Working Paper

PLANNING FOR THE IDENTIFICATION AND ASSESSMENT OF STRATEGIC TECHNOLOGIES

Industry Branch
December, 1981

Planning for the Identification and Assessment of Strategic Technologies

This paper presents some of the issues, options and decision criteria for the identification and assessment of Strategic Technologies. The contents are intended to be used as a planning "check list" in the development of the Strategic Technologies Work Program (STWP). It should be noted that the identification and assessment of Strategic Technologies represents only one, albeit a major, element of the STWP. Other important considerations, which could by themselves be the subject of a separate discussion paper include: Policy Formulation, Program Operation, Management and Control and, Program Marketing. An example of an overall planning framework is shown in Fig. 1.

The importance of formulating a Program Plan is made evident by the fact that the STWP represents a significant departure from the existing mode of policy development activities of the federal government in general and MOSST in particular. Under these circumstances, there is considerable pressure on MOSST to "sell" the concept to decision makers as well as other departments, agencies and the private sector. A Marketing Plan, therefore, should form a major thrust of an overall Program Plan.

Figure 1

STRATEGY AREAS

Program Marketing

Strategy for:

1) Identifying areas of Support and Resistance
2) "Packaging" of Program
3) Communications
4) "Lobbying"

Program Management and Control

Plan and Develop:

1) Assessment Management Function
2) Program Management Function
3) Management Information System
4) Quality Control System
5) Policy Reassessment
6) Program Evaluation

Resource Plan

Strategy for:

1) Personnel
2) Information
3) Developing Organizational Linkages

COMPONENTS

Identification and Assessment of Technologies

Develop Mechanisms for Identifying and Assessing:

1) Opportunity Technologies
2) Future Technology Problems and Needs
3) Technology Threats

Policy Development

Identify:

1) Areas for gov't involvement
2) Existing Policy Gaps
3) Specific Policies for:
   - manpower
   - invention
   - innovation
   - diffusion

Program Operation

Develop:

1) Funds allocation System

Information Network

Strategy for:

1) Needs Identification
2) Sources Survey
3) Information Analysis
4) Storage System
5) Retrieval

To assist in the formulation of a marketing strategy as well as an organizational development strategy, it would be useful to identify, in advance, the resource requirements, organizational linkages and potential constraints that are associated with the development and implementation of the STWP. With respect to the identification and assessment component, many decisions must be made which clearly define the nature, extent and timing of these elements.

More specifically, decisions are required in the following areas:

1) Development of an information system.

2) A methodology for the identification of strategic technologies.

3) A methodology for the assessment of strategic technologies.

First-three paragraphs here

Information System

It is imperative that an adequate information network which meets the general and specific needs of the STWP be established. This would require that the most current, comprehensive and relevant data be acquired, stored and made readily available. Because the STWP is in its first

stages of development within MOSST, the existing information system must be upgraded considerably.

The exact nature of the information system requirements would depend on the choice of methodologies for identification and assessment and the characteristics of the strategic technologies being assessed. Once the assessment priorities have been set, the scope of MOSST's involvement as well as the subject areas can be determined. At this stage the information network can be designed to fit the specific needs more precisely. This would include the designation of information sources and the depth, quality and quantity of data needed as well as the timing of these data flows. Although specific inputs would depend on the assessment requirements, a tentative list of the areas of interest would include:

1) International activities and policies

In addition to acquiring "technology specific" data, it is important to develop sources which will help identify potential threats on an ongoing basis.

2) Domestic government activities

Sources and flows should be further developed between MOSST and other federal departments and agencies as well as between MOSST and provincial government bodies.

3) Industrial activities

For each area of concern, industry contacts should be made to gain an appreciation of the potential problems inherent in linking the research to commercial exploitation.

4) S&T Policy Research Issues

As a complement to MOSST's internal capability in this area, it would be useful to identify sources to improve our understanding of the innovation cycle.

5) Socioeconomic Forecasts

An important element of developing scenarios for the evolution of particular technologies is to identify likely future socioeconomic trends, needs and events. These forecasts can be used as a back-drop to each technology assessment.

