering services represent, of course, both engineering and consulting capabilities. They are also a source for new designs for processing plants.

Technical societies are a source of technical skills. They may also be a resource for technological searches.

The Industry-based Design Council works alongside government efforts to increase the use of industrial design.

2.2 Assessment of Capabilities

To assess the adequacies and inadequacies of these identified capabilities, they were compared with the capabilities required for technology transfer, as that was described in Part I of this report.

2.2.1 Adequate Capabilities

Canada's basic strength in regard to technology transfer is the existence already of many of the elements required. These are concentrated in IT&C and NRC, with the key market-related elements being in IT&C.

The technical skills required for technology transfer are abundant in Canada. In general, Canada is strong in science and technology. There is also a wealth of information available on the role science and technology play in the country.

Related to this, there is a strong base for the engineering and testing capabilities that may be required once a technology supply is in hand. This includes both facilities and their personnel.

The capacity to fund innovative ventures, both debt and equity capital, also seems to be in place. There is some debate about whether the existing venture capital industry supports riskier start-ups sufficiently. There is evidence, for instance, that the size of investments actually made by venture capitalists is larger than that which would be expected if a preponderance of start-ups were being funded.[8] Also, the degree of control sought in these investments may not be conducive to such ventures. These questions, however, are related to parallel questions about the level of entrepreneurial activity. The potential for both entrepreneurial activity and venture capital investments will be more nearly realizeable when facilitated by a program which increases the likelihood of success by means of a demand orientation.

There are smaller, Canadian manufacturing firms with a capacity to absorb technology. These would be the users of a technology transfer program. These users are, of course, a basically necessary component of any program. As such, they represent the counterpart to Canada's strong scientific capability.

Finally, the need for further development of science and, particularly, industrial sector policy is well recognized.

In addition to the above, several existing capabilities are partially adequate to transfer technology. A complete technology transfer program would supplement these capabilities. These include information services which conduct systematic searches of existing technologies (particularly, Canadian technology) and make product surveys. They also include experience in arranging licenses. Finally, the consulting services available to new and start-up companies are in this category.

2.2.2 Inadequacies of Current Capabilities

Overall, the most important element required for technology transfer, but missing in Canada, is the centralized coordination necessary to direct a long and diverse process which pulls science together with industry. Nor has a market-orientation -- which is the basic essential and which must underlie the process -- been articulated. Another element which must be included is an emphasis on personal involvement throughout the process, in contrast with an information-oriented approach. The centralized coordination will also be necessary to strengthen an advocacy of technology transfer which has already begun, an active as distinct from a more neutral approach.

Such a coordinated effort must develop the capacity to search foreign technologies thoroughly. It must also develop criteria for the selection of those projects which will actually be carried through to completion. These criteria will depend upon the further formulation of industrial sector policy.

Structurally, two links, especially that between science and industry as well as that between government and industry, must be widened and strengthened through an increase in the movement of people between the elements.

2.3 Special Questions

Finally, the following special questions have been identified and must be addressed by a technology transfer program.

- The "not invented here" syndrome: It may be socially more acceptable to invent than to copy in Canada, in contrast to the Japanese philosophy. Industrial decision makers, scientists and technologists have to be convinced that technology transfer is desirable and they must be rewarded for transferring it.

- There is a lack of specific objectives for technology transfer -- a vague feeling exists that Canadian-owned firms are at a disadvantage compared to Canadian subsidiaries of foreign owned firms in acquiring technology.

- There is a lack of common objectives between government and industry for transferring technology.

- There is a lack of a strong commitment on the part of individuals involved (government, industry, individuals) to transferring technology.

The identification of these special questions completes the assessment of Canada's technology transfer capabilities. These capabilities represent a foundation which is the critical nucleus necessary for future Canadian technology transfer. Part III of this report suggests a temporary, experimental program which might build on this nucleus.

Part III

TECHNOLOGY TRANSFER IN CANADA:

AS IT COULD BE

Annual Cost	3, 250, 000	60 prof	31 support
Income	1, 490, 000		
Exp.	1, 760, 000		
	3, 250 000		
Studies	150, 000.		

3.0 Technology Transfer in Canada: As It Could Be

The above analysis of technology transfer as it exists in Canada today provides the information necessary for designing an experiment to test technolcgy transfer as it might exist in future years. That analysis described the resources -- in terms of the capabilities required for technology transfer -- which are currently in place and around which it might be possible to build an integrated and more effective tecnnology transfer mechanism. The analysis also identified other technology transfer capabilities which have not yet been provided and which might be added for more effective transfer.

3.1 Temporary Program Recommended for Experimental Test

The first part of this report described a fully-integrated technology transfer process which has proven effective in diverse settings. To test the longer-term efficacy for Canada of implementing such a technology transfer process which is both functionally and structurally more complete than existing efforts, in pursuit of the overall objectives identified for Canadian technology transfer in Part I (see Section 1.2, page 7), we suggest the temporary creation of an experimental program based in existing Canadian capabilities.

3.1.1 Experimental Design

The design elements of the experiment are 1) the sixteen technology transfer functions to be performed and 2) the industries within which these functions might be performed. Upon completion of the program, experimental results are expected to support conclusions as to which of the sixteen functions are more important for those industries, among four sampled, into which there is the most effective transfer of technology. Results should also indicate the relative magnitude of impact which might be expected from any technology transfer program implemented on a wider scale. Based on both short- and longer-term evaluative measures developed in Section 3.2.3 below, experimental data would be analysed to determine a rating for the effectiveness of the overall technology transfer experiment, as well as that of each function, as it operated in a sample industry. To allow sufficient time for impact to be created and measured, the experiment would be programmed for a duration of five years.

Based on the data gathered in the present study, our preliminary hypothesis as to the relationship between functions and industries is characterized in Table 1 in Appendix A, page 70. (Functions are represented in Table 1 by groupings according to areas of activity that are described below. See Table 2A, Appendix A, page 71, for that grouping.) Whereas each row suggests which functions may be more important to achieve immediate impact in an industry, the comparative importance of the columns suggests which functions may have more general relevance across industry lines and thus be of longer-range importance for the wider economy. More complete information from the Line Branches as the experiment progresses, as well as further profiles of individual firms, would serve to test this hypothesis.

3.1.2 Recommended Program

3.1.2.1 The Technology Transfer Unit (TTU)

To conduct this experiment, we suggest the temporary creation of a Technology Transfer Unit (TTU). This unit's activities would be a joint effort between both government and industry. As the earlier discussion of the structural requirements for technology transfer indicates, the link between government and industry is one of the two particularly vital links required for the successful transfer of technology. This temporary, experimental Technology Transfer Unit should itself be organized, for the program to succeed, as the central bridging link through which both the public and private sector, in a combined effort, cooperate together to perform the tasks required.

The TTU, both by drawing upon existing capabilities and by creating additional functions, would be responsible to coordinate the performance of the sixteen experimental technology transfer functions. The existing capabilities which would be employed include, among other resources, an even mix of the existing government and industry resources outlined in Part II of this report, in keeping with TTU's role as a link between the public and the private sectors. The TTU's activities are expected to be grouped into five areas.

3.1.2.2 Five Areas of Activity

TTU's areas of activity are based on groupings of the technology transfer functions to be performed. (Table 2A, page 71, fully illustrates these groupings.) Overall, TTU would be responsible for the performance and integration of all four phases of technology transfer.

Problem-Technology Matching and Screening: The largest area of TTU activity encompasses all the first three technology transfer phases: this activity, summarized, is that of matching a problem to technology and then screening that match. Thus, in this area of activity TTU would be responsible, in terms of the requirements of each phase, for the identification of markets, for gathering up the technology necessary to meet the demand represented by these markets and for appropriately screening these possible transfers of technology.

This first area of activity would have the major responsibility of coordinating those phases whose functions are peculiar to technology transfer. The next three areas of activity would involve groups of functions within the implementation phase.

Applications Engineering; Testing: This area of activity includes two functions. One is applications engineering; the other is testing for reliability, safety, and maintenance requirements and testing against or creation of standards. This would require the necessary laboratory facilities and, in terms of the resources that are used, this activity would be comparable with the matching and screening activity.

