Defence Research and Development Canada
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A Value Framework for Science and Technology Projects

A Case Study

Greg Luoma
Luoma Tech Inc.

Andrew Vallerand
DRDC Centre for Security Science

Defence Research and Development Canada – Centre for Security Science

Technical Memorandum
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September 2013

Canada

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IMPORTANT INFORMATIVE STATEMENTS

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Abstract

A framework to describe and assess "Value" has been elaborated. Value is taken as associated with "Measures of Impact", measures that many S&T programs wish to be in a position to document from their outputs. Strategically, the framework also distinguishes between *potential value* (available but not exploited and sustained) and *realized value* (exploited by operators or end users) or even *lost value*. To verify and validate this value-based framework, existing data from a Case study, the CBRN Research Technology Initiative (CRTI) Call for Proposals #5-#9 projects have been used. To simplify the task, "Measures of Performance" normally associated with schedule, budget and scope of the project were not included in the assessment to encourage a specific focus on value and the "Impact**"** related measures: the logic that has been applied here is that although a well-managed project is important, if it generates no impact, it provides little value to clients. The premise of this effort is that S&T projects can be not only mapped but assessed for Value based on various measures of "impact" using the present Value Framework approach. Preliminary data from a Case Study of Call for Proposals #5-9 Projects (N=98) of the CRTI program indicate that all of them easily map first and foremost to the 2 types of S&T *Outputs*: documents (i.e. advice) or technology (i.e. sensor). Further, all of the outputs of the above projects easily mapped to one of the 5 Types of Value by considering the following *ontology*: 1) Knowledge/Advice, 2) Building the related Community of Practice, 3) Maturing Innovative Concepts/Technology, 4) Transitioning/Exploiting Innovative Concepts/ Technology, and 5) Support to Special Ops or Major Events with Concepts/Technology. The data analysis also validates the current value framework as a very useful framework to document Value in terms of influence or impact, vis a vis clients and their desired outcomes, regardless if output of the projects was a document or a technology. It is recommended that, as S&T organizations shift their focus from being technology-focused to (client) outcomes-driven, the concept of value and related measures of impact for Projects align well with the documentation of influencing outcomes that matter to client, stakeholder or partner. Finally, it is suggested that the framework is broadly applicable to many government-led S&T programs, provided it reflects the strategic goals of the program, the needs of client, stakeholder or partner and the guidance for S&T investments.

Résumé

Un cadre visant à décrire et à mesurer la « valeur » a été conçu. La valeur est considérée comme étant liée aux « mesures d'incidence », que de nombreux programmes de S et T souhaitent être en mesure de documenter d'après leurs extrants. À des fins stratégiques, le cadre fait également la distinction entre la valeur potentielle (accessible, mais non exploitée ou soutenue) et la valeur réalisée (exploitée par les opérateurs ou les utilisateurs finaux), voire la valeur perdue. Pour vérifier et valider ce cadre axé sur la valeur, les données existantes tirées d'une étude de cas, soit les projets des appels de propositions 5 à 9 de l'Initiative de recherche et de technologie CBRN, ont été retenues. Par souci de simplification, les « mesures de rendement » généralement associées à l'échéancier, au budget et à la portée des projets n'ont pas été incluses dans l'évaluation, afin que l'accent puisse surtout être mis sur la valeur et sur les mesures liées à l'« incidence » : selon le raisonnement retenu ici, si la bonne gestion des projets est importante, les projets qui n'ont pas d'incidence ont peu de valeur pour les clients. Cette approche repose sur la prémisse selon laquelle les projets de S et T peuvent non seulement être mis en correspondance, mais aussi évalués en fonction de la valeur, à la lumière de différentes mesures de l'« incidence » et selon l'approche actuelle du cadre de valeur. Les données préliminaires tirées d'une étude de cas englobant les projets des appels de propositions 5 à 9 (N = 98) du programme de l'IRTC donnent à penser que les projets peuvent tous facilement être classés d'abord et avant tout dans l'une ou l'autre des catégories d'extrants suivants en S et T : documents (p. ex. conseils) et technologie (p. ex. capteur). En outre, tous les extrants des projets susmentionnés peuvent facilement être classés dans l'une ou l'autre des cinq catégories de valeur de l'ontologie suivante : 1) savoir/conseils; 2) établissement de la communauté de pratique connexe; 3) développement de concepts nouveaux ou d'une technologie novatrice; 4) passage à une autre étape ou exploitation des nouveaux concepts ou de la technologie novatrice; 5) soutien des activités spéciales ou d'envergure grâce aux concepts ou à la technologie. L'analyse des données valide le cadre de valeur actuel, confirmant qu'il est grandement utile pour documenter la valeur mesurée, en termes d'influence ou d'incidence pour les clients ou eu égard aux résultats attendus par ces derniers, que le résultat du projet soit un document ou une technologie. À mesure que les organismes de S et T deviennent moins centrés sur la technologie et misent davantage sur les résultats (pour les clients), il est recommandé que le concept de valeur et les mesures d'incidence des projets qui y sont liées cadrent bien avec la documentation des résultats déterminants auxquels les clients, les parties prenantes et les partenaires accordent de l'importance. Enfin, il semble que le cadre soit largement applicable à un grand nombre de programmes gouvernementaux de S et T, étant donné qu'il tient compte des objectifs stratégiques des programmes, des besoins des clients, des parties prenantes et des partenaires, ainsi que de l'orientation des investissements en S et T.

Executive summary

A Value Framework for Science & Technology Projects: A Case Study

Greg Luoma, Andrew Vallerand; DRDC CSS TM 2013-013; Defence R&D Canada – Centre for Security Science CSS; September 2013

While completing a project on time and budget within scope is very important, by itself, it may not automatically provide "value" to the client, stakeholder or partner. Value to the client, stakeholder or partner is normally found when the outputs are exploited, sustained and have impact, though we normally tend to focus on the performance aspect of project management, not necessarily its effectiveness or value.

To address this gap, a framework to describe and assess "Value" has been elaborated. It is associated with some "Measures of Impact", in line with the "influence" that many S&T programs wish to document. The framework also distinguishes between *potential value* (available but not exploited and sustained) and *realized value* (exploited by operators or end users). To verify and validate this value-based framework, existing data from the CBRN Research Technology Initiative (CRTI) Call for Proposals #5-#9 projects have been used as a Case Study. To simplify the task, **"**Measures of Performance**"** related to schedule, budget and scope of the project were not included in the assessment to focus on value and related "Measures of Impact", as described above. The premise is that S&T projects can be assessed for value, potential and realized, using the present Value Framework approach and secondly that the value of Outputs (from S&T projects) in the hands of end-users is related to "Measures of Impact".

For the present case study, the following *ontology* was considered. Preliminary data from Projects from Call #5-9 (N=98) of the CRTI program indicate that all of them easily map to first and foremost the 2 types of S&T *Outputs*: documents (i.e. advice) or technology (i.e. sensor). Further, all of the outputs of the above projects easily mapped to one of the five Types of Value**:** 1) Knowledge/Advice, 2) Building the related Community of Practice, 3) Maturing Innovative Concepts/Technology, 4) Transitioning/ Exploiting Innovative Concepts/Technology, and 5) Support to Special Ops or Major Events with Concepts/Technology. Five different Measures of Impact were also found to be closely associated with Value. Each measure of Impact used a scale of 3 simple degrees to score each project ("Good"; "Improve"; "Not so Good"). The data indicate that about half of the projects have already gone beyond *potential value* to *realized value* by having already added capability or capacity to clients, stakeholders or partners; by the same token, it also indicated that about half only achieved Potential value, whereas only a few had lost value. Regrettably, a total of about 38% of Projects did not document well the potential or *realized value*, suggesting that a change in staff behavior may be required going forward to better document and communicate value to facilitate exploitation. A total of about 33% of projects produced an exploitation plan that needed "to be Improved" and that was simply "Not so Good". Pleasantly, it was also found that a number of mature innovative technologies from closed projects could still be exploited.