Once the general and specific data requirements have been identified, the sources must be investigated and decided upon. Some of the available options include:

(1) The existing MOSST data base.

(2) Other federal and provincial government data bases.

3) International organizations jointly supported by governments and/or non-profit institutions such as the UN, OECD, EEC, IAASA, etc.

4) Canadian owned MNE subsidiaries operating abroad.

5) Canadian science counsellors abroad.

6) Specialized consultants such as ADL, The Rand Corp, Battelle, MIT, etc.

7) Industry Associations and Institutes.

8) Conferences, Symposia and Expositions.

9) Individual Canadian experts designated as advisors.

10) Advisory panels of experts.

To ensure that the system remains responsive and up to date, it must be managed carefully and should be adequately staffed with research and clerical people.

The Identification of Technologies for Assessment

The most important operational component of the STWP, in terms of MOSST's involvement, is the determination of areas of science or technologies which deserve more careful analysis.

As a starting point, the Ministry's Strategic Overview of April 1981 lists the following four general categories of technologies which could be considered MOSST's responsibility and within its existing mandate.

a) There are certain areas of technology which are of interest to a number of departments in terms of fulfulling their mandates but for which there is no national lead department. Space technologies belong to this category. Toxicology is another area of recognized importance to Canada and of interest to several departments that needs to be addressed in a concerted way.

b) There are areas of technology which will reach commercialization within a 5 to 15 year timeframe and which can create opportunities or pose threats for Canadian industry. These are areas which industry itself may not be willing to research and to develop because of the long-term framework, because of the need to apply its financial resources to more immediate projects, because the research facilities do not exist in industry, because industry without government assistance cannot hope to compete with what is done in other countries or

because the development of the technology requires a concerted effort for which only the government can take the lead. In the absence of a sponsor in government, the probability of developing the technology may be seriously diminished. Telidon is an example of such a technology which found a sponsor.

(c) A third category is comprised of a group of technologies which can have an important bearing upon the productivity and competitiveness of industry but which for the most part, are not central to implementing the mandates of the science-based departments. For example There is a broad group of manufacturing and process technologies which, if not developed and adopted by Canadian industry, will have an adverse effect on our competitiveness. These include robotics, computer-aided systems, and plastic processing.

(d) A fourth category would consist of technologies which are of interest not only to departments in terms of their mandate, but also in terms of their potential industrial application. Bio-technology, ocean technology, energy conservation

technologies, environmental protection technologies, and various electrochemical technologies are within this category.

Within these broad categories of particular interest to MOSST, specific technologies can be selected which have significant social or economic potential. As described in the Strategic Overview, these technologies might include:

a) new technologies which would lay the base for Canada's future domestic and international competitiveness possibly by capitalizing on an early lead in research and development e.g. biotechnology;

b) technologies which could significantly enhance the productivity and competitiveness of established industries, including technologies to enhance the value of the natural resource base e.g. robotics;

c) so-called "core" technologies which can have a significant impact on innovation and output across a number of industry sectors e.g. composite materials;

d) technologies which will be essential at some future date in order to realize national economic objectives or implement national policies, the implication being that the R&D may need to be commenced now so that the unavailability of a certain technology does not impose a constraint at some later date e.g. hydrogen ;

e) technologies which are an essential element to broaden the industrial structure of selected regions, based upon regional strengths, problems and opportunities e.g. ocean technology ;

f) technologies under development outside Canada, whose commercialization could pose a significant threat to Canadian industry ;

Categories a), b) and c) can be classified as "opportunity" technologies which could contribute to economic growth and enhanced competitiveness. Categories d) and c) can be viewed as "technology needs" in that their development is necessary to avoid a future constraint or to resolve a specific regional development problem. The last category is not strategic in the sense that it does not exploit an opportunity or satisfy a future need for specific technologies, but identification of these threats could represent a valuable input to industrial adjustment or adaptation policies.