Starting-up Manufacture: This area is actually composed of two matching areas:

Acting as the Entrepreneur's Advocate: A large portion of the technology transfer process in the implementation phase centers on an entrepreneur's efforts to get started-up and into manufacturing with the new product. In this area of activity the TTU would act as the Canadian entrepreneur's advocate and back him up with professional services in key areas to help insure an actual, successful start-up. The specific functions included in this area of activity would be as follows: help acquire funding (including an active role in negotiations), assist with patent and licensing arrangements, demonstrate the new product in test markets, prepare the full business study, and consult on any problems in manufacturing or marketing.

Funding: The demand side of the funding function would be provided in the area just above; the funding area of activity provides the supply side. Technical innovations, even those transferred in, have an inherent degree of risk. The TTU in this area of activity would represent the government as it stands ready to take risks that a private entrepreneur might not otherwise take. Specifically, the function of this activity would be to package the financing -- including both debt and equity -- required for a complete technology transfer project.

Exchanging Technical Personnel: This activity is not specific to any phase or function. Rather, because of the critical importance of one structural requirement for technology transfer -- a strong, operating linkage between science/technology and industry -- a complete activity area is suggested to strengthen this link. In a sense, the demand orientation of the overall technology transfer process is directed toward bringing industry together with science. This suggested activity area would focus on one particularly important and effective method for building this linkage stronger: the exchange of personnel between science and industry. This area would actively serve as a clearinghouse and facilitator to place scientific and technical personnel needed in industry and vice versa.

3.1.3 Sources of Capabilities for the Technology Transfer Functions: Use of Existing Canadian Resources

As explained earlier, the experimental program would be founded on existing Canadian capabilities. Thus, where available, the technology transfer functions required in the experiment would be provided from those existing capabilities. These capabilities would be a mix (as noted above) from both public and private sector resources, reflecting that the TTU is to be a combined government-industry effort.

When a function required in an area of activity is already being performed by an existing institution, TTU would play only a coordinating role to insure the integration of one function with another. Further, in this case, TTU would coordinate with the existing institution only those of the institution's activities that related directly to a specific technology transfer project.

As an example, the Industrial Development Bank (IDB) (or the Technical Information Service or Canadian Patents and Developments Limited -- these are only a few of the other examples of the several existing capabilities) is currently performing functions which are necessary for effective technology transfer. TTU would coordinate those activities with IDB but no IDB activity, except those directly related to technology transfer, would be involved.

Functions which are not currently available would be created by TTU in each of the areas of activity as required. (These newly created functions would, of course, also require coordination into the overall process by TTU.)

3.1.4 Temporary Charter: Shift to Private Self-Support

There are several examples in Canada of partnerships between government and industry which rely on government initiative to begin a program but which are slated to draw, over time, the greater proportion of their support from the private sector. The Canada Development Corporation is a current case in point. We suggest that the technology transfer experiment described here be undertaken in that general tradition.

This is the approach embodied in the program design described above and further detailed in succeeding pages. The TTU should represent a real partnership between government and industry in reinforcement of the structural link between the two.

Government action and funding would be important to initiate the test of technology transfer addressed by this experimental design. However, the initiation process itself would include industry as a partner. As indicated above, existing private sector capabilities would be integral to the overall combined effort. Also, private financial support is a necessary part of the total projected program revenues (the retainer fees expected to be paid by companies for scientific/technical services, as described in Section 3.2.1.4, are an example).

Beyond the duration of the experiment itself, any further, more permanent technology transfer program would depend principally on the initiative and level of private support which could be mustered. Indeed, transfer of responsibility from public to private hands could be taken as a major indicator of the value of the technology transfer program to industry. The extent to which the private sector responds to the experimentally introduced technology transfer program (or parts of that program) by its assumption of the initiative to underwrite their costs would be a market test of the technology transfer program itself. The amounts expected to be required for funding support are detailed in Section 3.2.2.

3.1.5 Recommended Studies

In addition to an experimental test of a more complete technology transfer mechanism, we suggest that two studies be undertaken. These studies would concern the formulation of policy related to technology transfer. The studies are described later.

3.2 Description of Experimental Program by Area of Activity, Illustrated with a Case History

To describe the experimental technology transfer program suggested above requires specifying:

A) The sources for the capabilities required to perform each of the technology transfer functions. As described in Section 3.1.3 above, existing Canadian technology transfer capabilities would perform those functions for which capabilities currently exist. TTU would be the source for the other functions.

B) The orgranization. This includes staffing requirements. It also includes the interfaces to be established between the experimental program and existing institutions; these interfaces would be intended to strengthen the structural links required for technology transfer.

C) Expected benefits. This is the longer-term impact which the program is expected to generate.

D) Expected program costs.

E) Expected program revenues.

F) Measures for the evaluation of experimental results. These include longer-term measures of impact, as well as shorter-term measures of output.

A set of specifications has been developed for each area of activity of the recommended experimental program. The specifications are described below by area of activity and have been summarized in Tables 2A, page 71, and 2B, page 72, in Appendix A. At appropriate breaks in this description, a case history is developed to illustrate how the experimental technology transfer program might operate.

3.2.1 Sources of Capabilities for Technology Transfer Functions (A), Organization (B), and Expected Benefits (C)

Three specifications -- resources for functions, organization, and expected benefits -- are described first. These specifications are described for each area of activity in turn. These specifications are summarized in Table 2A.

3.2.1.1 Introduction to the Case Study

The case study developed alongside the program specifications described below traces through step-by-step the sometimes overlapping or parallel events which might be expected to typify the experimental program's conduct of one complete technology transfer project. The basic facts for this case study are taken intact from one of the technology transfer projects in the United States with which Abt has firsthand experience. To serve descriptive purposes in this report, those facts have been framed in the Canadian situation so that they can illustrate how the TTU might be expected to oversee the numerous functions required as it undertakes the transfer of technology into Canadian industry. Thus the case study below, while based on an actual situation, is a forward projection of how the recommended experimental program might be expected to operate.

3.2.1.2 The First Area of Activity: Problem-Technology Matching and Screening

The description of specifications for the suggested experimental program begins with the TTU's matching and screening area of activity and the specification of that activity's resources for functions, organization, and expected benefit. The matching and screening area of activity includes, overall, three of the four technology transfer phases. Because this represents a substantial portion of all activities of the experimental program, the specifications given here are divided into several sub-groups.

Resources for the performance of functions will be specified first; later organization and benefits will be described. In addition, the specification of resources for functions is divided into each of the three phases in the area. Finally, the resources specification for each phase is previewed by development of the case study through that phase.

It may be effective to parallel the reading of the following specifications with a review of the description of phases and functions in Part I of this report. The performance of the series of technology transfer functions discussed in Part I is the structure underlying the operation of the experimental program and, particularly, this first area of activity.

3.2.1.2.1 Resources for the Performance of Functions (A), Previewed by the Case Study

3.2.1.2.1.1 Demand Phase

It is in the demand phase that TTU's matching and screening activity would give full force to the demand orientation fundamental to the technology transfer process. This phase includes two functions: problem identification and analysis, as well as, the initial demand survey.

Case Study: The case study is set in the construction industry. (See Section 3.4 for the industries recommended for the experiment.) TTU as the advocate for technology transfer would initiate the process. To do this, TTU, with the cooperation and assistance of the government agencies concerned, would bring together perhaps four leading Canadian developers of commercial and residential construction. These should be medium-sized, aggressive firms.

These firms would have decided to participate in the technology transfer program through the efforts of TTU. In the past, they probably each would have separately sought improved products from their suppliers. TTU would have made a presentation and conducted discussions with the senior managements in each firm separately. Based on these discussions with TTU, the management groups would have agreed that they all, as members of the construction industry, share in common a need for several improvements in supplier items. They would have concluded that they would each benefit if, working together through the technology transfer program, they could induce supplier firms to provide improved products.

Now with the senior management of each firm committed to the program, the first step would be to identify specific problems with supplier items -- in particular, problems that have a substantial technological component. Such a problem represents a potential market for the missing technology. The managements should recognize that this "demand" (as contrasted with "supply") orientation is critical. If the demand, or market, for a technology is identified before the supply of that technology itself is sought, the search for and development of that technology has the potential for being more efficient.

To identify these problems, the TTU staff, with the assistance of other government offices concerned, would use a combination of individual discussion and seminar techniques. In the seminars, participants would be made more aware of the possibility for changing, through technology, problems that have, so far, been tolerated. This would be done through a display of current, state-of-the-art developments in the relevant industry. This starts the participant thinking in terms of problems -- his own problems -- that he might envision being ameliorated through the employment of technology.