In conclusion, preliminary data analysis of this case study indicates that the current value framework is a useful framework to document value in terms of influence or impact, vis a vis

clients and their outcomes, regardless if the output of the projects was a document or a technology. It is suggested that consideration be given to having partners assess projects by including measures of Impact. It was found that focusing on Value and Impact, probably represents a close link to documenting an influence on outcomes. This is important for programs that are outcomes-driven. However, a more rigorous analysis is required to reveal additional insight into different metrics, impacts and communities. It is recommended that, as S&T organizations shift their focus from being technology-focused to (client) outcomes-driven, the concept of Value and measures of impact seem to align well with influencing outcomes that matter to clients, stakeholders or partners. Finally, the framework is generally applicable to any government-led S&T programs, provided it reflects the strategic goals of the program, the needs of stakeholders, operators and end users and the guidance for S&T investments.

Sommaire

A Value Framework for Science & Technology Projects: A Case Study

Greg Luoma, Andrew Vallerand; DRDC CSS TM 2013-013; Recherche et développement pour la défense Canada – Centre des sciences pour la sécurité; Septembre 2013

Si le respect de l'échéancier et du budget du projet est crucial, il n'est pas en soi garant de « valeur » pour le client, la partie prenante ou le partenaire. La valeur, aux yeux du client, de la partie prenante ou du partenaire, existe généralement lorsque les extrants sont exploités, qu'ils sont soutenus et qu'ils ont une incidence. Or, en gestion de projets, ce sont généralement les aspects liés au rendement qui retiennent l'attention, et pas nécessairement l'efficacité ou la valeur.

Pour combler cette lacune, un cadre visant à décrire et à mesurer la « valeur » a été conçu. Il est lié à des « mesures d'incidence », lesquels cadrent avec l'« influence » que de nombreux programmes de S et T souhaitent pouvoir documenter. Le cadre fait également la distinction entre la valeur *potentielle* (accessible, mais non exploitée ou soutenue) et la valeur *réalisée* (exploitée par les opérateurs ou les utilisateurs finaux). Pour vérifier et valider ce cadre axé sur la valeur, les données existantes associées aux projets des appels de propositions 5 à 9 de l'Initiative de recherche et de technologie CBRN ont été retenues à titre d'étude de cas. Par souci de simplification, les « mesures de rendement » liées à l'échéancier, au budget et à la portée des projets n'ont pas été incluses dans l'évaluation, afin que l'accent puisse surtout être mis sur la valeur et sur les « mesures d'incidence », que nous venons de mentionner. Cette approche repose sur la prémisse selon laquelle, d'une part, les projets de S et T peuvent être évalués en fonction de la valeur potentielle et réalisée, au moyen de l'approche actuelle du cadre de valeur, et, d'autre part, que la valeur des extrants (des projets de S et T) se trouvant entre les mains des utilisateurs finaux est liée aux « mesures d'incidence ».

Aux fins de la présente étude de cas, *l'ontologie* suivante a été retenue. Les données préliminaires des projets issus des appels de propositions 5 à 9 du programme de l'IRTC donnent à penser que, d'abord et avant tout, ceux-ci peuvent tous être classés dans l'une ou l'autre des catégories *d'extrants* suivants en S et T : documents (p. ex. conseils) et technologie (p. ex. capteur). En outre, tous les extrants des projets susmentionnés peuvent facilement être classés dans l'une ou l'autre des cinq catégories de valeur suivantes : 1) savoir/conseils; 2) établissement de la communauté de pratique connexe; 3) développement de concepts nouveaux ou d'une technologie novatrice; 4) passage à une autre étape ou exploitation des nouveaux concepts ou de la technologie novatrice; 5) soutien des activités spéciales ou d'envergure grâce aux concepts ou à la technologie. Cinq mesures distinctes de l'incidence semblent également être étroitement liées à la valeur. Chacune repose sur une échelle de trois degrés permettant de classer simplement chacun des projets selon leur incidence (« Bon »; « À améliorer »; « Pas très bon »). Les données révèlent qu'environ la moitié des projets sont déjà passés de l'étape de la valeur potentielle à celle de la valeur réalisée, ayant déjà contribué à accroître les moyens ou la capacité des clients, des parties prenantes ou des partenaires; elles révèlent aussi qu'environ la moitié des projets en sont encore au stade de la valeur potentielle, et que seulement quelques-uns ont entraîné une perte de valeur. Malheureusement, la valeur potentielle ou réalisée n'a pas été bien documentée pour environ

38 % des projets, ce qui donne à penser qu'il faudrait modifier le comportement du personnel afin de mieux documenter et communiquer la valeur à l'avenir, et de faciliter l'exploitation. Environ 33 % des projets ont généré un plan d'exploitation « À améliorer » ou tout simplement « Pas très bon ». Agréablement, il en ressort également qu'un certain nombre de technologies novatrices éprouvées qui sont issues de projets terminés pourraient encore être exploitées.

En conclusion, l'analyse des données préliminaires valide le cadre de valeur actuel, confirmant qu'il est grandement utile pour documenter la valeur mesurée, en termes d'influence ou d'incidence pour les clients ou eu égard aux résultats attendus par ces derniers, que le résultat du projet soit un document ou une technologie. Nous proposons qu'il soit envisagé de demander aux partenaires d'évaluer les projets en se servant de mesures d'incidence. Il a été établi que le fait de miser sur la valeur et sur l'incidence permet probablement d'établir un lien étroit avec la documentation d'une influence sur les extrants. Voilà qui est important dans le cas des programmes axés sur les résultats. Cela dit, une analyse plus rigoureuse devra être réalisée pour faire ressortir d'autres données concernant différentes mesures, incidences et communautés. À mesure que les organismes de S et T deviennent moins centrés sur la technologie et misent davantage sur les résultats (pour les clients), il est recommandé que le concept de valeur et les mesures d'incidence des projets qui y sont liées cadrent bien avec la documentation des résultats déterminants auxquels les clients, les parties prenantes et les partenaires accordent de l'importance. Enfin, il semble que le cadre soit largement applicable à un grand nombre de programmes gouvernementaux de S et T, étant donné qu'il tient compte des objectifs stratégiques des programmes, des besoins des parties prenantes, des opérateurs et des utilisateurs finaux, ainsi que de l'orientation des investissements en S et T.

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1 Background and Context

Enhancing the value from S&T investments by ensuring that they stimulate economic growth and prosperity is a major policy platform of the current federal government. Most government agencies that invest in S&T are currently determining ways to achieve greater value from their investments when measured against these parameters. However, value can be realized in a number of ways, depending on the role and mandate of the organization, and the scope of the investment program.