In relation to overall national policy formulation then, S&T policies which deal with the above categories will impact on general economic policies in different ways. It is envisioned that "opportunity technology" policies, for example, would form an important thread of an industrial strategy, while "technology needs" policies would play a supportive role with respect to a particular national economic policy, such as the NEP. The category of "technology threats" would generate policies which support a strategy for industrial adaptation. As a result of these different relationships between S&T and economic or industrial strategy, it will sometimes be difficult to decide who should play the lead role.

There are three distinct capabilities which should be developed within MOSST to identify strategic technologies which are included in the "opportunity, need, or threat" categories. First, a preliminary assessment function, which is technology oriented, must be implemented. That is, the costs and benefits of developing a particular technology must be evaluated. Secondly, an early warning mechanism must be established to help identify external threats. The emphasis here should be placed on designating reliable information contacts and sources abroad. Finally, a separate but related mechanism is needed to identify future needs and problems which will require a technological solution. In this last case, the assessment would be problem oriented, and there may be a number of potential solutions ranging from existing technologies to those which have yet to be developed. Each of these capabilities is discussed in further detail below.

Preliminary Assessment Function

Individual technologies or areas of science can be chosen from a broad list of known technologies and assessed against a predetermined set of criteria to measure their

suitability for a more comprehensive assessment. This preliminary review or screening is advisable given the large number of technologies available for study and the high cost of conducting a complete assessment (estimates given in the U.S. in 1976 range from $100,000 to $300,000 per assessment depending on the nature of the technology). To place this assessment function in the context of the STWP, an overall framework has been prepared as shown in Fig. 2.

In order to develop this screening mechanism further, it is useful to review more closely the "opportunity categories" which were previously mentioned. The "opportunities" can be measured generally in terms of the satisfaction of national objectives, which can be then compared against an estimate of indigenous capability. For the opportunity categories, three possible matrices can be constructed.