First, senior management would be queried for its statement of problems. This typically results in an overview, with problems stated in broad categories. With this as a guide, the problem definition would have to be brought down to a concrete, detailed level of specificity, particularly regarding the technical component of the problem. This is essential to the success of a later step: ascertaining an applicable technology to solve the problem. To achieve specificity, the discussion would be widened so as to involve personnel from both the operating and technical levels within each of the companies.

The first general statement of the problem might be that of a "need to improve the efficiency of the housing production process through the reduction of construction costs." In the U.S. every $100 increase in the price of a house prohibits 15,000 more families from obtaining a mortgage, thus eliminating that many more prospective customers. As a result, holding or minimizing price levels through the reduction of costs is particularly important for a developer.

To focus the problem-identification process on specifics, several areas of the developers' operations with potential for cost reduction would be considered. One might be materials used in construction. This area would then be further divided. One sub-area that might stand out is the electrical system required for housing. Little advanced technology is used in these electrical systems, and installation is subject to high labor costs; thus it would appear susceptible to cost reduction. To further specify the problem, the electrical system might be divided into two components: one, the distribution system which carries current to outlets and, two, the switching system which turns current in individual sections of the distribution network on or off. The switching system might be selected as the better bet: compared with the distribution system, the range permissible for its operating characteristics (such as voltage) is not as limited. Thus, through a process of specification in successively greater detail, the following manageable problem might have been specified: to reduce the in-place cost of electrical switching systems in residential and commercial construction.

This problem identification step would begin the process of completing a formal "Problem Statement." (See Appendix B, page 73, for examples of problem statements taken from technology transfer projects in the construction industry.) During the problem identification step, the "Specifications and Constraints" section of the problem statement would be completed. In later steps, the remainder of the problem statement would be completed.

Thus TTU might have completed the first function in the demand phase and the one fundamental to the technology transfer process: problem identification and anlysis. The next step would be to make an initial survey of the overall demand -- that is, market demand for a solution to the problem, if that solution were to be found.

The four developers in the group with which TTU would be working should, themselves, represent an important portion of the Canadian construction market. Checking with each of these four, TTU might find universal demand for a lower-cost switching system, if the switch were available. Also, since virtually all residential and commercial construction requires wiring with switches, the market would appear to be substantial. Statistics, for instance, from 1972 for residences alone show that there were close to a quarter-million housing starts in that year.[9]

Thus TTU might have completed both functions of the demand phase. Overall, TTU would be expected to generate, from the demand phase, 160 problem statements annually. We suggest that the experimental technology transfer program deal with four industries. On the average, four companies per industry might be expected. If a company produces an average of 15 problem statements and two-thirds of these have industry-wide relevance, TTU would achieve its goal.

<u>Resources for the Performance of Functions (A)</u>: Except for the problem-identification capabilities of the Line Branch Officers, neither of the functions required in the demand phase are currently available from existing organizations. Both would be provided by the new organization in conjunction with the Line Branches.

3.2.1.2.1.2 Supply Phase

The central task in the supply phase is the systematic search of available foreign technologies, another key function for successful transfer. Two other functions are required in this phase: the discovery of technical alternatives and product survey. (Chronologically these precede the search.)

Case Study: Upon completion of the demand phase, TTU would have identified a problem calling for lower-cost switching systems in housing electrical systems; an initial survey would have indicated an apparently promising market. Now, with a ready market in hand, the next step should be to locate a supply of the technology necessary to solve this problem.

To begin, TTU would conduct a session to discover the technical alternatives that might solve the problem. Technologists from perhaps six disciplines would be gathered for a "brainstorming" session. These individuals would be located through efforts of the staff in the technical personnel exchange area of activity.

The problem would be described to the assembled group. They would be asked for suggestions as to possible solutions. Any criticism of the ideas produced would be discouraged so as to create an atmosphere conducive to innovation. Several possible solutions would probably be suggested. One might be to switch by remote control without a physical link into the electrical distribution network, perhaps using a radio signal as the actuating device. Another might be to maintain the physical linkup but use low-voltage line for the switch circuit; the voltage level in the distribution network could be reduced for the switch circuit by use of a relay. Several other possibilities might be suggested.

Armed with these alternate possible solutions, the TTU would survey products currently in use to see if one of the suggested alternatives is possibly already available locally. This would include use of the BEAM program's Construction Information System.

If no such products were discovered, TTU would conduct a systematic search of both domestic and foreign sources in an attempt to locate technologies that might be developed into one of the suggested alternatives. Both formal and informal methods would be used. Informally, contact would be made with the "technological gatekeepers" in those companies identified as potentials for the relevant technology. The Science Counsellors abroad would be notified of the needed technologies.

Formal methods of search would also be employed. This would include patent searches, particularly European patents. It would also include computerized searches by the Technical Enquiries Section of the Technical Information Service at the National Research Council. Many thousands of technological developments could swiftly and inexpensively be surveyed in automated searches.

To search computerized banks of technological developments, TTU might select, from thesauruses developed for such searches, key words descriptive of each of the possible alternatives. With these key words as input, the computer would probably yield about a thousand related titles at a cost of about $250. Of these, approximately a hundred would probably appear potentially relevant and an abstract would be obtained for each. These hundred abstracts would probably indicate that about ten articles might hold a sought-for development. These would be acquired and reading one out of the ten articles might uncover the fact that a special conductor cable to carry low-voltage had been developed. This experience with the computer search would reflect what could be expected for TTU in most such searches: each thousand titles produced by the computer search should yield roughly one potentially applicable technological development.

TTU would contact the developer of the cable who might be named in the article. He might point out the extreme thinness of the cable. If the cable were combined with an adhesive backing, it might be possible to install the cable on the outer surface of, not inside, interior housing walls: it would be painted over to become invisible. Thus installation labor could be saved, both at initial installation and during any required re-wiring. It might also appear that the cable itself would be significantly lower-cost than conventional material. In its current state of development the cable probably would not have been combined with a relay device to reduce voltage. Further engineering would be necessary to make the cable applicable, in fact, to the identified problem.

The technologist who developed the cable might have become interested in the project and, through TTU's efforts, decide to join in the development of the complete low-cost switch package. At this point an initial agreement should be reached on the outlines of a licensing arrangement. It might provide for the technologist to participate partly through license fees and partly through equity.

Thus, in this example of the transfer of technology, a person (the technologist) would be transferred from an external science and technology establishment into Canadian industry. This would be in parallel with the more formal transfer of written information contained in articles and patents. This would be a key factor in the program since it is the embodiment of technology in individuals which provides much of the motive force for the technology transfer process. Also, much of the information required for the successful use of the technology would probably not be written down but be part of the individual technologist's know-how.

This emphasis on personal involvement would be maintained throughout the experimental technology transfer program. It would begin with the personal contact with company managements necessary for a successful initiation of the problem identification step. It would include the transfer of people, as well as ideas, in the search step just described. It would continue in later steps in gaining provisional commitment from intended users of the technology and in entrepreneurially pursuing the development of the project through to actual sales in the marketplace.

The systematic search for a technology to fill an identified market would thus be completed: a match would have been made between a supply of technology and the demand for that technology. Overall, TTU's searches would be expected to yield matches one-half of the time. As a result, the supply phase of the technology transfer process would be expected to yield 80 matched problem-statement/technology-supplies annually.

Resources for the Performance of Functions (A): (The resources outlined here and in later specifications were described earlier in Part II of this report.) Existing Canadian scientific/technical skills could be called upon to provide the discovery of technical alternatives function; these include:

-- Department of Industry, Trade and Commerce

- o the Science Advisors in the Office of Science and Technology

-- National Research Council

- the Technical Enquiries Section of the Technical Information Service

- the several research laboratories (plus the activities of the Provincial Research Councils)

-- Universities and community colleges

- Industrial Research Institutes and Centers for Advanced Technology, sponsored by IT&C; these help make available:

- both the laboratory facilities and technical personnel of these institutions

-- Industry

- industry research associations, where they exist

- technical societies.

For the remaining two functions in the supply phase -- product survey and systematic technology search -- current Canadian capabilities would only partially provide the necessary resources. These functions would be performed by a combination of existing and new capabilities.

For product surveys, the current Canadian resources include:

-- Department of Industry, Trade and Commerce

- the "New Products Bulletin" of the Industrial and Trade Enquiries Division

- the Construction Information Program of the Construction Division

-- National Research Council

- the Technological Developments Section of the Technical Information Service.