Most recently, reports from Jenkins suggested that value is generated and realized when the outcome of the government investment generates wealth and opportunity for the private sector, particularly for Small and Medium sized Enterprises (SMEs) (Jenkins, 2011, 2013) . In this role, government investments support industry leadership in developing new products, capabilities and technology. However, this is but one view of value based on an industry position that it is the primary driver of productivity improvements, economic growth and prosperity in Canada. It should be noted that recently the National Research Council of Canada announced a profound transformation of their business line by moving in broad terms, from S&T discovery (mostly at Technology Readiness Level (TRL) 3) (European Space Agency, 2008) to prototypes and products (at TRL 7-9) ready for exploitation and commercialization by Industry (National Research Council of Canada, 2013). This represents a shift from pure research to economic development, with products that have value (i.e.: the quality that renders something desirable or valuable) for those who need them. Another organization that has obtained outstanding successes with transition of innovative and disruptive technologies is Defence Advanced Research Program Agency (DARPA, 2000). The enormous success of DARPA has been measured historically by the transition of its concepts and technologies into military capabilities in the hands of U.S. Armed Forces. Interestingly, most successful projects seemed to harness at first, the ingredients for high impact, very high user support of the innovative/disruptive technology, solid exploitation plan with global market analysis, culminating with both a very high "Return on Investment" (i.e.: Output/its Cost; Investopedia 2013) and a very high "Return on Innovation" (i.e.: Impact/its Cost; Goldense Group, 2013)[1] , all measures discussed below are in line with solid business innovation (DARPA, 2000).

In some cases, government investments in S&T also provide great value if they develop capabilities and capacity to deal with unique, high impact events that undermine public safety, security and confidence. Thus government must utilize S&T investments to increase the capability and capacity to prepare for, prevent, protect, respond to and recover from criminal activities, terrorist events or major natural occurring emergencies, even if the solutions are not commercially viable. In other words, in some cases government must lead in developing new concepts, technologies, products and capabilities if it is in the national interest to do so. Moreover it is incumbent on government to do so for those instances where the national safety and security is at risk and there is no effective commercial means to acquire the needed capability and capacity, as one example.

[1] Note: there is no present consensus of terms such as "Return on Investment" and "Return on Innovation"; as such they are loosely used here for the sole purpose of contrasting one to the other

Therefore, the ideal S&T investments serve both major value objectives, but this is often not possible in public safety and security, where the potential market for the outputs is small or inconsistent. Thus, value assessments for the S&T investments must determine whether value was created relative to the defined roles and mandates of the organization, with support to industry as only one of a number of measures of effectiveness. Thus a framework for measuring value must be flexible to accommodate a variety of types of S&T investments that may or may not have commercial outputs, but will always address the national capability and capacity to address events that impact the military, public safety and security or other. Such frameworks for Value represent a gap that needs to be addressed.

2 Methods: A Value Framework for S&T Projects

An effective value measurement framework must incorporate subjective and objective criteria that describe the type and degree of value produced by the projects and activities that are undertaken in the program, particularly with respect to how the outputs have impacted operational capabilities and capacity. Further, some value criteria should measure the effectiveness of the delivery approaches in achieving the desired outcomes within the constraints imposed on the program by the need to accommodate the individual and shared priorities of government agencies, a small number of allowed delivery methods, and a limited budget. Therefore, a value measurement framework will ultimately by design serve as a broad index of "Return on Innovation" as opposed to a more simple Return on Investment (Anthony, 2013) for stakeholders within the constraints of the governance structure, mandate, scope and processes used to formulate and execute the program. In many ways, this could be viewed as a strategic effort to ensure that S&T efforts are better aligned on the key drivers of value for clients, stakeholders or end-users.

Value can also be measured as either *potential* or *realized* depending on whether the output was exploited by operational personnel and other end users. In some cases, a project can also present a *lost value* and this should be captured. This is a fundamental but often overlooked distinction in value. It should be noted that S&T **Outputs** will normally be either a *Document* or a *Technology*. If the output is knowledge or advice contained in a report, then value is realized if the knowledge in the document was transferred and/or taken up by operators or end users to formulate policy for example. If the output is a tangible Technology, product or capability then value is realized if it is transitioned (in the hands of users as a left behind) or operationalized (used in client Operations) or commercialized or used in Major Events or Special Operations. If the output is supporting Operations (client or more special Operations) then the value is realized through improved operational readiness or planning capability, or reduced risk during such operations. It is important to highlight that sometimes one does not need a large multi-million dollar, multi-year project to accomplish either a high "Return on Investment" or a "Return on Innovation". Case in point, it was noted that in the subject case study, when a low cost S&T effort with a mature high TRL technology and with a focus on value for its Interdepartmental clients was integrated into Ops, it changed national capability for Border Security between Ports of Entry and it changed the related Support to Ops during Special Ops such as G8/G20 when the technology improved surveillance and interdiction (Meunier & Vallerand 2010). Finally, if the output is to build national capacity through support to Communities of Practice then the value is realized through supporting workshops, creating sustainable collaborations, and delivering new or additional capabilities that support national responses to public safety and security events. This is another good type of value that can be generated.

Within the limited scope of this effort, the goals of this study are first and foremost to develop a framework to assess Value in S&T projects. Secondly, it is the intent of this effort to develop ways to identify activities with the highest *potential value,* activities with the highest *realized value* and report and communicate the value in the right way for each stakeholder group so that they can capitalize (i.e.: act) on that value. Thirdly, it was the intent of this study to verify and validate the Value framework with a number of case study projects of interest. Thus, measurable

criteria must be developed that allow a wide variety of activities to be compared and evaluated for their relative value propositions. In addition, changes to the governance, delivery processes and communication practices may be needed to maximize value on the client side, as changes in behavior in the S&T Program staffs may also be required to maximize not only the exploitation but the sustainment of the newly documented value. Together these constitute a new strategic framework of interest for S&T programs.

2.1 Various Types of Value

As mentioned above from the two known types of deliverables, document or technology, and with the present ontology, we are considering five types of value provided by S&T deliverables (outputs). In order to quantify each type of value, subjective and objective measures are required to enable comparisons of broad areas of technology, large variations in size and scope of projects and activities, and wide varieties of output types. As mentioned above, the common focus of these comparisons is determining whether the output was exploited by operators, end users or stakeholders to generate improved capability or capacity to act in their domain of interest.

Table 1 documents how the five types of value (from any outputs) can be rated from *potential* to *realized value* (potential, medium, high) based on the mandate of the program in question. Evidence for the various types of value and degrees of *potential* to *realized value* is discussed in more detail below.

Table 1 Ontology of five (5) Types of Value Further, three (3) Degrees of Lost-to-Potential-to-Realized Value for each of these 5 various types of Value are shown. Though "Realized value" is evaluated and measured as a whole, we have presented here (only) language that illustrates what a more highly realized value might look like; "realized value "is still taken and measured as one in the Results Section below.