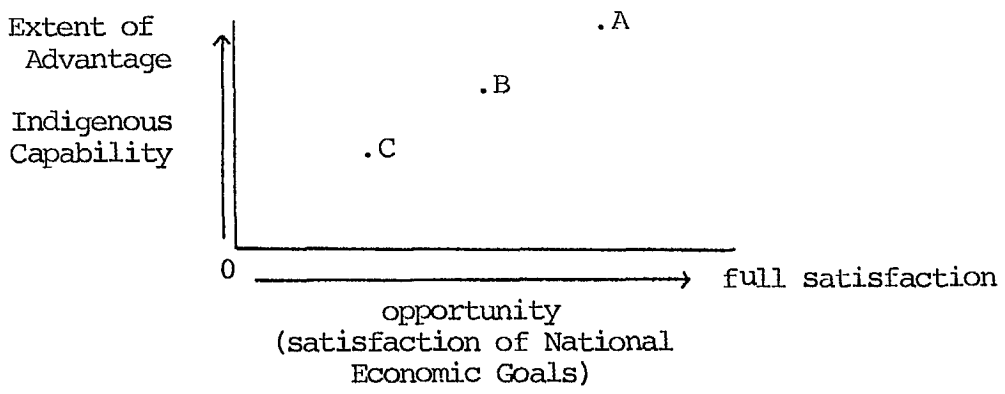


Fig. A: National Economic Opportunities

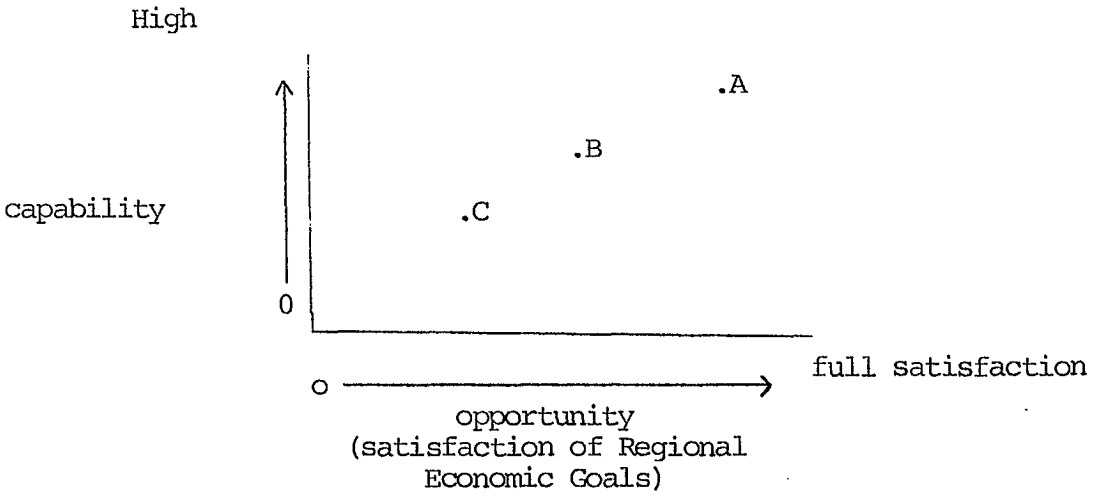


Fig. B: Regional Economic Opportunities

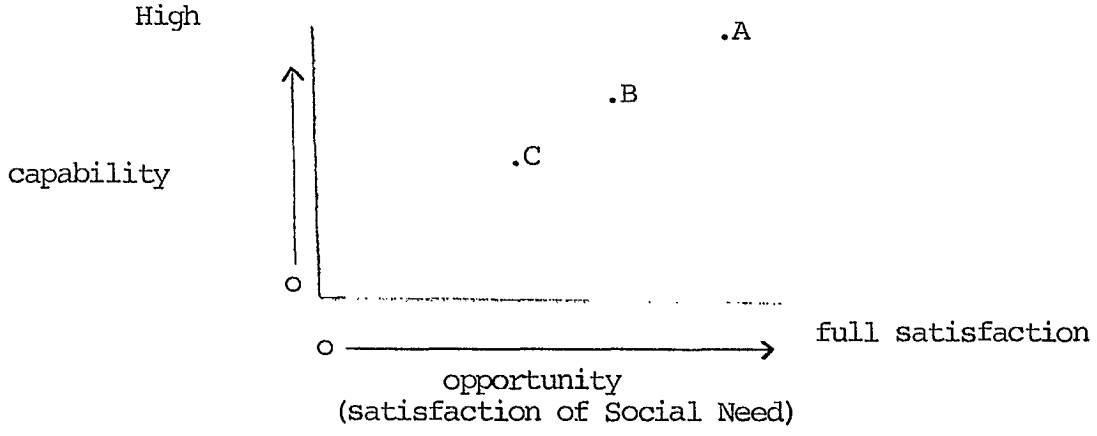
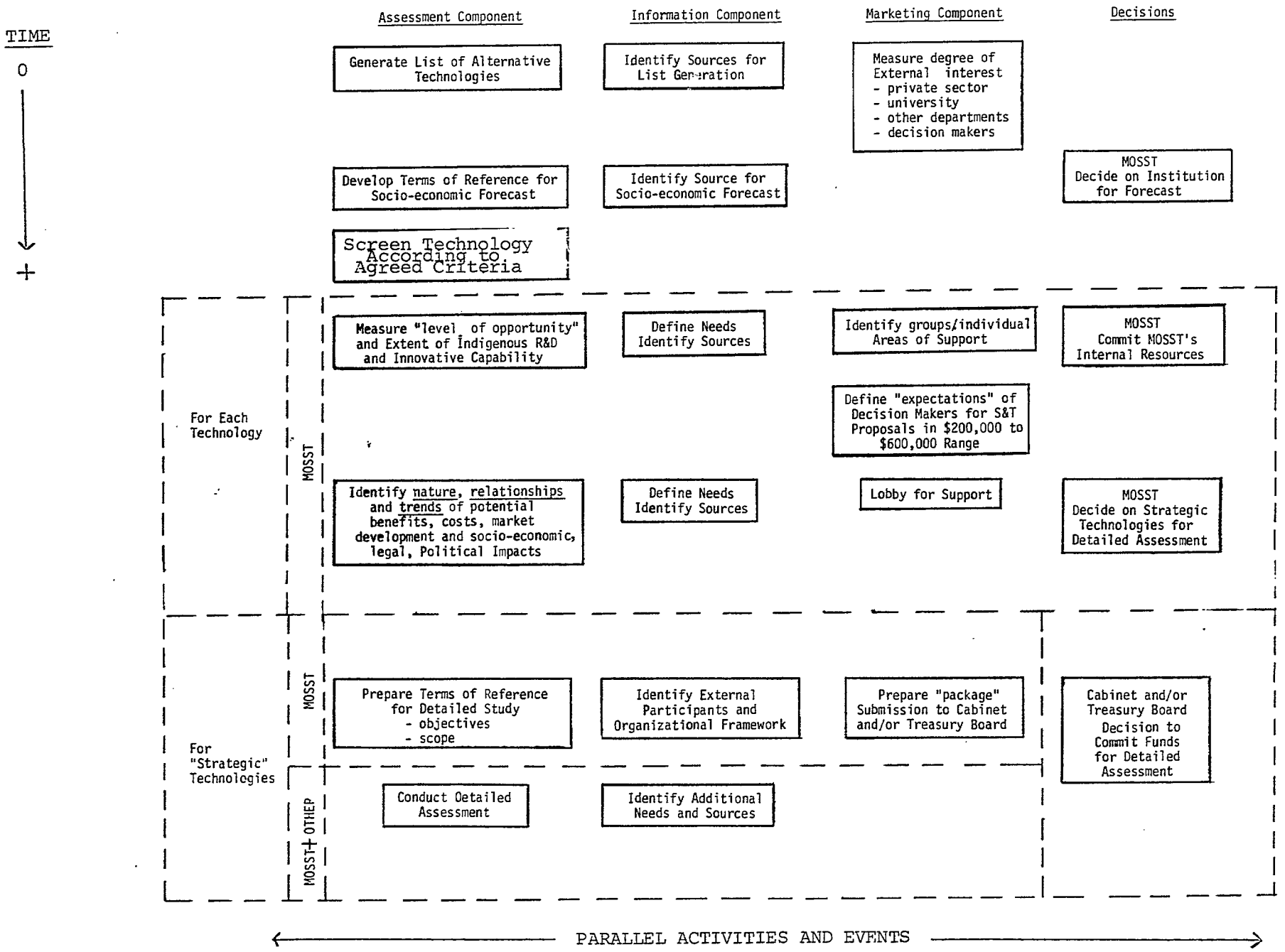