To conduct the technology search, the existing resources include:

-- Department of Industry, Trade and Commerce

- the "New Products Bulletin"

-- National Research Council

- both the Technical Enquiries Section and the Technological Developments Section

-- Department of External Affairs

- the Science Counsellors abroad

-- Industry

- technical societies.

As sources of supply to the searches, there are:

-- National Research Council

- the National Science Library
- its research laboratories

-- Department of Consumer and Corporate Affairs

- the Patent Office

-- Other government Departments

- scientific and technical publications
- research laboratories

-- Industry

- industry research associations
- commercial consulting and engineering services.

3.2.1.2.1.3 Screening Phase

The first function in the screening phase typifies the purpose of the phase: it requires developing criteria for the selection of those technology transfer projects which will be carried into implementation. The other three functions in this phase are: market acceptance, technical feasibility, and user commitment. The steps in this phase, like those of other phases, are not necessarily simply sequential; they will overlap and sometimes parallel each other.

Case Study: In the case study to this point, a technology transfer project would have been developed by matching a need for low-cost switching with a technology that might meet that need. Now TTU would screen this project to determine whether it would be carried into the implementation phase. Of course, all technology transfer functions involve a continuing process of selective screening; this phase simply emphasizes it at the "watershed" stage following the making of a demand/supply match.

The project would probably meet the test of basic criteria successfully. Commercializing this technology would appear to offer the prospect for immediate impact in Canadian industry: there would be a prospect for significant sales, profits and employment. Longer run, the project should help spur design and engineering capabilities in Canadian industry and help develop the institutional linkages between science/technology and industry.

To establish expected levels of market acceptance, TTU would conduct a market study more thorough than that of the initial demand survey in the demand phase. The total market size, in terms of both units and dollars, would probably be large as expected. It might appear that a manufacturer of the switch package should be profitable at a share-of-market substantially below the market share that seems possible.

TTU would also check the technical feasibility of the project in detail. This might confirm that the thin cable with adhesive backing could be directly applied to the exterior of internal walls. The new switch system would also be costed at this point. This initial costing should confirm the necessary cost advantage over conventional materials and labor.

To complete the test of market acceptance and the screening phase, TTU would seek a firm purchase commitment, provisional only on cost and actual availability, from each of the four original construction industry members. This might be a commitment to buy a minimum number of switch packages. This "acid test" is an important step for insuring that there is indeed a market for the technology transferred. By underscoring the demand orientation of the entire technology transfer process, this test would substantially increase the likelihood for success of the project.

Overall, of the 80 problem-technology matches that enter the screening phase, about one-half or 40 would be expected to be selected for implementation annually.

Resources for the Performance of Functions (A): Except for the technical feasibility function, these functions will be created and provided by TTU itself. The numerous scientific /technical capabilities listed on page 45 might be applied to the technical feasibility function.

Also, though TTU would itself develop and apply basic criteria in the problem selection process, close contact would be maintained with (a) the Ministry of State for Science and Technology as it develops science policy and (b) the Office of the Industrial Policy Advisor in IT&C as industrial policy is developed.

This completes the specification of TTU's resources for performance of the technology transfer functions included in the matching and screening activity. The description of that activity's specifications now turns to organization and expected benefits. (The case study will be concluded following description of these and further specifications.)

3.2.1.2.2 Organization (B) and Expected Benefits (C)

In order to oversee and perform all its functions, the matching and screening organziation would require a staff of approximately 20 professionals. This (and following) staffing figures do not include support personnel for the professional staff. Support personnel required would total about half the number of professional staff. Staffing figures do include man-years which would be drawn from those existing organizations currently providing technology transfer functions.

As indicated in Table 2A, page 71, the TTU, for purposes of the matching and screening activity, should link governmental, scientific-technical, and enterprise-related structural elements, if it is to perform its overall technology transfer task. Thus the matching and screening activity should interface with:

-- Department of Industry, Trade and Commerce

  o the point of contact to be the Office of Science and Technology

-- National Research Council

  o at the Technical Information Service

-- Ministry of State for Science and Technology

  o at the level of policy formulation

-- University and community college-based research

  o at the Industrial Research Institutes

-- Industry associations

  o at industry research associations, if they exist.

The longer-term impact expected from the matching and screening area of activity is an increase in sales, profits and employment for participating firms.

3.2.1.3 The Remaining Four Areas of Activity

The matching and screening area of activity has been specified as to sources of capabilities for performance of functions, organization, and expected benefits. These items are now specified for the three areas of activity which would be responsible for the implementation phase as well as for the final activity area responsible for promoting the science-industry linkage. (These specifications are summarized in Table 2A, page 71, also.) Following these specifications, the case study will be concluded with the development of events that might typify the implementation phase.

3.2.1.3.1 Applications Engineering; Testing

Existing resources appear to be adequate to provide these functions, if these resources are coordinated by the engineering and testing area of activity. These resources include:

-- Department of Industry, Trade and Commerce

- the Office of Design, in conjunction with the National Design Council

-- National Research Council

- the Industrial Engineering Section in the Technical Information Service
- its research laboratories

-- Universities and community colleges

- Industrial Research Institutes, including personnel and facilities

-- Industry

- industry research associations
- commercial consulting and engineering services
- Design Council.

It is expected that three installations would be required to serve several industries and geographical areas. Staffing the three installations would require a total of about 30 professionals. This activity area should link industry with science. With the exception of MOSST, the institutions interfaced with this area would be as for matching and screening.

The activity in this area should benefit smaller firms by increasing their technological capability. It should also aggregate larger markets through the development and widened use of industrial standards.

3.2.1.3.2 Starting-Up Manufacture

3.2.1.3.2.1 Acting as the Entrepreneur's Advocate

As described in Section 3.1.2.2 above, there are five functions to be performed in this area of activity. The function of assisting with funding, as well as that of conducting test market demonstrations, would be provided from within the new organization for the area. Existing capabilities could partially fulfill the remaining three functions so that these functions would be provided by a combination of existing and new resources. Resources for patent and licensing arrangements include:

-- National Research Council

- o Canadian Patents and Developments Limited

-- Department of Consumer and Corporate Affairs

- o the Patent Office.

Several capabilities exist which could partially fulfill both the business study and assistance with manufacturing/ marketing functions:

-- Department of Industry, Trade and Commerce

- o the Counselling Assistance to Small Enterprises (CASE) Program

-- National Research Council

- o both the Technical Enquiries Section and the Industrial Engineering Section of the Technical Information Service

-- Industry

- commercial consulting services.

This activity area would be staffed with five professionals. Its interfaces would be within a single structural element, the enterprise element. They would be intended to link up human managerial resources with realizable business opportunities. For purposes of this area, TTU would interface with universities and community colleges (at the business school and, in particular, any programs for the study of small business). It would also interface with industry associations.

The benefits to be expected from this activity are an increase in the generation, growth, and profitability of new firms.

3.2.1.3.2.2 Funding

The basic resources necessary for this function are already in place in Canada. The funding area of activity would serve as a means to coordinate and orient those resources to the specific requirements of the technology transfer process.

Several government incentive programs might provide funds:

-- Department of Industry, Trade and Commerce

- notably, the Program for the Advancement of Industrial Technology (PAIT) and the Industrial Research and Development Incentives Act (IRDIA)

-- Department of Regional Economic Expansion

- notably, regional development programs

-- National Research Council

- notably, the Industrial Research Assistance Program (IRAP)

-- Defence Research Board

-- the Provinces

  o industrial development programs.

Other resources for debt and/or equity funds include:

-- the chartered banks

-- the Industrial Development Bank

-- the private venture capital industry

-- Canada Development Corporation.

This area's staff would include three professionals. The purpose of the funding activity's interface would be to link better the finance and enterprise structural elements. This activity would interface with:

-- Private financial community

  o at Canada Development Corporation

-- both the Department of Industry, Trade and Commerce and the National Research Council

  o at their incentive programs

-- Industry associations.

The longer-term impact of this activity should be to increase the initiation of small technological companies.

3.2.1.3.3 Exchanging Technical Personnel

Though the staff of two professionals projected for this activity area would create much of the service from afresh, three National Research Council programs would assist: Deferred Scholarships, Industrial Postdoctoral Fellowships, and Senior Industrial Fellowships.

The personnel exchange activity would encourage greater movement between science and industry. It would interface with:

-- National Research Council

- at the incentive programs just above

-- Universities and community colleges

- at the Industrial Research Institutes

-- Industry associations.