Ontology for Type of Value from either Document or Technology as Outputs	**Degrees of Value: from Lost to Potential to Realized**			
	Lost Value	***Potential Value***	***Realized Value***	***Realized Value (Highly)***
1) Knowledge / Advice	nil	Reported	Given or Transferred	Implemented into policy / doctrine, etc.
2) Community of Practice Building	none	Community created or maintained	Sustainable collaboration in Community	National capability created or grown in Community
3) Maturation of Innovative Concept/Technology	nil	Created or advanced	Evaluated in operational role	Available, as Off-the-Shelf, or other
4) Transitioning, operationalizing, or commercializing	none	Transitioned: left behind or Tested and proven mature	Operationalized: Supported in client Operations	Sustained through commercialization

		for service		
5) Support to Operations with a CONOPS or Special Ops or Major Events with Concept/Technology	none	Recommended for Special Ops (Olympics, Afghanistan, etc.)	Participated in Special Ops and/or with a 'CONOPS' for use	Increased readiness or reduced risk

1) The Value of *knowledge, advice and expertise* is usually measured in terms of the impact it has on policy and doctrine along with planning for public safety and security events. The output that normally generates this type of value is a Report. Some examples of measures of value are:

- Improved operational policy, doctrine and preparedness supported by documentation;
- Reduced risk for operations to be undertaken by stakeholders;
- Recognition and awards from stakeholders, and
- Publications in peer-reviewed journals and presentations at international forums.

2) The Value of *building Communities of Practice* is usually demonstrated through increased sharing of information, capability and best practices among experts and agencies across Canada, along with ensuring the availability of key capabilities throughout the country (capacity building). The output that normally generates this type of value is a Report, a Web Portal, an enduring collaboration or a Technology (Centre of Excellence?). The Effectiveness of building the Community can be measured by:

- Sponsorship of workshops to enable sharing of information, development of road maps, etc.;
- Creation of new and/or enduring Communities or collaborations that share/develop knowledge, capabilities and best practices;
- Development of joint concepts, protocols or approaches to solving public safety and security problems;
- Providing first look at new capability through "first buys" Investments; and
- Engaging stakeholder and operators to increase end user operational knowledge and capacity.

3) The Value from *developing and maturing concepts,* technology, products and capabilities can be measured in many ways, most of which require feed-back from operators, end users or industry. The output that normally generates this type of value is a Report that documents the gain in maturity or an innovative technology at a higher TRL and/or a prototype-level product, technology or capability that can be considered for acquisition by operational end users. Some measures include:

- Publications in journals for low maturity technology (below TRL5) (RD projects);
- Evidence (through operator interest in transitioning the output) that the project or activity could be starting to close a capability gap or meet an operational need;

- Leave behind capability for mature technology (TRL 5-7) (TD projects); and
- Superiority of technology or capability over existing/competing technologies and capabilities.

4) The Value from *transitioning, operationalizing, or commercializing* critical concepts, technologies and capabilities is realized when there is "client-market pull" to ensure that the output or outcome is adopted for policy or service by end users, operators, industry or other stakeholders. The output that normally generates this type of value is a Report that documents the depth of the exploitation or an innovative technology being exploited and a mature concept, product, technology or capability that is ready for acquisition and has a positive impact on operations. It can be measured through:

- Activities to demonstrate effectiveness in realistic operational scenarios (TRL7-8), preferably customer driven;
- Implementation of the concept, technology, capability by at least one operator champion; and
- Industry interest and support for commercialization of the technology, product or capability.

5) The Value of *Support to Operations with a CONCOPS or support to Special Operations* and Major Events with concepts or technology is generally measured in terms of the impact the support has on planning or success for Ops or Major events or providing unique experience and expertise during the events that reduces risks during an event. The output that normally generates this type of value is a Report that forms part of future planning for operations, direct technical support that becomes part of normal CONOPS, or the provision of Innovative Technology that is now regularly employed with a CONOPS in such Ops or Special Ops. This category exists for the sole purpose to recognize the paramount importance of supporting Ops with a recognized important CONOPS or supporting Major Events like Afghanistan, Olympics, which is the "raison d'être" of many S&T programs. Thus such value can be measured in terms of:

- Considered of enough National/International value to support Special Ops such as Olympics, Afghanistan etc.;
- Size and scope of improvements to a) Ops effectiveness, b) cost of operations, c) planning and d) policy;
- Reduction in risk to individuals/infrastructure during events, backed by objective evidence; and
- Demonstrable improved approaches to planning and preparedness for operations, especially special events, including a formal 'CONCOPS' (Concept of Operations).

While some of the above measures are objective, most require interpretation by experts and stakeholders to determine the extent and level of the value that was realized by the project or activity. Therefore, specific examples should be used where the activities or projects created value and they should be confirmed with stakeholders

2.2 Aligning Value with Strategic Goals and Client/Stakeholders Outcomes

The values of projects and activities undertaken by any S&T program must also be measured by through their alignment with the strategic and intermediate outcomes that form the mandate of the program. Many programs would be expected to influence 'clients' outcomes through investments in S&T, provision of advice, knowledge and expertise, and support to Communities (as appropriate) and to capacity building, etc. This provides the link between the desired outcomes and the outputs of the individual projects and activities that should produce the value.

Any other government-led S&T programs will have its own set of strategic outcomes that should be linked in a similar way to a set of outputs that produce the value. Thus they are all consistent with the types of value described above while providing the context for determining the priorities for investments and measuring the degree to which individual projects and activities have succeeded in producing value. Essentially the overall "Return on Innovation" (Impact relative to cost) for any government-led S&T program (sum of the individual value measurements) should measure the success of the S&T investments in meeting three objectives:

- Alignment to Strategic goals of the program;
- Meeting the needs of stakeholders, operators and end users described in the previous section; and,
- Whole of government guidance on the role of S&T investments as described in the Jenkins report.

Programs should adjust the measures of value so that the "Return on Innovation" matches the strategic objectives of individual programs. However, since most government led S&T programs have objectives that are similar in nature in the sense that they support their client, stakeholder and end users, the guidelines above for developing measures of Value as index of "Return on innovation" may apply. Thus the framework described in this study is viewed as and considered generally applicable to government-led S&T programs.

2.3 Measurement of Value

The discussion above suggests that most S&T efforts can benefit from a number of similar measures to determine if some type value has been produced. Outputs of projects and activities can also be assessed for their potential to produce *realized value* using a combination of measures supported with evidence. What is implied is that from the outputs of most S&T programs produce many types of value, many measures, and each measure has a scale of several degrees. For the present effort, we are considering : a) five types of value (shown above), b) five measures of value (described below) and c) each measure is assessed by a scale of three degrees ranging from "Good" (Green), to "Improve" (Yellow) and "Not so Good" (Red). Such language was judged somewhat more appropriate for the purpose and more 'meaningful' than the same 3 point scale represented by the terms "high", "medium" and "low". It is assumed that this simple framework is sufficient to assess all projects and activities. Using this approach therefore, high degrees on all five measures of value would be an indication that the value has progressed beyond potential toward *realized value*. Conversely, low degrees on two or more measures of value

would indicate that the project or activity is unlikely to produce *realized value*. It is important to note that this framework describe and assess "Value" in line with the "Impact" that many S&T programs need to address (3SL, 2013).

1) The first measure of the value is the *"breadth and depth of impact on operational capability or capacity*". While this is a subjective measure it should be supported by objective evidence from stakeholders, operators or Communities of Practice. If the output of the project or activity does not address a real operational need, preferably confirmed by more than one operator, then the value is reduced. Some evidence of impact on operations might include:

- Outputs directly increase the capability or capacity of one or more operator(s) or end user(s);
- Changes to policy, doctrine or operational plans are based on knowledge or advice provided;
- Operational planning and/or implementations are positively impacted by the outcome; and
- The output produces a demonstrable increase in the capability and/or capacity to address specific operational events within the mandate of the program.

