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A Technology Transfer Decision Framework for Publicly Funded Research Organizations

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A TECHNOLOGY TRANSFER DECISION FRAMEWORK FOR PUBLICLY FUNDED RESEARCH ORGANIZATIONS

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SUMMARY

This paper introduces a framework that facilitates the decision making process for selecting the most appropriate pathway for technology transfer from publicly funded research organizations. These organizations are often faced with having to serve both public and private good mandates. The various types of R&D performed by publicly funded research organizations are examined and criteria are identified for selecting the most appropriate technology transfer option. The concept of a technology transfer scorecard is also introduced to facilitate the decision making process.

INTRODUCTION

Publicly funded research organizations (PROs) - such as universities and government laboratories - are often faced with a broad range of R&D objectives which can lead to varying technology transfer options. For example, in a study of R&D in the USA, Crow and Bozeman (1998) found that 51% of government laboratories and 23% of universities viewed technology development as a major mission. Basic research was viewed as a major mission by 70% of universities and 42% of government laboratories. Technology transfer to industry was undertaken by 40% of universities and 52% of government laboratories.

Unlike the private sector which is mainly motivated by economic factors, PROs are driven by both social and economic objectives making the selection of the most appropriate technology transfer pathway a daunting task. A private company will typically exploit a technology primarily for commercial advantage; a PRO must consider whether to broadly disseminate a technology for the benefit of society-at-large or make it available to one or only a few companies to exploit.

The objective of this paper is to introduce a framework that facilitates decision making when it comes to selecting the most appropriate pathway for transferring a particular technology. The discussions will apply primarily to federal laboratories, although many of the principles also apply to universities. For the purpose of this study, technology is defined in its broadest sense, from non-proprietary knowledge to intellectual property. Typical technology receptors for PROs include the general public and the scientific community (e.g., for broad dissemination of knowledge) to policy makers to private firms. R&D is performed either by the PRO alone or in collaboration with one or more partners, including other PROs and/or the private sector. Collaborations can be carried out on a task- or cost-shared arrangement, or on a user pay basis, Brand (2003).

There are several factors that impact on the selection of a technology transfer pathway; e.g., Lundquist (2003) considered seven distinctive lines of description to detail technology transfer. One complicating factor for PROs in particular is the ownership of intellectual property. In universities, ownership can either reside with the inventor or the university or both; whereas, in the Canadian federal government, ownership is retained by the Crown. This can lead to complications in negotiating agreements when universities collaborate with government laboratories. As well, the performance of scientists in PROs is often based on the number of scientific papers published, Bozeman (2000), which can conflict with the need to keep information proprietary when developing technologies for commercialization. Barring these complications, there are some well defined criteria that can be used in facilitating the decision making process. These criteria will form the basis for the decision framework.

Why do PROs Perform R&D?

There are five basic reasons why publicly funded research organizations perform R&D:

- *To develop and maintain their core competencies* – in order to remain relevant, R&D laboratories must conduct research to develop their technical and scientific expertise. This research is generally cutting-edge to ensure that lab equipment and techniques are state-of-the-art.
- *To broadly disseminate knowledge* – publicly funded research organizations have a responsibility to conduct research for the health, safety and security of the general public. This research generally leads to publications and reports that are broadly available to the scientific community, the media and the public.
- *To provide policy support* – PROs and in particular government laboratories conduct research in support of policy analysis and the formulation of regulations and legislation. This research is targeted predominantly to senior officials and policy formulators within government departments and agencies.
- *To support the private sector* – industrial R&D is generally performed on a collaborative basis with private enterprises. This research is conducted on a cost shared or cost recovery basis and the companies involved are given access to the results, generally through a license agreement.
- *To launch commercial ventures* – some universities and government agencies have adopted a mandate to promote the formation of new start-up companies as a way of exploiting new technologies. This generally occurs when there is no acceptable receptor to commercialize the technology.

What is the nature of the R&D performed by PROs?

There are several types of R&D performed by publicly funded research organizations. These are generally classified according to the mandate of the organization and who pays for the research. With respect to mandate, the traditional role of universities has been to conduct predominantly exploratory (curiosity-driven) R&D, while government labs have focused on long term strategic R&D and policy support. However, in recent years, PROs have increasingly partnered with industry to carry out more applied R&D; e.g., Cohen et al. (1998).