Over the longer term, this activity should make univerity and government research activities more aware of industrial needs.

3.2.1.4 Concluding Chapter of the Case Study

If the project to develop a low-cost switch package had successfully passed screening, TTU's efforts would turn to the final phase, implementation. The steps in this phase are relatively more familiar than earlier steps so that they require less explanation. Also, the steps during implementation would be overlapping and would not necessarily follow a particular sequence.

Performance of the functions required for the implementation phase requires relatively more effort from the private rather than public sector. This is reflected by the increased reliance on existing private sector capabilities in the specifications of resources for TTU's three activity areas which are responsible for implementation. Thus in the following conclusion of the case study, industry, as the private sector partner in the combined government-industry TTU effort, would bear the larger part of the responsibility for performing the individual functions required for implementation. As explained earlier, balancing the program so that government and industry together provide an even mix of the necessary functional efforts is important to the structural design of the experiment.

To begin implementation, the low voltage technology that had been located would have to undergo further development. An adhesive backing would have to be mated with the new thin cable; a relay would have to be added to the system. This would be an opportunity to start Canadian firms thinking in terms of engineering and design in addition to their traditional focus on manufacture.

This applications engineering would of course require funding. (Later, starting-up manufacture would also have to be funded.) The four construction industry firms probably would share in supporting the applications engineering through retainer payments of $15,000 annually to the engineering and testing activity. The government, through its funding of the remainder of that activity's budget, would absorb the engineering and development risks that no individual company is prepared to shoulder.

Once the applications engineering for the new switch package were completed, it would be tested for reliability, safety, and maintenance requirements, if any. TTU might also develop standards for the performance of mass-produced switch packages. If these standards were widely adopted, the effect would be to aggregate the market for the new switch, thus enhancing the attractiveness of the switch to prospective manufacturers. In the construction industry this is a serious problem since local building codes tend to vary widely. However, because this switch system's voltage would be below the range covered by most codes, its introduction might allow for the propagation of standards that have the potential for being very widely adopted.

The new "switch pack" (so named, by this time) would now be complete, including all engineering drawings and specifications. TTU, maintaining the demand orientation, would demonstrate the new product in test markets. This would give the new switch early exposure to its intended customers and provide an opportunity to confirm demand for the switch when it is presented physically and in its commercial form.

To complete this technology transfer project would require that the new switch-pack now actually be produced and sold. Either an existing manufacturer would have to be found who was interested in expanding his product line, probably a current supplier to the construction industry; or a new company would have to be started up. In this case, since the cable technology itself would be new, a new company would probably be started.

An entrepreneur with the appropriate managerial and technical background would be located and the licensing agreement finalized. This licensing agreement probably would not contain serious restrictions on export marketing because the technology, as transferred in, had not been developed for the electrical switch market at that point.

To fund the start-up, TTU would help the entrepreneur develop proposed terms for a financing. This would call for beginning a complete business study to cover all the major aspects of the new operation: marketing, organization, manufacture, and finance. Out of this study would come key information such as the expected total funds required. The study would also put a sound footing under planning for the company's first couple of years. With proposed terms of the financing in hand, TTU would then assist the entrepreneur with his negotiations for these funds.

The funding area of activity would act as packager of the financing to ensure that sufficient funding were made available to the project. This financing would probably include a combination of government funds and private venture capital funds. Including government funds would have the effect, once again, of allowing the society at large to absorb some of the risk of the new venture.

Finally, to complete this technology transfer project, TTU would provide consulting services to the entrepreneur and his new operation, once the company were underway. This consultation effort would probably focus on the requirements of introducing customers to the value and use of a substantially changed product. One important service TTU might provide here would be helping to create a program for briefing tradesmen on the installation and re-installation of the new wiring.

(In the actual case in the U.S., once the low-voltage wiring technology was matched to the need, product development took less than a year. Exclusive of the prototype development costs, the project cost about $100,000; in 1972, the project yielded a benefit close to ten times that amount.)

3.2.2 Expected Costs (D) and Revenues (E)

The specification of the recommended program's five areas of activity now turns to the remainder of the specifications, which include program finances and measurement. These are summarized in Table 2B, page 72. The specifications begin with expected costs and revenues.

3.2.2.1 Expected Program Costs (D)

The costs of each of the experimental program's areas of activity would be, principally, the costs of maintaining skilled technology specialists. One such specialist would be expected to require total funding, on average, of $50,000. This is a fully loaded cost: it includes computer costs, general and administrative costs (including support personnel for the professional staff), and overhead.

Table 2B indicates the expected costs of each area of activity. Note that the funding area of activity is a case separate from the others: based on prior experience with such personnel and their support costs, it is expected that the staff necessary for that activity would require a higher per-staff member level of funding. The investment funds, as distinct from operating costs, required for this activity are expected to be provided from a combination of government and private sources.

Total annual operating cost for all activities of the experimental program is expected to be $3,250,000. The major portions of this would be the matching and screening activity at $1,000,000 and the engineering and testing activity at $1,500,000 annually.

3.2.2.2 Expected Program Revenues (E)

Annual revenues, by activity area, for the five year period are projected in Table 2b. Each annual figure is projected as an amount which is expected to be the average for the five year period. During the early years of the five year period, actual results should be lower than average; toward the end of that five years the revenues are expected to increase.

Matching and screening revenues would come from a royalty taken on the sales of new product lines. The

$1,000,000 projected annual revenue is based on an expectation of $20,000,000 in such sales.

Each company participating in the program would be expected to retain engineering and design services for $15,000 annually. This would produce a total annual revenue of $240,000.

Assistance to entrepreneurs is expected to generate a small fee in the form of equity from the ventures which it would help start up. Dollar inflow, in this case, would depend upon the sale of a venture to new investors, at which time paper gain in equity held might be realized. However, ventures are not expected to mature to this stage during the five year period projected. Thus no revenue is shown. (If ventures matured and this revenue began to be generated, one sale per year would be expected to net $200,000.)

The funding activity's source of revenue would also include capital gain in equities taken in ventures, but based on a substantially larger investment than that represented by the stock held in the entrepreneur's assistance activity area. These revenues would also include interest paid on loans made to ventures. This activity's revenue is expected to average a total of $250,000 annually. This amount does not include cash flow from principal repayments.

Personnel exchange would have no source of revenue.

These projections indicate that $1,760,000 annually would be the average funding expected to be required to support the experimental program. In early years, the figure could be expected to be substantially higher. As discussed in Section 3.1.4, it would probably be necessary for all funding to be government-provided initially. In time, industry would be expected to begin funding the program, if it appeared to hold value for industry.

3.2.3 Measures for Evaluation of Experimental Results

Over the longer-term -- four years and beyond -- this experimental program would be evaluated for its broader impact. Shorter-term -- zero to three years -- intermediate measures of output would be used to evaluate the program's experimental results. (These measures are summarized in Table 28, page 72, also.)

The longer-term impact of screening and matching would be measured in terms of new jobs and profits generated in smaller and medium-size Canadian firms. Shorter-term output measures would include the number of problems identified, searches performed, and technology demand/supply matches made.

Impact measure for engineering and testing would be in terms of the number and growth of design and engineering units created in Canadian industry. Output measures would include numbers of retainer contracts, new standards promulgated, and new applications engineered.

The impact of assistance to entrepreneurs would be in terms of the number of its new firms that survive beyond three years. Output would be measured by the number of entrepreneurs funded, license arrangements completed, and business studies performed.

The funding activity's impact parallels the above. Its output would be measured in terms of the number of deals examined and number of companies started.

The impact of personnel exchange would be in terms of an increased flow of people and ideas between industry and research. Its output would be measured in terms of the number of personnel referrals solicited and completed.

This concludes the description of the recommended experimental program.

3.3 Description of Recommended Studies

Two studies are recommended. These studies would examine and recommend the formulation of policies to strengthen the structural framework within which technology transfer operates. Each study would focus on a different facet of that structure and the policies related to it.

One study is recommended to formulate how government purchases could be used to reinforce the recommended experimental technology transfer program through use of the government as market and the private sector as supplier. This study would also examine what barriers exist to retard this use of fiscal power.

A second study would consider the regulation of subsidiaries of foreign multi-national corporations. This study would examine how these regulatory policies should be shaped to strengthen the technology transfer program. It would include an examination of regulations concerning tariffs, foreign investment screening, and taxation.

Each study is expected to cost about $75,000 for a total of $150,000. This one-time cost is not included in the annual costs projected for the experimental program.