2) The second measure of value is the "*amount of stakeholder, operator or end user support for the activity and its outputs"*. This can be supported by evidence that stakeholders or operators have:

- Supported and participated in the project or activity as it was being completed;
- Accepted and (preferably) implemented outputs such as recommendations, advice, protocols, capabilities and/or products;
- Used or contributed to sustainment of a "left behind" capability in an operational role;
- Transitioned the outputs (particularly "left behind" capability) directly to service; and/or
- Initiated a procurement or plan to acquire and support the output of the project.

3) The third measure that identifies value is a "*realistic plan to exploit or continue to mature the technology, product, capability, advice, operational support or capacity, with the support of the right stakeholders"*. Some evidence that exploitation plans are in place are:

- Description of how the advice, knowledge or support will be used in follow-on operations, policy or doctrine development;
- A plan to further the technical maturity of the output of the activity so that it can be transitioned to service; this could include a plan for Operational Test & Evaluation under realistic field conditions.
- A sustainment plan supported by industry partners, stakeholders and/or operators;
- A commercialization plan to offer the output to many customers, preferably inside and outside Canada; and
- Identification of a first customer who intends to acquire and/or adopt the output.

4) The fourth measure linked to value is whether the "*important outputs of projects and activities have been reported and communicated effectively to the right stakeholders, operators, end users and partners"*. Evidence of effective communication is provided by:

- A communication strategy and road map that identify the stakeholders, communications and time frame for distribution;
- Availability of documents describing the outputs that are appropriate for a variety of audiences;
- Distribution lists for key documents with confirmation of distribution;
- Follow-on requests from stakeholders based on documentation sent to them; and
- Recognition by stakeholders such as operators and end users that communications from the CSSP program have been used in making policy, doctrine and/or acquisition decisions.

Report of the Value and Communication of the Value of the report are very important in realizing the full value from projects and activities, and failure to inform the appropriate audiences will usually lead to poor levels of engagement and weak exploitation. An example of this concept is the incorrect belief that advice contained in a 300 page report is considered "advice given" even if it was not distributed to all key stakeholders. Normally, if one desires to be recognized for having their "advice taken", there should be evidence that "advice was given" in the first place.

5) The fifth measure of value is the "*level of the impact of the project or activity on policy, doctrine, Communities of Practice or Operations relative to the level of investment". The measure essentially describes the "efficiency"* of the activity in producing the output by taking the magnitude of the impact from Measure 1 and amortizing it against the level of effort expended. While the more simple "Return on Investment (ROI)" only measures the output relative to the cost, other measures can be used to determine the "Return on Innovation", a more interesting measure of efficiency that does focus on impact over cost , not just the output over cost. Thus, evidence for this measure of value can be presented in terms of:

- Return on Innovation – "Impact over cost of effort", which is quite different than the more well-known Return on Investment – "Output over cost of effort";
- Return on technical investment – potential to create major shifts in policy, doctrine, operational capabilities or capacity relative to the level of effort;
- Potential to have broad impact on the cost or time required to plan for one or more special events or to implement new protocols, policy, etc.; and
- Potential to produce key risk reductions in planning or operations (e.g. loss of life or confidence in government) that cannot be quantified in cost or time.

Note that each measure of impact is assessed by degrees ranging from "Good" (Green), to "Need to Improve" (Yellow) and "Not so Good" (Red); (see below). Once the measures of value are identified and assessed, the overall potential (for on-going efforts) or realized (for completed efforts) value can be assessed for each project and activity. Potential value should be assessed at regular intervals so that changes can be implemented when needed to ensure that the project or activity has the best opportunity to provide the greatest value. In addition, the assessment process

should be used to identify additional activities or actions that can be implemented to increase the value that is realized from the efforts as they are completed or soon after completion.

2.4 Evidence to assess Degrees of Value from *Potential* and *Realized* Value

To ensure that the potential or underlying value of a project or activity is realized, it must be captured, and hopefully exploited and sustained. This can be achieved in some cases by simply preparing a comprehensive report of the activity and outcomes and presenting them to the appropriate stakeholders. In other cases, such as when the output is a maturing technology or capability, the full value can only be realized if the technology or capability is transitioned to service, operationalized or commercialized. In many cases sustaining the technology or capability after the development activity or project is complete is a major issue affecting realized value. Thus, to realize the full value from projects and activities, additional activities are often required. This makes the close-out process a critical element in ensuring that value is realized for most projects and activities. Alternatively and likely rarely, value of a transaction can also be lost (incomplete or early termination of a project for instance).

Three lines of evidence measure how well the value has been realized (captured, exploited and sustained) have been identified. One can already appreciate the value of Communication here, as lines get blurred between captured, exploited and sustained, unless the evidence is communicated appropriately.

1) The first level of evidence that indicates that there is "*some potential value to be realized*" from the project or activity requires that the outputs were properly documented and delivered to key stakeholders and/or operators that could benefit from them. Preferably the documentation is provided to stakeholders, operators and end users with the appropriate level of technical detail and operational impact statements that facilitate understanding and appreciating the value operationally. Evidence would be presented in the form of:

- Final reports and other communications with the appropriate distribution lists;
- Requests for feed-back from stakeholders and operators on what they are doing with the "left behind" capability, influence from completed efforts, and interest in follow-on activities;
- Receipt and distribution of final reports from contractors that triggered release of hold-backs;
- Logs of time allocated to supporting operations, activities completed, and consequences;
- Reports on participation and input to operational planning or execution; and
- Awards and positive feed-back from operational staff on the value of the input.

2) The second level of evidence that indicates a *"moderate degree of value has been realized"* from projects and activities requires that the outputs (the "left-behind" capability) were delivered and utilized by stakeholders, operators or end users. While left behind capability does not require investment by the recipient, the fact that operators and end users are making use of it indicates

that it addresses an operational need and is appropriate for field use. The left behind capability does not have to be a technology or product but can also be knowledge, capacity, new expertise, etc. The value realized from the left behind capability would be demonstrated as:

- New knowledge, advice or expertise that supports policy, doctrine or operational planning at the request of an operator or end user;
- Field trials or exercises with participation of operators or end users to demonstrate the impact of the new technology or capability in operational environments;
- A prototype technology or capability left behind for the end user in the project that enters into service;
- Improved operational expertise or capabilities that are directly the result of a CSSP project or activity.

3) The third level of evidence that indicates *"high realized value"* is often equated with more mature outputs (TRL7) (or equivalent) of activities and projects, where the output is operationalized or commercialized with the support of operators, end users or industry partners. The willingness of operators, end users and industry partners to contribute to the development costs demonstrates a high level of commitment to implement, support and sustain the output of the project or activity. Mature outputs at Technology Readiness Level (TRL) 7, 8, 9 should produce this level of realized value. However, high value can also be measured for knowledge, advice, expertise or support if it leads to the development of new doctrine, policy, or fundamental improvements in operational planning and execution. High realized value could be demonstrated in the form of:

- Implementation of knowledge or advice as new doctrine, policy or approaches that impact operational effectiveness or safety;
- Commercialization plans and/or new technology products and capabilities that are led by an industry partner in the project or activity;
- Successful adoption, acquisition and/or sustainment of the outputs of the activity or project by at least one stakeholder or operator;
- Successful participation in planning and field support to special events or other real operations;
- Follow-on activities at the request of an operator that lead to successful operationalization or commercialization such as first buys or commercialization support; and
- Plans to integrate the output of the project or activity (e.g. workshop) with in-service doctrine, equipment or capabilities to exploit its potential value more fully.