R&D funded exclusively from public funds fall under three categories: exploratory, long-term strategic and technology development. In each of these cases, the objective of the R&D is to expand on the scientific and technical knowledge base *for the public good*. The information or knowledge derived from such activities is either broadly dissemination (e.g.,

in scientific publications and reports), used for the safety, health and security of the public, or to promote certain critical sectors of the economy key to the well being of the nation such as energy supply and conservation, the environment, national defense.

Collaborations with the private sector have allowed PROs to broaden their mandate by assisting individual companies in troubleshooting operational problems, carrying out proof-of-concept for emerging technologies and developing new technologies. Geisler and Clements (1995) found that companies are particularly interested in the technical expertise, resources and knowledge that reside in government laboratories. These collaborations are either carried out on a task- or cost-shared basis; or on a user-pay basis where the company pays the entire cost of the work. In addition, PROs have increasingly entered into licensing arrangements with companies, provided incubation facilities or launched new business ventures such as the creation of start-up companies. These types of activities have created new challenges for PROs with regards to technology transfer.

TECHNOLOGY TRANSFER PATHWAYS

The relationship between the type of R&D performed and its purpose is shown in Table 1. The various activities identified are categorized according to the shading of each box. The activities depicted in *light grey* are most typically performed by government labs and represent R&D performed *in support of their departments' policy mandate*. These types of activities are justified on the basis of legislative requirements as specified by Acts. Technology transfer in these cases occurs mostly in the form of non-proprietary knowledge and information, either broadly disseminated to the general public or made available to policy groups within government departments responsible for legislative and regulatory formulation. These types of activities lead principally to the well-being of public and to country's international standing in the science community.

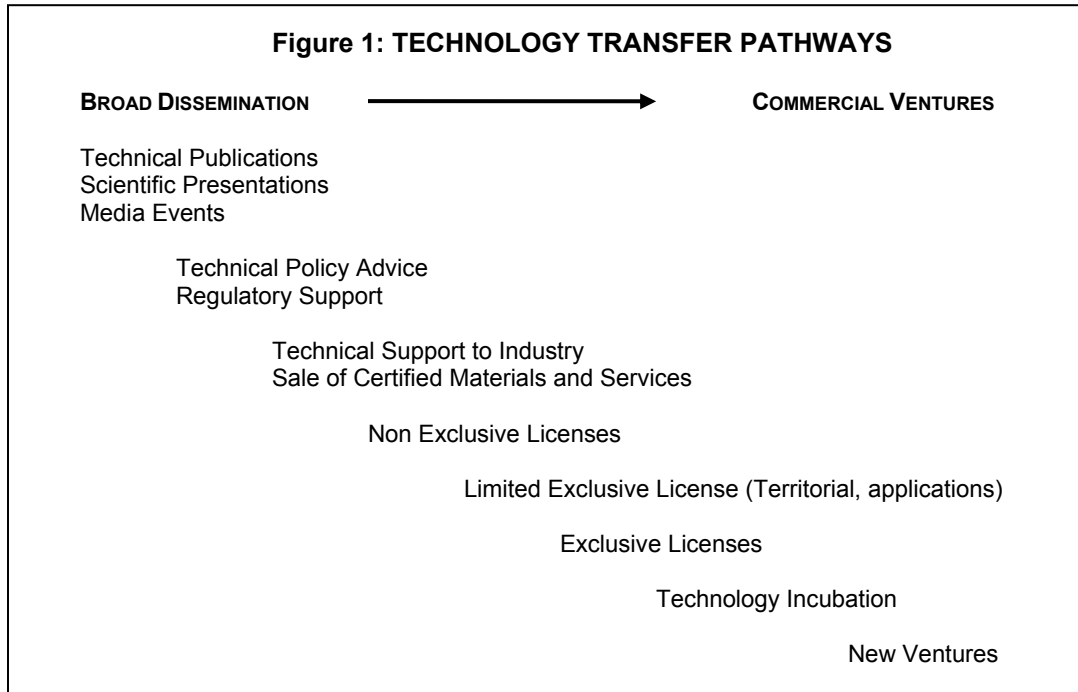
The boxes shaded in *medium grey* represent work performed by government labs *in support of companies not capable or willing to undertake the R&D alone*. These types of activities benefit mostly individual companies or specific sectors of industry. Technology transfer involves intellectual property (i.e., proprietary knowledge) that the company uses to improve an existing process or product or to create a new product or process. In some cases, the activities are justified on the basis that the "client" pays for the work under a cost recovery arrangement; i.e., on a user-pay basis. Cost- and task-shared arrangements with individual companies must be justified on the basis that there is a "public good" component to the work; i.e., the intellectual property created can be used for broader applications/purposes. The benefits accrued from these activities are mostly economic in nature, directly benefiting the company(ies) involved, and indirectly, society-at-large.