Fig. C: Social Opportunities

STRATEGIC TECHNOLOGIES WORK PROGRAM (STWP) - DEVELOPMENT FRAMEWORK FOR "OPPORTUNITY" TECHNOLOGIES



All technologies can be placed in each of the above matrices; however, conceptually, it is more likely that either a social or economic theme would be associated with their development. Those technologies which are perceived as having a high degree of opportunity with a correspondingly high potential for R&D and commercialization, such as technology A, would be candidates for intensive assessment. Technology C, on the other hand, should not be examined further while technology B, may be examined in depth, subject to the availability of resources.

Conceptually, the methodology of identifying "opportunity technologies" as shown in Figures A, B & C seems straightforward; however, the task of measuring the levels of goal satisfaction and innovative capability is complex and characterized by a high degree of uncertainty.

The key to minimizing this uncertainty in the eyes of those who "hold the purse strings", is to ensure the credibility of the overall process. This can be achieved by maintaining objectivity, a high degree of professionalism, and an acceptable level of comprehensiveness.

Objectivity at the preliminary assessment stage is not difficult for MOSST to portray in that our mandate is not sector oriented and it is envisaged that all work will be completed internally with some consultation with outside experts.

Professionalism, on the other hand may be difficult to display in view of MOSST's traditional lack of public involvement in assessing strategic technologies. To add credence in this area, a "highly reputable" agency could be contracted to perform part of the assessment. A logical area for their involvement, and one where we have little expertise, would be the generation of a 10 to 15 year socio-economic forecast for Canada. Such a forecast could also be used as a framework for identifying future needs and problems.