When this level of success is achieved for a project or activity, it should be promoted extensively within the operational and stakeholder community to build support for the program and increase the engagement of operational staff, end users and industry.

The value spreadsheet in Table 2 provides a means to tabulate the value assessments of projects and activities. It can also be used to document the lost, potential and realized values from activities that were completed as long as sufficient details and records are available to quantify

what work was completed and how it impacted stakeholders. The use of color coding makes it easy to visualize and differentiate those projects which have realized maximum value from those that have high potential value that has not been realized yet. Further, it provides a means to direct actions and document follow-on activities that have been or are being undertaken to increase realized value. Thus this analysis provides a quick and pragmatic means to track the success, the impact the value of the individual projects and activities as part of the larger program.

The examples or case studies in Table 3 below show the application of the value framework to a portion of the program now known as the CRTI Program. In order to validate the present Value Framework, Eight CBNRE experts from Government and Industry with intimate, long and broad knowledge of the CRTI program were used to apply the value framework to 98 projects from CRTI Call for Proposals #5-9. The resulting chart is shown below in Results.

Table 2: Value Framework: Example of the Framework of value assessment for an S&T program, as documented in the spreadsheet below project by project from the Case Study known as the CRTI program Calls for proposal #5-9. See Methods for the description of the Ontology considered, for the definition of the 5 types of Value created, for the definition of the 5 types of Measures of Impact, for the definition of the simple assessment of degree of value scale, and finally for the assessment scale of potential to realized value, or lost value.

Project #	**Types of Value Created: 1) Advice, 2) Build CoP, 3) Mature Tech, 4) Transition, 5) Support to Ops**	**Value Assessment through some Measures of Impact (Good=Green, Improve=Yellow, Not so Good=Red)**					**Degree of Value: Realized (Green), Potential (Yellow), Lost (Red)**	**Notes: Summary of key Statement Actions/Activities to Increase Realized Value**
		Operational impact (degree)	Stakeholder/end user support (degree)	Realistic Exploitation plan	Communication (was advice or tech formally given & communicated)	Impact Relative to Level of Investment		
CRTI 05-0092TA	3) Maturing technology	GOOD	GOOD	NEED TO IMPROVE	NOT SO GOOD	NEED TO IMPROVE	POTENTIAL	Need better communications of Value of results to potential users. Need commercialization plan/partner to realize full value

3 Results

3.1 Overall assessments of Value through the present Value framework

Ninety-eight Individual projects files were located, all from the CRTI Call for Proposals #5-9. These 98 projects were used to assess the type of value that was to be generated by their execution, and this was assessed by eight CBRNE Experts from Government and Industry, all with intimate knowledge of the CRTI Program. All had access to experts and publications or other existing project records.

The results indicate first and foremost that all projects could easily fit inside the current framework of 5 types of Value. It was also found that of the 5 types of VALUE, a relatively equal distribution is found across almost all of them, though the larger percentage is pleasantly found in "Support to Ops" (29%). By the same token, a high percentage of projects was supporting "Community of Practice Building" (9%) and "Maturing of Innovative Technology" (28%), where together (37%) their influence or impact may be somewhat delayed and not immediately at hand (Fig. 1).

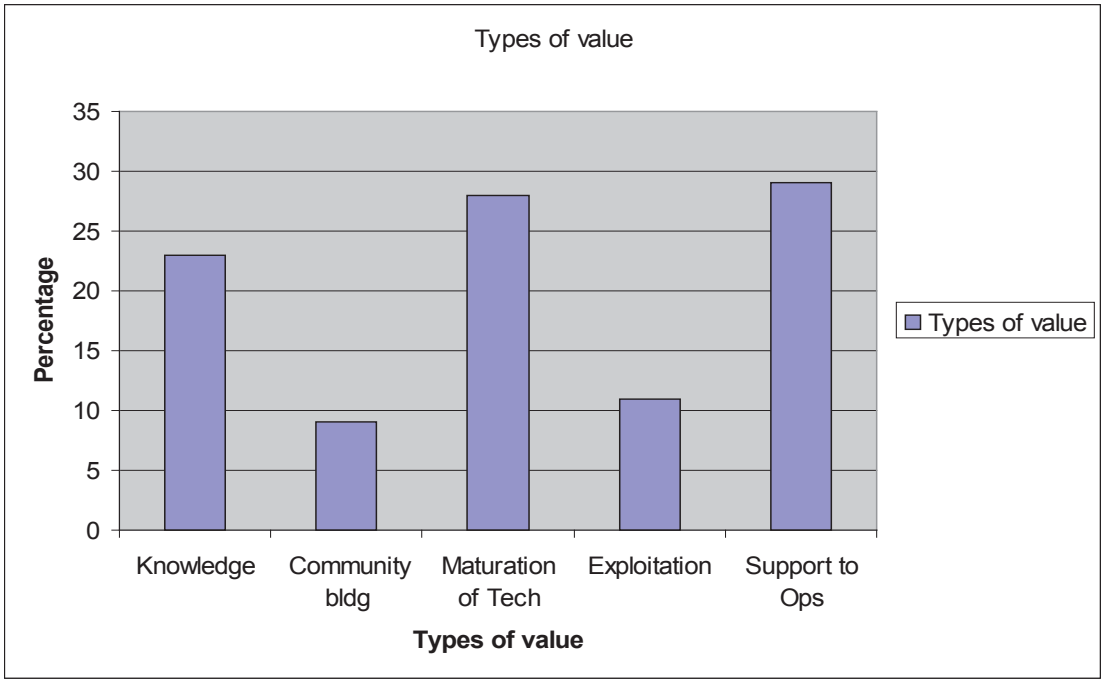

Figure 1 Percentage of projects supporting the 5 different types of value

Since about 26 projects had incomplete data sets for the present purpose and 4 projects were regrettably terminated while in progress, 68 projects with full data sets were used in the present analyses. They are analyzed below.

Regardless of the type of value targeted, it was reported that most projects (76%) produced a broad operational impact of some type, with a small fraction (24%) only that indicated a "need to improve" on that topic (Fig 2). Similarly, it was reported that most projects seemed to be associated with a "good" Stakeholder/End user support (88%), with only a very small fraction (11%) requiring "improvement" (Fig 3).