The boxes shaded in dark grey apply to public institutions that have adopted a mandate to facilitate the creation of new ventures to develop and commercialize advanced technologies. Technology transfer typically occurs during the technology incubation stage, when the start-up company is in transition from the laboratory to a commercial enterprise. The transfer of intellectual property can occur through a license agreement or through

Table 1: TECHNOLOGY TRANSFER DECISION FRAMEWORK

	PUBLICLY FUNDED			JOINTLY FUNDED				
	EXPLORATORY R&D	LONG-TERM STRATEGIC R&D	TECHNOLOGY DEVELOPMENT	COLLABORATIVE RESEARCH (COST AND TASK SHARING)	COST RECOVERY/ REVENUE GENERATION	LICENSING	TECHNOLOGY INCUBATION	NEW VENTURES
Develop and maintain core competencies (technical and scientific expertise)	Curiosity driven R&D Cutting edge research	Advances in new fields of research	Breakthrough “next generation” technology	Cutting edge research Problem solving Technology improvements	Problem solving Advanced analytical techniques New materials			
Broad dissemination of knowledge (publications, information to general public)	Scientific publications Presentation at conferences Handbooks and manuals	Health and safety Consumer protection	Environmental Protection Energy and food supply National defense					
Policy support (analysis, legislation, regulations)		Scientific advice and consultations Regulatory and legislative support	Technologies in support of national priorities and security					
Private sector support (industrial R&D)				Problem solving Technology Improvements Breakthrough technology dev.	Analysis Sale of products Problem solving Proof of concept Technology evaluation	Access to Crowned owned IP Conditions and limitations on use of technology Royalty provision	Access to lab space, equipment, admin and technical personnel Financial and technical support	
Commercial ventures (partnerships, equity sharing)							Access to lab space, equipment, and personnel Financial and technical support	Financial and technical support Transfer of technical personnel

an equity sharing arrangement with the new start-up company. The term new venture can include start-up companies with an associated transfer of personnel from the PRO who take an active role in the creation and operation of the newly created company. The justification for launching a new venture is based on the lack of an existing commercial enterprise that is willing or capable of developing and commercializing the technology. The new venture and the public institution from which the technology originated derive a direct benefit from this form of technology transfer; while the public derives an indirect benefit. The various pathways for technology transfer are depicted in Figure 1.



CRITERIA FOR SELECTING TECHNOLOGY TRANSFER PATHWAYS

There are several criteria that can be used to assist in selecting the most appropriate technology transfer pathway. These criteria are based upon R&D factors and marketplace (or business) factors. Experienced organizations use a rigorous process in examining these criteria, involving both technical and business professionals.

Typical R&D questions that are asked when examining technology transfer options are:

- What was the objective of the R&D? e.g., support of public policy or the private sector?
- What was the justification for the R&D? e.g., mandated by legislation or justified on the basis of costs being recovered?
- Who paid for the R&D? e.g., public funds or user-pay?
- What are the outputs of the R&D? e.g., knowledge or intellectual property?
- What are the benefits of the R&D? e.g., social or commercial/economic?
- Who are the main beneficiaries of the R&D? e.g., the general public or private enterprise?

Marketplace or business factors include:

- Applications
- Market Competition
- Economic wealth generation
- Job creation

When taking all of these criteria into consideration, one can reach decisions on how best to exploit a particular technology. This process is generally done almost intuitively.

Organizations with extensive technology transfer experience can work through these criteria with relative ease to arrive at the most appropriate option. On the other hand, organizations with little experience in technology transfer are often conflicted by these criteria, and make decisions that are inappropriate; or get swayed by 'political' pressures.

Ideally, it would be desirable to have a framework that would facilitate the decision making process and provide for some level of consistency in the way technology transfer options are considered. This would eliminate some of the guesswork that goes into making decisions; and provide a tool to arrive at the most appropriate transfer pathway for a particular technology. This framework would also serve to close the communication gap that often exists between technical and professional staff, allowing them to follow a systematic approach at examining issues and arriving at decisions.

TECHNOLOGY TRANSFER SCORECARD

The proposed technology transfer decision framework is based on the concept of a scorecard. The premise is that a score can be assigned to each of the criteria described in the previous section. The most appropriate technology transfer pathway would then depend on the total score arrived at for a particular project. The notion of a technology transfer scorecard is depicted in Tables 2a and 2b.