3.4 Industries Selected

Each of the Canadian industry sectors are the potential users -- the potential market -- for the experimental technology transfer program described above. The success of the program would depend in part on an accurate selection among these industries to determine which are the actual market: which industries would actually "buy" (or could be stimulated to buy) ex-house technology. To buy, in this sense, means to use effectively the technology transfer machinery that would be erected.

The industries selected determine specifically which companies would be involved in developing the TTU government-industry partnership. It is not possible at this time to describe the government-industry interface precisely, since that interface would depend upon a final selection of industries.

The criteria for whether an industry is a good prospect for technology transfer are twofold. First, industry members should display the capability to absorb transferred technology and generate an immediate impact in their industry in the form of successfully commercialized new products. This will depend on a willingness and ability to define problem areas in sufficient detail, to test the ubiquitousness and magnitude of these problems among other industry members, to work with the technology transfer program in developing technologies matched to the defined problem, to commit to use these new products, and to encourage and assist supplier firms in the manufacture of the new product. The second criteria concerns the industry's capacity to meet the longer-term objective for enhancement of a design and engineering capability indigenous to Canadian industry. This requires an interest in and willingness to work with technical innovations.

To apply these two major categories of criteria and thus select the candidate industries which would participate in the initiation of the Canadian technology transfer program, we used a two- step process. We first met with representatives of the nine Line Branches in the Department of Industry, Trade and Commerce. In these interviews, we queried whether that Line Branch's industry area should be considered, under the terms of the criteria established, as a candidate for final selection in the second step. This first step resulted in the selection of six industry areas to be examined in the second step.

These industry areas were:

-- Foods

- including both processing and commercial farming

-- Chemicals

- particularly pharmaceuticals

-- Electronics

-- Transport vehicles and machinery, together

- particularly, forest-harvesting equipment

-- Materials

- including both construction and the processing of minerals

-- Wood

- particularly furniture and paper conversion.

The second step in the selection process was a series of interviews with firms from the selected industry areas. To a large extent, identification of firms to be interviewed depended on the prior interviews in the Line Branches. The interviews with firms resulted in a selection of the four industry areas ranking highest in terms of the two major criteria. They are foods (including processing and commercial farming), electronics, materials (including construction and the processing of minerals), and wood (particularly furniture and paper conversion). Transport vehicles and machinery together (particularly forest-harvesting equipment) would also be recommended, except for the contingency that further information is required to make a determination in this case.

In the foods area, there are already several government-industry efforts afoot, including some particular successes, to increase the use of technology in Canadian firms. Firms in the electronics industry seem prepared to operate as an industry and one firm interviewed was interested in government assistance for the transfer of technology. Impact in the construction industry (in the materials area) could in turn have an important impact on GNP because of the size of the construction industry. Also, there is a major program already underway to make product information more accessible to that industry. Although not a sufficient condition for successful technology transfer, that capability is a necessary one. On the minerals side of materials, the further processing of Canada's natural resources is key to its economic growth. Also, there appear to be strong Canadian firms in this area interested in such development. In wood, there are aggressive, medium-sized firms in both paper conversion and furniture who are interested in the greater use of technology.

3.5 Special Questions

This recommended experimental program is expected to deal with the four special questions posed in Part II as follows:

With respect to the "not invented here" syndrome, this technology transfer program would place in its proper perspective the question of invention vs. the use of existing technology: the use of existing technology ("transferring technology in") would be treated as the first step in an extended process which is expected to lead first to an increase in design and engineering departments in Canadian industry, then ultimately, to industrial research and development units which are continuously involved in the act of invention. In fact, industrial personnel routinely read technical journals, attend seminars, and talk with business associates: all of this leads industry to the new use, albeit unplanned, of already existing technology -- i.e., to transfer technology. This existing but uncoordinated practice of technology transfer should provide the necessary foundation for instituting a more planned, coordinated program which in turn should lead ultimately to a greater flow of inventions.

Specific objectives for the technology transfer program have been established in Part I. These relate directly to building a strong, distinctly Canadian industrial infrastructure. Further, these objectives, along with the plans for the experimental program, are in terms of both the specifics that industry requires and the general impact desired by government. Conflicts in objective between government and industry should be minimized since the focus is on industry-wide problems.

The advocacy approach, in combination with the emphasis on personal involvement throughout, which are both key to the success of this program, are directed expressly at developing the strong commitment required on the part of all individuals involved. The advocate's role is directed at developing commitment to program activities at each step in the process -- including commitment from company managements in the beginning, from an involved technologist later, and, of course, continually increasing commitment from intended users of the new product.

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7. Peter McQuillan and Howard Taylor, "Sources of Venture Capital - A Canadian Guide", (Canada: The Department of Industry, Trade and Commerce), p. 127.

8. Ibid., p. 135. This study shows a median investment of $185,000.

9. _Secondary Manufacturing Industries_ (Ottawa, Canada: Market Analysis Branch, Office of Economics, Department of Industry Trade and Commerce, December 1972), p. 49.

APPENDICES

Appendix A: Tables

1 - Preliminary Hypothesis of Relationship Between Industry Areas and Technology Transfer Functions (Grouped According to Area of Activity of Recommended Experimental Program)

2 - Summary of Program Specifications by Area of Activity

A - Sources of Capabilities for Technology Transfer Functions (A), Organization (B), Expected Benefits (C)

B - Expected Costs (D) and Revenues (E), Measures for Evaluation of Experimental Results (F)

Appendix B: Sample Problem Statements

-- Durable Exterior Surfacing Materials

-- Fireproofing Materials

-- Detection of Lead-Based Paints

-- Accelerated Test Methods for Materials

Appendix A

TABLES

Table 1 Preliminary Hypothesis of Relationship Between Industry Areas and Technology Transfer Functions (Grouped According to Area of Activity of Recommended Experimental Program*)

Area of Activity / Industry	Problem-Technology Matching and Screening	Applications Engineering; Testing	Starting-up Manufacture		Exchanging Technical Personnel
			Acting as the Entrepreneur's Advocate	Funding	
V/STOL	X	X		X	X
forest harvesting equipment	X	X	X	X	X
communications equipment	X	X			X
mineral exploring equipment	X	X	X	X	X
heavy electrical equipment	X	X		X	X
milling machines	X			X	X
heavy chemicals	X	X		X	X
pharmaceuticals	X		X	X	X
plastics and rubber	X	X	X		X
steel metallurgy	X	X			X
wood	X	X	X		X
meat packers	X			X	X
fish-farming	X	X	X	X	X
hydro-ponics	X	X	X	X	X
dairy automation	X		X	X	X
protein concentrates	X	X			X

* The grouping of functions into activity areas is described in Section 3.1.2.2 beginning on page 33; this grouping is also illustrated in Table 2B, page 72.

Table 2A SUMMARY OF PROGRAM SPECIFICATIONS BY AREA OF ACTIVITY: Sources of Capabilities for Technology Transfer Functions (A), Organization (B), and Expected Benefit (C)

Area of Activity	Functional Responsibility: Phase	Functional Responsibility: Function Performed	Resources for Performance of Functions: Capability Required	Resources for Performance of Functions: Source of Capability*	See List on Page:	Organization: Staff Professional	Organization: Staff Support	Organization: Structural Element Linked	Organization: Institutions Interfaced; See Page:	Expected Benefit
MATCHING AND SCREENING	Demand	Problem identification and analysis	Market identification	TTU and Line Branch Officers	--	20	10	G S/T E	49	• Increase sales, profits, and employment for participating firms
		Initial demand survey								
	Supply	Technical alternatives discovery	Scientific/technical skills	E I	45					
		Product survey	Product survey	E I and TTU	46					
		Systematic technology search	Search	E I and TTU	46					
	Screening	Basic criteria test	Criteria test	TTU	--					
		Market acceptance	Market identification	TTU	--					
		Technical feasibility	Scientific/technical skills	E I	45					
		User commitment	Market identification	TTU	--					
APPLICATIONS ENGINEERING; TESTING	Implementation	Applications engineering	Engineering	E I	51	30	15	E S/T	52	• Increase technological capacity of smaller firms • Aggregate larger markets
		Testing								
ACTING AS THE ENTREPRENEUR'S ADVOCATE	Implementation	Project funding (demand side)	Funding	TTU	--	5	3	within E	53	• Increase the generation, growth, and profitability of new firms
		Patent and license arrangements	Licensing	E I and TTU	52					
		Test market demonstration	Market identification	TTU	--					
		Full business study	Management consulting	E I and TTU	52					
		Assist manufacturing marketing								
FUNDING	Implementation	Project funding (supply side)	Funding	E I	53	3	2	F E	54	• Increase the initiation of small technological companies
EXCHANGING TECHNICAL PERSONNEL	(All)	Matching technical personnel with industrial needs		TTU	--	2	1	S/T E	55	• Increase awareness of industrial needs in research operations
					TOTAL:	60	31			