The degree of comprehensiveness relates directly to the question of how far MOSST should go before deciding on whether an in-depth assessment is warranted. The answer to this question lies in part with the nature of the technology being assessed. Above all, the assessment must give a clear indication that there is a net potential benefit

associated with the development of a technology on the basis of an "educated" subjective appraisal which is supported by a quantitative analysis. Before making a formal submission, it should be appropriate to say that some form of S&T policy action seems in order but further work is necessary to determine more precisely the nature and extent of federal government support.

Developing the framework for analysis further, more specific elements of the process can be identified which would help us to gain an appreciation of:

1) the level of opportunity associated with a technology i.e. the range of application, the possibility for exports and the contribution to overall economic growth;

2) the measure of potential benefits in terms of contribution to profits, effect on employment and effect on the quality of life;

3) the research development and innovative capability of Canadian institutions which measures the "fit" of the technology with our expertise and industrial structure;

4) The market development time frame, which measures the nature and growth in demand for each application. This area is closely linked to the economics and perceived user benefits of a given technology and its competitive alternatives;

5) The potential impacts on other components of the social/political/economic system. Identification of negative impacts would also be a priority here.

Although each of these elements should be examined in depth, for the purposes of the preliminary assessment, it would be sufficient to focus on the measurement of opportunity and the research, development and innovative capability of Canadian institutions and industry in a manner shown by the matrices presented earlier. The other areas, which are concerned with predicting future demand, costs, benefits, and impacts, involve more complex analysis and should be left for the detailed assessment phase. It would be sufficient to indicate cost and benefit impact areas, relationships and trends and to identify potential negative impacts on society, the environment or within the political arena.

Early Warning Mechanism

To identify R&D activities or emerging technologies abroad which are likely to pose a threat to Canadian industry, a fairly complex monitoring/assessment system must be put in place which is markedly different from the preliminary assessment system for opportunity technologies. The objective of such a system would be to impact on anticipatory structural adjustment policies through the early identification of technological threats. Although there may be some argument as to what is meant by early, ideally the reaction time period should be long enough for adjustment policies to take effect before the potential negative impacts of the foreign development become a reality. The early warning mechanism should be capable of:

1) Identifying the nature and level of foreign R&D effort in specific technological areas.

2) Measuring the impacts of technology transfers between countries.

3) Measuring the technological exposure of Canadian industry to foreign developments. Here, specific sectors can be emphasized.

4) Measuring the existing private sector and government R&D capability to react to the effects of technology transfers and foreign R&D programs.

The desired result of the system is to identify and isolate future gaps in the competitiveness of Canadian industry which will not be covered by existing government policies.

Conceptually, an early warning mechanism seems quite feasible. However, in practice, such a system has yet to gain acceptance among economic policy makers mainly because of the high level of uncertainty associated with the innovation process and the lack of understanding of the role of technology in the international marketplace.

Insofar as MOSST is concerned, the implications of this situation are twofold. First, there is a need to better understand the viability of an early warning mechanism as an input to economic or industrial policy. Secondly, on the condition that the viability has been proven and accepted by MOSST and the details of a mechanism worked out, the

initiative must be integrated with industrial policy development.

Future Technology Needs and Problems

In many respects, the identification of future technology needs is similar to the assessment of opportunity technologies. However, the mechanism would operate over a wider range and a greater emphasis would be placed on forecasting. When in place, the system might include the following assessment components:

1) A detailed socioeconomic forecast which would describe future scenarios and corresponding human wants.

2) An assessment of the probable industrial structure and priorities for economic development.

3) An assessment of the technological component needed to support a future industrial structure.

4) An assessment of our existing capability to satisfy future technological needs.

An important characteristic of the "technology needs" component of the STWP is that it is problem rather than technology specific. Because of this, a complete assessment could include an analysis of a number of technological solutions for a particular application. The assessment would then take on a technology specific mode as each alternative is evaluated. The end result would be an extremely comprehensive study which recommends a technological solution that may not be the optimum with respect to the problem under investigation but surpasses alternate technologies in other areas of application. A further complication is the possibility, over time, of an unknown technology becoming more appropriate than the chosen technology.

Clearly, an acceptable systems approach to arriving at an identification of and a technological solution to a future need would involve a large amount of financial and human resources relative to opportunity technology assessements.