A score of 1 to 10 is assigned to each criterion, depending on the character of the project. For example, if the objective of the R&D was strictly to support public policy, a score of 1 would be assigned; whereas, if the objective solely supported private industry, a score of 10 would be given. A score between 1 and 10 would be assigned to projects with the dual objective of supporting both public policy and private industry (e.g., to promote energy efficiency in private industry). The exact score would depend on the extent to which the project supports public policy and/or private industry.

Once a score is assigned to each of the criterion, then the total score can be used as a guide in arriving at an appropriate technology transfer pathway. For instance, a total score of less than 30 would suggest that the project is heavily weighted towards supporting the public good and therefore, the knowledge gained would be most appropriately transferred through broad dissemination. On the other hand, a score greater than 90 would imply a technology developed for and paid by an individual company, and the rights to the technology would most likely be transferred to that company. A sample scorecard is shown in Figure 2.

It is important to stress that this framework is only meant to serve as a guide to help arrive at decisions regarding technology transfer. It does however allow for a systematic approach in considering the factors that impact on a particular R&D project; and provides some level of justification for the decisions taken. For example, a company that argues for exclusive or sole rights to a technology that scores 40 points in the scorecard would realize that the score reflects a large public funding component with policy implications; and/or that the technology developed has broad applications in a highly competitive marketplace. The decision to transfer a technology exclusively to a particular company would have to be supported by all the factors that lead to a score of 70 to 90 points.

Table 2a: TECHNOLOGY TRANSFER SCORECARD - R&D FACTORS

OBJECTIVE OF R&D	Support of Public Policy	Technology Development in Support of Departmental Goals	Support of Private Industry
	1	5	10
JUSTIFICATION FOR R&D	Mandated by Legislation	Support Government Priorities	Cost Recovery
	1	5	10
WHO PAYS FOR R&D	100% Public Funds	Cost Shared with Industry	User Pays 100%
	1	5	10
OUTPUTS OF R&D	Non-Proprietary Knowledge	Mix of Intellectual Property and Non-Proprietary Knowledge	Intellectual Property
	1	5	10
BENEFITS OF R&D	Social	Socio-Economic	Economic
	1	5	10
BENEFICIARIES OF R&D	Society-at-Large	Private Sector with Indirect Benefits to Canada	Private Enterprise
	1	5	10

Table 2b: TECHNOLOGY TRANSFER SCORECARD - MARKETPLACE FACTORS

MARKET APPLICATIONS	None	Broad Applications	Single Application
	1	5	10
COMPETITION	None	Extensive	Limited
	1	5	10
ECONOMIC GROWTH	None	Industrial Sector Growth	Single Company
	1	5	10
JOB CREATION	None	Industry Wide	Single Company
	1	5	10

SCORE	TECHNOLOGY TRANSFER OPTION
Less than 30 points	Broad Dissemination of knowledge
30-50 points	Non-exclusive license
50-70 points	License with limited exclusivity
70-90 points	Exclusive/sole license
Greater than 90 points	Transfer of patent rights to company(ies)

Figure 2: SAMPLE TECHNOLOGY TRANSFER SCORECARD

DEPARTMENT/AGENCY: _____

PROJECT TITLE: _____

PROJECT DESCRIPTION:

CRITERIA:

	Brief Statement	Individual Score	Confidence Level [^]
Objective of the R&D			
Justification for the R&D			
Who pays for the R&D			
Outputs of the R&D			
Benefits of the R&D			
Beneficiaries of the R&D			
Applications			
Market Competition			
Economic wealth generation			
Job creation			
TOTAL SCORE			

[^]The Level of Confidence relates to the degree of certainty in assigning a score to a particular criterion, reported as High, Medium or Low.

CASE STUDIES

A number of case studies were selected from government laboratories to test the scorecard. These case studies involved R&D performed under a variety of circumstances and funding scenarios (i.e., a combination of public and private funds). In all cases, technology transfer was involved. The objective was to determine whether the scorecard could serve as a reliable guide for assessing the most appropriate technology transfer pathway for each of the case studies analyzed.

In order to validate the process, a Working Group of technology transfer practitioners from the various government laboratories reviewed the case studies and participated in assigning scores. The scorecard was found to be user-friendly and the process was deemed to be quite straight-forward, with little or no controversy in assigning scores.

A summary of the results is presented in Table 3. Total scores ranged from a low of 21 to a high of 83. The preferred technology transfer pathway is indicated for each case.