* E I = existing institutions currently performing technology transfer function

Table 2B SUMMARY OF PROGRAM SPECIFICATIONS BY AREA OF ACTIVITY: Expected Costs (D) and Revenues (E), Measures for Evaluation of Experimental Results (F)

Area of Activity	Expected Annual Operating: Costs	Revenues (Five year Average)	Revenues Source	Evaluation of Experimental Results: Shorter-term Output Measures (Numbers of:)	Longer-term Impact Measures (In Terms of:)
Matching and Screening	$1,000,000	$1,000,000	Royalties on new sales	• Problems identified • Searches performed • Demand/supply matches made	New jobs and profits generated in smaller and medium-size Canadian firms
Applications Engineering; Testing	1,500,000	240,000	Retainer fees	• Retainer contracts • New standards promulgated • New applications engineered	Number and growth of design and engineering units created in Canadian industry
Acting as the Entrepreneur's Advocate	250,000	-0-		• Entrepreneurs funded • License arrangements completed • Business studies performed	Number of new firms that survive beyond three years
Funding	400,000*	250,000	Interest (later, capital gain)	• Deals examined • Companies started	(as above)
Exchanging Technical Personnel	100,000	-0-		• Personnel referrals solicited and completed	Increased flow of people and ideas between industry and research
TOTAL :	$3,250,000**	$1,490,000 (Average other funding required: $1,760,000)			

* - source of investment funds required expected to be a combination of government and private sources

** - does not include $150,000 one-time studies cost

Appendix B

SAMPLE PROBLEM STATEMENTS

DURABLE EXTERIOR SURFACING MATERIALS

A) Need

Exterior surfacing materials for buildings and other constructed facilities are needed to provide increased durability, color retention, and heat dissipation in comparison with current construction materials. Either bulk materials, laminates, or coating systems would be possible candidates.

B) Background

Uncounted millions of dollars are spent each year in cleaning and resurfacing exteriors of buildings and other structures. Construction materials suffer soiling from air and water-borne chemicals and particulate matter, radiation damage from the sun's rays, corrosion effects, - damage from thermal extremes, and wear and erosion from natural and man-made impacts. Corporate images, individual or civic pride, or cost-effective maintenance procedures lead to expenditures of effort and materials (and thereby funds) for massive amounts of cleaning, repainting, and refacing.

Obviously, substantial amounts of money could be saved if new buildings could be constructed with highly durable exterior surfacing materials which would require little or no cleaning and maintenance for a major portion of the design lifetime of the building.

C) Constraints and Specifications

Environmental influences to be withstood include:

1. Temperature extremes (-50 degrees to +120 degrees F.).
2. Radiation from the sun.
3. Corrosion from pollutants in the surrounding medium.
4. Erosion by wind, rain, snow.
5. Wear from normal traffic and from extreme treatment such as vandalism.

6. Soiling from absorption or attachment of air or water-borne materials.

7. Color permutation.

Service lifetimes may range from 20 to 100 years. Environmental severity varies from one geographic region to another, so solutions which meet only a subset of the above specifications may be useful.

D) Representative Available Equipment

E) Relevant Technology

Coatings for existing construction materials would perhaps provide the most rapid and economical approach for near range improvement of durability. Such coatings would, in addition to being stable in the service environment, have to be compatible with the structural substrate. Various cementitious materials, metals, and organic materials are currently used as portions of exteriors of buildings. Coatings which would substantially improve the durability of any of these materials would be major contributions.

Development or application of monolithic materials of extreme stability in building exterior use is an alternative approach. Much glass has been used as exterior finish in building construction in recent years, for example, because of its inherent resistance to weathering. Relatively stable materials of this sort, with structural properties as well as a durable exterior, would provide attractive alternatives to coatings.

FIREPROOFING MATERIALS

A) Need

Fireproofing materials of extreme stability under detrimental routine service conditions, as well as in fire situations, are needed. These materials would be used to isolate structural elements of buildings from potential fire damage, but could be used as parts of structures if sufficient mechanical properties were developed.

B) Background

Public safety demands that structural elements in certain classes of buildings be protected from potential fire damage, to allow time for the building to be safely evacuated in case of a major fire. In structures using steel elements -- columns, beams, trusses -- such protection must be provided by isolation of the metal from the potential fire site, since steel loses strength and stability at the elevated temperature levels typical of fires. This isolation is provided by sheathing each structural member in an isolating layer of fireproofing material, which prevents or delays the attainment of damaging temperature levels in the metal.

Dramatic proof of what can happen to structural steel when subjected to intense fire heat is afforded by the destructive fire which ravaged Chicago's McCormick Place in January 1967. This mammoth exhibition building -- 1095 feet by 345 feet -- was built in 1961 at a cost of $40,000,000. In the 1967 fire, the upper level exhibit area of exposed steel construction suffered great structural damage -- complete collapse of the roof. Damage to the building exceeded $20,000,000, and losses of revenue ran $300,000,000 per year as rebuilding proceeded. Luckily, the fire occurred at 2 A.M., when the building was virtually unoccupied by people, as the roof collapsed within 20 minutes of the first report of fire.

Typical fireproofing materials currently in use include Portland cement concrete, masonry materials, gypsum, perlite, and vermiculite, and mineral fiber-based compositions. Building codes dictate the thickness of any given approved material needed to effect a certain fire rating, expressed in terms of number of hours of resistance to fire damage. Fire ratings of from one to four hours are typical, with fireproofing material thicknesses on the order of one to four inches. Improvements in the application of such traditional fireproofing materials -- as measured by decreasing costs or increasing effectiveness -- appear to be at a standstill. Yet life safety considerations are making fireproofing needs even more stringent. It is apparent that new materials and innovative techniques are required to provide substantial improvements in fireproofing techniques.

C) Constraints and Specifications

For each metal, there are certain critical temperatures above which a structural element cannot be exposed and still remain structurally safe. In steels, for example, temperatures above the 1000-1200 degree F. range typically lead to substantial degradation of structural properties, and at 1700 degrees F., steel cannot support its own dead weight. The fundamental concept of fireproofing in building construction is, then, to design and build the structure such that this critical temperature cannot occur in the structural metal element within the design safety period. Maximum temperatures in fires often reach 1700 to 1800 degrees F., and have been known to exceed 2000 degrees F.

Fireproof coverings used to insulate steel from fire must resist the destructive effects of a fire, and must also resist detrimental service influences. Any fireproofing material must be durable under conditions of normal impact, wear, temperature changes, etc. Moisture deterioration can be particularly damaging, as condensation occurs within walls or around columns. Coverings near the floor may be subjected to periodic wetting due to cleaning procedures. Damage costs in buildings which suffer small fires are often high due to extensive water damage caused by sprinkler systems. Thus, the ability of fireproofing materials to withstand moisture effects is quite important.

Placement of the fireproofing material can be an important cost factor. Factory-applied fireproofing would be possible, except at joints, if the material were durable enough to withstand shipping and handling. Site applied techniques, such as spraying, could provide economies.

Since each increment of thickness of fireproofing subtracts useful space from a building, thickness of the ideal containment material should be the minimum possible consistent with protection requirements.

Standard tests for fire endurance commonly in use subject a protected structural component to a given time-temperature exposure which simulates an actual fire. Performance is defined in terms of the period of resistance before failure is observed. In a typical test pattern, air temperatures reach 1000 degrees F. in 5 minutes, 1700 degrees F. in one hour, and 2000 degrees F. in 4 hours.

One extremely important consideration in development or selection of fireproofing materials is any potentially toxic emission under either routine service or fire conditions. Life safety is the ultimate criterion in fireproofing, so protection of the structure of a building is trivial if toxic fumes from burning material have overcome the users of the building. A tragic nursing home fire where many died from toxic fumes released by burning carpet underlayment while the structure survived virtually intact, dramatically points up this life safety consideration.