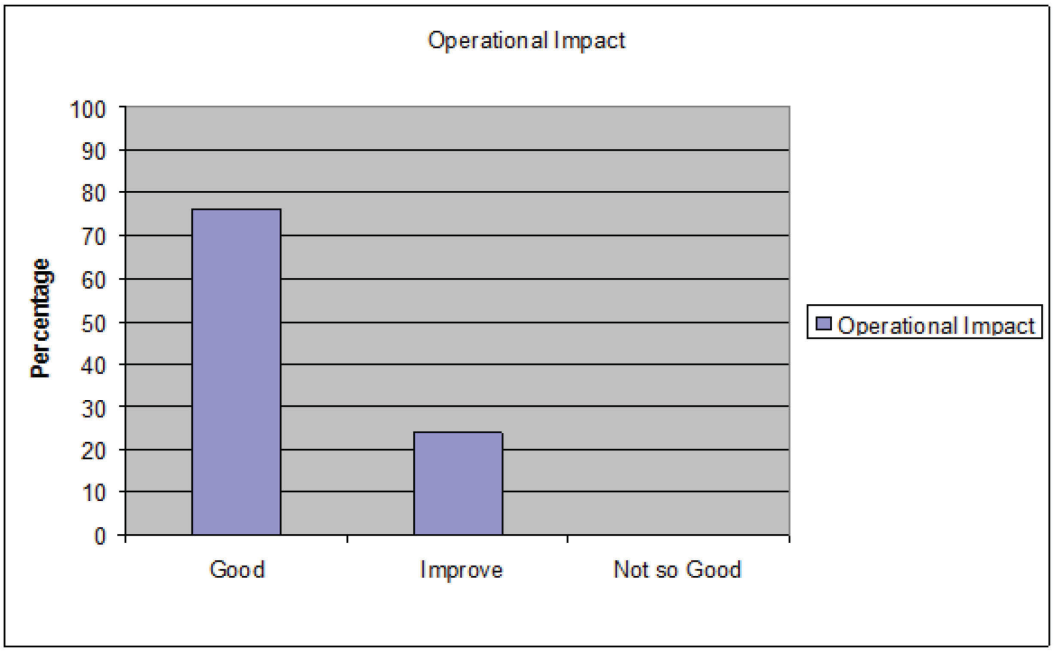

Figure 2 Percentage of projects with various degrees of broad operational impact.

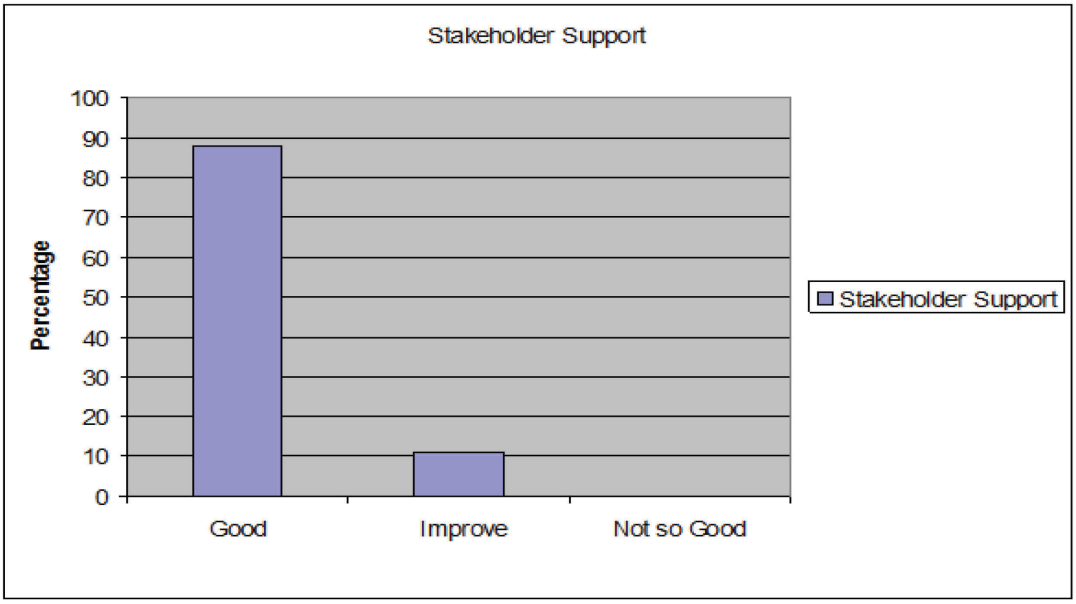

Figure 3 Percentage of projects with degrees of stakeholder/end user support.

It was also observed that a total of as much as 33% of the Exploitation Plan of Projects "needed improvement" or was "not so good" (Fig. 4): indeed, 29% and 4 % of the Reports on Exploitation was judged respectively as "needing improvement" or "not so good". In a similar fashion, it was observed that the Value of the Transaction was not reported/communicated to Partners as well as it should have been by a large sum of 40% of projects (38% and 2 %; see Fig 5).

Though most projects (80%) were assessed as proving a good "impact relative to the investment" (taken as an index of "Return on Innovation"), there was still a 19% that showed a requirement to improve (Fig 6).

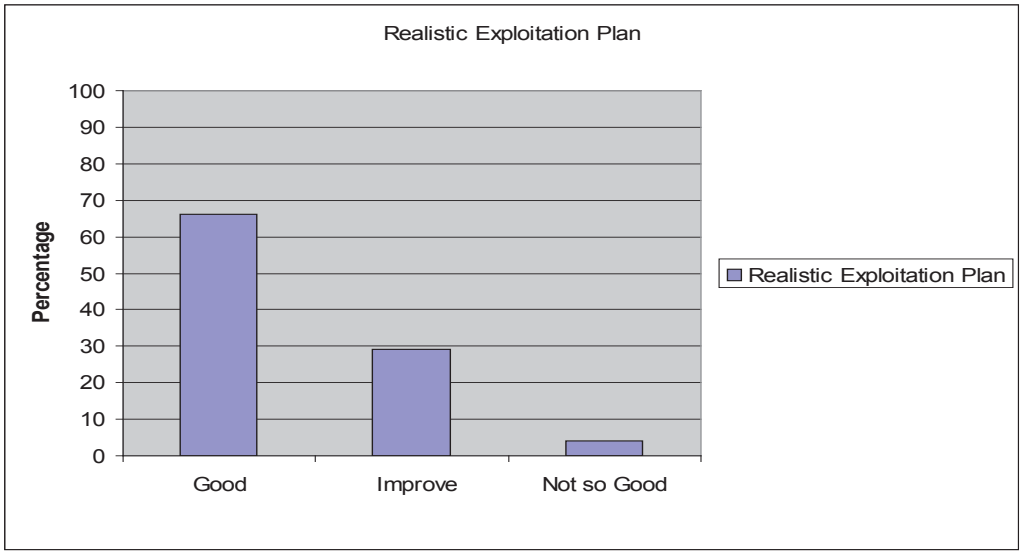

Figure 4 Percentage of projects with various degrees of a realistic exploitation plan

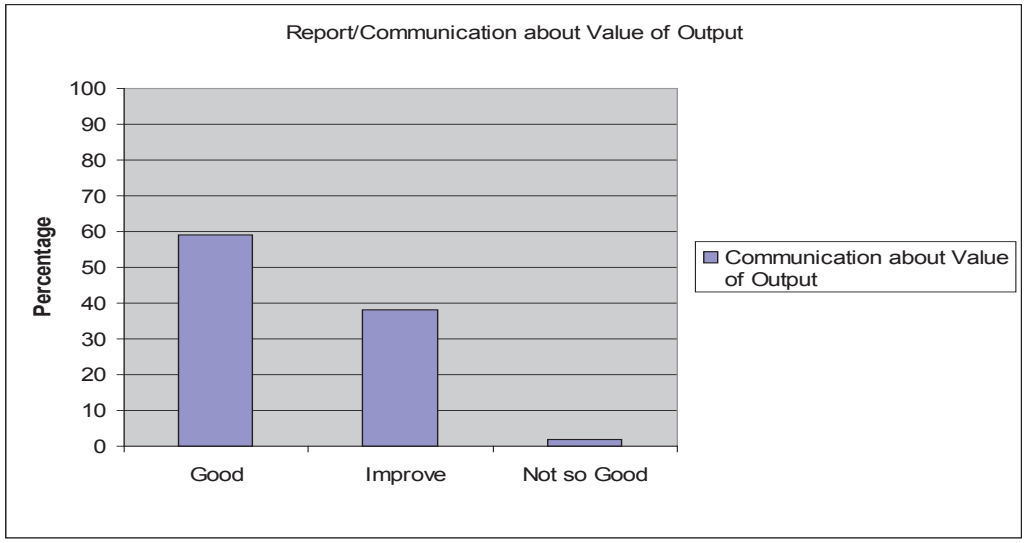

Figure 5 Percentage of projects with various degrees of report/communication about the value of output