With the exception of one case study, the scorecard was deemed to be a valuable tool for decision making. In Case #5, the laboratory in question chose to launch a new start-up company to commercialize the product, even though the score would have indicated an exclusive license to the company that co-funded and co-developed the technology. Hence, exceptions will occur when a laboratory makes an “executive” decision to follow a certain technology transfer pathway not called for by the scorecard.

Case #6 was also considered to be a special case, since it involved a consortium of companies. Therefore, even though the score indicated an exclusive license, the exclusivity applied to the consortium members collectively, as opposed to a single company.

DISCUSSION

Technology transfer is not a single event, but rather a continuum of activities leading to the application of knowledge derived from an R&D project. The most appropriate technology transfer pathway is based upon the best information available at the time the decisions are made. This includes such factors as co-developer(s), technology applications, market competition and extent of economic benefits, to name a few. In essence, a snapshot is taken at a certain point to determine how best to transfer a particular technology.

If another snapshot is taken along the technology transfer continuum (i.e., as the technology evolves), more information may become available that could influence the outcome. For example, new applications for the technology may be found, market competition may increase, new players may become involved.

Table 3: SUMMARY OF CASE STUDIES

Case #	Project Description	Total Score	Preferred Pathway
1	<ul style="list-style-type: none"> • Research was conducted to investigate options to protect water supplies using Best Management Practices suited to farms. • The objective was to inform the public and the agri-food sector of the importance of good quality water. • The government funded the entire program as part of its public policy support mandate. 	21	Broad dissemination (publications, workshops)
2	<ul style="list-style-type: none"> • Joint research with a university was conducted to develop a method for significantly reducing the cost of producing the biopesticide <i>Bacillus thuringiensis</i>. • The government funded the entire research as a departmental priority. • The findings have been patented and published in the open literature. • This technology has extensive applications in the forestry, agriculture and medical entomology. 	48	Non-exclusive licenses to companies interested in commercializing the technology.
3	<ul style="list-style-type: none"> • A joint government-university project aims to develop a hybrid of microwave and optical technologies to create distributed fiber optic sensors and potential new applications in wireless communications. • The project is funded by the government and is expected to yield intellectual property. • Both the university and the government have an interest in commercializing the technology. 	60	Licenses with limited exclusivity (e.g., for specific applications).
4	<ul style="list-style-type: none"> • The world-wide threat of terrorism has precipitated the need to develop blast mitigation and decontamination systems. • Research co-funded by industry and government has led to a unique system with immediate applications in both military and civil first response fields. The system also has applications as a large surface/vehicle decontamination system. • The technology has worldwide market potential. 	77	Exclusive or sole license to the co-developer of the technology.
5	<ul style="list-style-type: none"> • An enhanced method of separating ionized molecules extends the capabilities of mass spectrometers and dramatically increases their throughput. • This technology, co-funded by industry and government, promises to accelerate the development of therapeutic drugs and therapies. • The technology is protected by patents and is expected to create jobs and wealth. 	78	Exclusive or sole license to the co-developer of the technology.
6	<ul style="list-style-type: none"> • A Consortium co-funded by gold producers and government was formed to develop technology to increase gold plant recoveries. • Consortium members applied the proprietary technology to reduce operating costs, extend the life of mines and improve gold recoveries. 	81	Licenses exclusive to consortium members.
7	<ul style="list-style-type: none"> • The government working jointly with a company developed a moored device that could be positioned under moving ice and left for several seasons to collect offshore pack ice thickness measurements. • This technology was needed by scientists and engineers in order to efficiently design offshore structures and ships and to constrain predictions of changes to the Arctic ice sheet with the onset of warming. • The technology has generated jobs and profits for the company. 	83	Exclusive or sole license to the co-developer of the technology.

In applying the Technology Transfer Scorecard to the decision making process, it is important to consider the “Level of Confidence” in assigning each score. A high level of confidence suggests that there is ample information to support the assigned score. On the other hand, a low level of confidence suggests that there is uncertainty in assigning a particular score. A low level of confidence flags the need for more analysis or information to substantiate the assigned score.

Many PROs, particularly universities, are increasingly considering non-traditional technology transfer pathways, such as the creation of spin-off companies to commercialize their technology. In some cases, the creation of a spin-off company is justified by the lack of a technology receptor in the industry. Some PROs also choose this route to play a more proactive role in the commercialization process and to derive greater financial benefits from its success. These decisions fall outside the scope to the scorecard.