Cost is generally an important factor in construction materials, but overall cost effectiveness during the service lifetime is a more accurate criterion. Since economies of volume production are difficult to project at the outset, it is suggested that cost not be used to eliminate possibilities unless its order of magnitude is higher than current materials.

D) Representative Available Equipment

E) Relevent Technology

Several approaches to the provision of fireproofing for structural elements seem possible. One approach is the application of a coating or thick layer of thermal insulation material to provide a barrier between fire and structural member. Such coatings might be composites of more than one material, where an outer flame retardant coating or other ignition hardening mechanism protects an inner thermal insulation cover. Another possibility is presented by intumescent coatings, where intense heat or direct flame leads to decomposition of the material to form a layer of foam. This layer of foam then protects the substrate and prevents additional flame spread.

A second type of approach would involve dissipation of the thermal energy of the fire in the vicinity of structural elements. Ablative materials, which absorb great amounts of energy as they are consumed provide one possibility. Heat sinks or energy conversion by transpiration or film cooling provide alternative possibilities.

The above discussion on possible characteristics of relevant technology is meant to be illustrative, rather than all-inclusive. There are many more areas of relevant technology which might also be suggested.

DETECTION OF LEAD-BASED PAINTS

A) Need

A portable non-destructive testing device is needed for the detection and measurement of lead contents in paint on walls and wood frames in buildings.

B) Background

Lead poisoning frequently occurs accidentally in young children from the ingestion of lead-containing paints, and is often manifested by severe cerebral damage (lead encephalopathy) or death. Some six to eight thousand children from the ages of one to four years inclusive are currently suffering the effects of such lead poisoning in New York City alone.

Lead-based paints were used in decades past for interior finishes in housing and other buildings. In older buildings, layers of such lead-bearing paint underlie surface finishes applied at later times. A ghetto child ingesting flakes of plaster or other wall material, or chewing on a window or door frame, can accumulate dangerous levels of lead in his blood system.

If suspect buildings could be readily tested for the presence of lead-containing paints, detection could be followed by removal of the dangerous materials. No portable, appropriate detection system for *in situ* lead detection is currently available for this purpose.

C) Constraints and Specifications

A detection system for determining the presence and amount of lead in paint substrates should be non-destructive, portable, readily operable by semi-skilled field investigators, reliable, and accurate. It should not require elaborate power input, shielding, or interpretation. It should be direct-reading, rapid, and capable of testing individual surfaces within a room. The detection system need not be simple in principle or in operation, as long as output to the operator is simple.

D) Representative Available Equipment

E) Relevant Technology

Several techniques are currently employed for the rapid identification of metals:

1. The shape and color of sparks in spark testing.

2. The behavior of the material in a controlled flame.

3. Wet chemical methods, either performed directly on the surface or with a small portion of the sample dissolved in the reagent.

4. Coloration of a coating due to the uptake of metal ions.

5. Spectroscopic methods, such as emission spectroscopy, x-ray fluorescence, and atomic absorption.

6. Electrical methods, such as eddy current tests, thermoelectrical tests, and electroconductivity.

It is hoped that one of these techniques can be adapted to the problem of lead detection in paint substrate.

ACCELERATED TEST METHODS FOR MATERIALS

A) Need

A short-duration test method for determining the suitability of materials for long-duration functions in buildings. An evaluation of the long-term fire resistance and the changes in appearance are needed in addition to that of the mechanical properties.

B) Background

New materials with an apparently high potential for building construction are continually appearing on the scene. Responsible manufacturers subject such materials to exhaustive tests spanning, often, ten years, before releasing them to the market. An example is DuPont Tedlar, a plastic coating for exterior siding and sheathing which was, according to the manufacturer, given ten-year exposure tests in all anticipated climatic conditions, and which survived all tests without deleterious effects before being released.

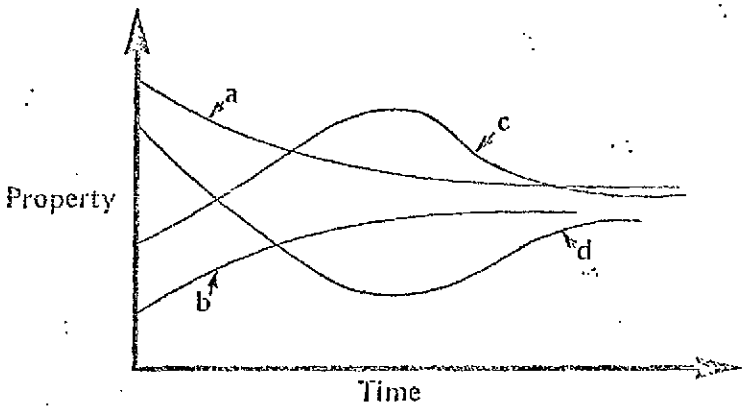
If the success of these tests could have been anticipated after, say, a year, then building construction which stood to gain from use of Tedlar would have had nine additional years of its use. Furthermore, its cost would have been reduced, partly because nine years of testing would have been eliminated, and partly because the momentum of the initial development could have been maintained into the manufacturing stage.

A further serious effect of the need for long-duration tests is that innovation in building materials must virtually be restricted to large, well-established firms. No one could conceive of creating a company on the basis of a discovery of a new material if the company could do nothing for ten years but try to find weaknesses in it. (And the industry could hardly be surprised if the results were found to be entirely favorable at the end of the trial).

On the other hand, the results of the premature release of materials which later prove to be unsatisfactory are far-reaching and severe. For example, there are many materials, and finishes for materials, which are introduced and sold with the claim that no further maintenance in the form of painting or corrosion protection will be needed. If such corrosion protection is later found to be needed, not merely unforeseen costs, but possibly danger of structural collapse, might be involved. Another example is of materials which, when new, resist the spread of fire by evolving a vapor or gas, giving a blanketing effect. The loss of this property over time could, obviously, have very serious consequences.

C) Constraints and Specifications

The tests to be made should determine in a comparatively short period -- a month to a year -- the properties which will be found in the material in five to fifty years. It is to be assumed that, when properties show a variation with time, that they do so monotonically with a decreasing rate, as in the curves a and b in the sketch.



The properties of some materials go through a maximum or a minimum, curves c and d, as, for instance, does the strength of some polyurethane foams during polymerization. However, these maxima and minima occur, so far as is known, always within a period of minutes or hours rather than years, and are not likely to be a disturbing factor in making long-term predictions.

Here is an incomplete list of properties which are needed at least as a function of temperature and sometimes as a function of ambient medium-air (if so, humidity may be important), soil (characteristics), water (salinity), paint, and so forth.

1. Strength:

a. Ultimate tensile strength.

b. Yield point, if any.

c. Limit of proportionality (perhaps to 5% excess strain).

d. Impact (Izod), notch sensitivity.

e. Ductility, elongation at rupture.

f. Shear.

g. Fatigue

h. Creep.

2. Softening temperature.

3. Melting temperature.

4. Bubble point.

5. Flash point.

6. Ignition temperature.

7. Solubility and reactivity to various reagents.

8. Color fastness.

9. Electrical properties: resistivity, dielectric constants, etc.

10. Density.

11. Thermal conductivity.

Many will be of little importance for any given material; some materials -- for instance, a new air-conditioner working fluid -- will require many properties not listed here.

D) Representative Available Equipment

E) Relevant Technology

In order to devise methods of accelerating tests, the mechanism producing long-term changes in the properties of each material or class of materials needs to be understood. To accelerate the test, the mechanism would obviously be intensified, for example:

1. Diffusion process -- for instance, the loss of plasticizers in plastic materials -- is probably diffusion limited, and the rate of diffusion might be accelerated by increasing the pressure gradient -- testing in a vacuum -- or increasing the temperature of the material -- or decreasing the resistance to diffusion by operating on thin films.

2. Chemical attack -- the strength of the reagent can be increased.

3. Component solubility -- thin-film specimens and possibly forced-convection mass transfer.

4. Thermal fatigue -- mechanical fatigue strength can be measured and thermal fatigue effects calculated from other properties.

5. Ultra-violet radiation -- increase the intensity.

6. Creep under steady loading -- increase either loading or temperature.

7. Crystal growth -- increase temperature.

8. Corrosion -- test properties of corrosion products for adherence and so forth, and make theoretical predictions.

This list is again highly incomplete, but illustrates the type of approach which can be used. However, linearity, or the absence of interaction effects, has been assumed.

Obviously, the raising of a test temperature to increase creep loading, for instance, will bring about a number of other changes which may help to mask or confuse the primary effect.