CONCLUSIONS

Publicly funded research organizations perform R&D for a variety of reasons and in support of different client groups in both the public and private sector. This can complicate decisions related to technology transfer.

The Technology Transfer Decision Framework is intended to serve as a guide when making decisions about the most appropriate pathway for transferring the outputs of R&D performed by publicly funded research organizations.

The rationale for selecting a particular technology transfer pathway can be quantified by using a simple ‘scorecard’ that allows those involved with the technology to analyze factors that impact on the decision making process. In completing the scorecard, raters can express their level of confidence in assigning a score to a particular criterion. A “low” level of confidence would generally call for more analysis to improve the precision of the score for any specific criterion.

Aside from serving as a guide for decision making, the Framework is also a useful communication tool between researchers and Business Development Officers and provides the justification for selecting one technology transfer pathway over another.

The Framework only serves as a guide since decisions can sometimes be influenced by factors outside the scope of this analysis (e.g., “executive” decisions).

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REFERENCES

1. Crow, M., Bozeman, B., 1998. Limited by Design: R&D Laboratories in the US National Innovation System. *Columbia University Press, New York*.
2. Brand, C.D., 2003, "Availability and Accesibility of the Nation's Research Infrastructure – The Transfer of Assistive Technologies by Federal Laboratories", *Journal of Technology Transfer* **28**(3), 197-205.
3. Lundquist, G., 2003, "A Rich Vision of Technology Transfer - Technology Value Management", *Journal of Technology Transfer* **28**(3), 206-284.
4. Bozeman, B., (2000) "Technology Transfer and Public Policy: A review of Research and Theory", *Research Policy* **29**, 627-655.
5. Cohen, W., Florida, R., Randazzese, L., Walsh, J., 1998. Industry and the academy: uneasy partners in the cause of technological advance. *Challenges to Research Universities*, pp. 171–199.
6. Geisler, E., Clements, C., 1995. Commercialization of technology from federal laboratories: the effects of barriers, incentives and the role of internal entrepreneurship. *Final Report to the National Science Foundation. Department of Management, University of Wisconsin-Whitewater, Whitewater, WI*.

TERMINOLOGY

Beneficiaries of R&D can either be society-at-large, the private sector or a combination of both.

Benefits of R&D are generally classified as being a social (or public good) nature, economic or socio-economic. Examples of social benefits include health and safety, national security, environmental. Economic benefits include industrial growth, job creation, expanded markets.

Competition relates to how many Canadian companies are capable and/or willing to commercialize a particular technology.

Confidence level relates to the degree of certainty in assigning a score to a particular criterion, reported as 'High', 'Medium' or 'Low'. This will help flag criteria where there is a low degree of confidence requiring further analysis.

Cost recovery/revenue generation stems from the recovery of full or partial costs in providing a good, service or use of a facility or from the sale of products.

Cost-sharing involves one or more external participants sharing specified costs of a common undertaking, including providing funds to a third party which actually performs the work.

Economic growth is the amount of industrial activity resulting from the commercialization of a particular technology; it might impact on a single company or multiple companies.

Exploratory R&D involves basic research leading primarily to the advancement of scientific knowledge.

Job creation can either occur in a single company or industry wide, depending on the nature of technology being commercialized.

Justification of R&D is what drives publicly funded research organizations to perform the R&D; e.g., it is mandated by legislation, support government priorities or cost recoverable.

Licensing refers to the transfer of intellectual property to external users under provisions of limited rights and privileges in exchange for a royalty payment.

Long term strategic R&D is conducted in support of national priorities leading to the development of knowledge and technologies aimed at the economic and social well being of Canadians.

Market applications refer to how the technology will ultimately be used; e.g., in a single application or in multiple applications.

New ventures refer to business enterprises that have been created to commercialize a technology developed by a public institution.

Objective of R&D is the purpose behind the R&D; e.g, publicly funded research organizations perform R&D either in support of the public good (e.g., policy support) or in support of private industry; or a combination of both.

Outputs of R&D refers to how the results will be treated; i.e., protected as intellectual property (including proprietary know-how) or broadly disseminated.

Task-sharing applies to work undertaken by one or more external participants in which each party carries out its share of the work in its own facilities, with no money changing hands between the participants.

Technology development refers to R&D performed in support of new and advanced products and processes either for social (e.g., health and safety, environment) or economic benefits.

Technology incubation allows external users to advance a technology towards commercialization by using publicly owned facilities and personnel in exchange for a fee or an equity sharing arrangement.

Who pays for R&D identifies the source of funding, either from the public purse, the private sector or a combination of both.