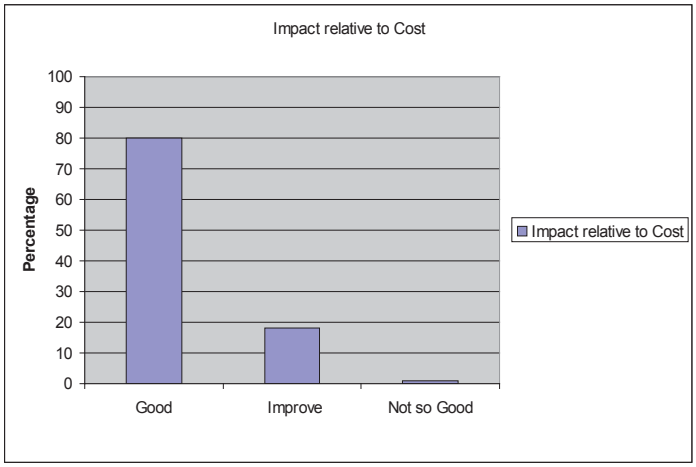

Figure 6 Percentage of projects with various degrees of ratio of impact relative to cost

Finally, Even though the majority of projects scored relatively well on most Measures of impact, it was found that only about half of the projects produce Realized value (51%). Similarly, about half did not and only produced Potential value (47%) (Fig 7).

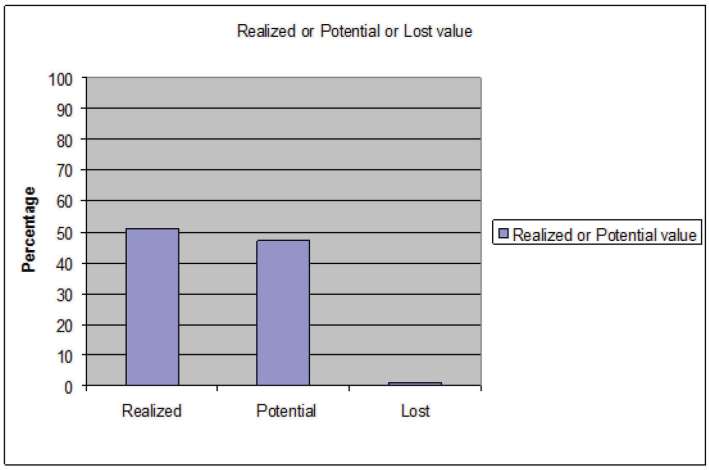

Figure 7Percentage of projects with degrees of realized, potential or lost value

3.2 Individual project by project assessments of Value through the present Value framework.

Individual project by project assessments of value through the present Value Framework are shown below for the Case study projects, in Table 3.

Table 3: Individual Assessments of Value from a case study S&T program: assessment of 98 documented projects

Project #	Types of Value Created: 1) Advice, 2) Build CoP, 3) Mature Tech, 4) Transition, 5) Support to Ops	Value Assessment through some Measures of Impact (Good=Green, Improve=Yellow, Not so Good=Red)					Degrees of Value: Realized (Green), Potential (Yellow), Lost (Red)	Summary of key Statement Actions/Activities to Increase Realized Value
		Operational impact (degree)	Stakeholder /end user support (degree)	Realistic Exploitation plan	Communication (was advice or tech formally given & communicated)	Impact Relative to Level of Investment		
CRTI 05-0006TA	3) maturing technology	Incomplete						
CRTI 05-0014RD	1) knowledge	Incomplete data set						
CRTI 05-0016RD	1) knowledge							
CRTI 05-0043RD	1) knowledge							
CRTI 05-0053TA	5) support to Ops	Incomplete						
CRTI 05-0058TD	3) maturing							
CRTI 05-0069RD	3) maturing							
CRTI 05-0078RD	3) maturing							Operationally challenging showing much future potential. PHAC is in negotiations to sell rights to commercial supplier. Watch
CRTI 05-0090TA	5) support to ops	Incomplete data set						
CRTI 05-0092TA	3) maturing technology							Need better communications of results to potential users. Need commercialization plan/partner to realize full value
CRTI 05-0106TA	5) Support to ops.	Incomplete						
CRTI 05-0108TD	2)building/sustaining CoP	Incomplete						
CRTI 05-0121RD	1) knowledge/advice	incomplete						

Project #	Types of Value Created: 1) Advice, 2) Build CoP, 3) Mature Tech, 4) Transition, 5) Support to Ops	Value Assessment through some Measures of Impact (Good=Green, Improve=Yellow, Not so Good=Red)					Degrees of Value: Realized (Green), Potential (Yellow), Lost (Red)	Summary of key Statement Actions/Activities to Increase Realized Value
		Operational impact (degree)	Stakeholder /end user support (degree)	Realistic Exploitation plan	Communication (was advice or tech formally given & communicated)	Impact Relative to Level of Investment		
CRTI 05-0122TD	3) maturing technology							
CRTI 05-0123TD	5) support to ops							lack of sustainment funding is an issue
CRTI 06-0138RD	1) knowledge/advice	Incomplete						
CRTI 06-0146RD	5) support to ops	Incomplete						
CRTI 06-0150TD	1)Knowledge/Advice,							knowledge build up to 07-0176TD project with CSA
CRTI 06-0156RD	1) knowledge/advice	Incomplete						
CRTI 06-0159TA	5) support to ops							DRDC-CSS trained staff being deployed to Afghanistan and now commercially deployed in drug interdiction in US
CRTI 06-0163TD	4) transition, operationalization, commercialization							commercialized by Danish government
CRTI 06-0169TA	4) transition, operationalization, commercialization							being commercialized
CRTI 06-0170RD	1) knowledge/advice							
CRTI 06-0171TA	5)support to ops							put into new specifications for storage magazines
CRTI 06-0186RD	1) knowledge/advice	Incomplete						
CRTI 06-0187TD	3) maturing technology	Incomplete						
CRTI 06-0188TA	4) transition, operationalization, commercialization	Incomplete						

Project #	Types of Value Created: 1) Advice, 2) Build CoP, 3) Mature Tech, 4) Transition, 5) Support to Ops	Value Assessment through some Measures of Impact (Good=Green, Improve=Yellow, Not so Good=Red)					Degrees of Value: Realized (Green), Potential (Yellow), Lost (Red)	Summary of key Statement Actions/Activities to Increase Realized Value
		Operational impact (degree)	Stakeholder /end user support (degree)	Realistic Exploitation plan	Communication (was advice or tech formally given & communicated)	Impact Relative to Level of Investment		
CRTI 06-0192TD	5) support to ops							
CRTI 06-0202TD	4) maturing technology							
CRTI 06-0204RD	1) knowledge/advice							impacted operations and policy and led to follow on project 09-0531TD
CRTI 06-0218RD	3) maturing technology							led to highly successful follow on project
CRTI 06-0230RD	2)building/sustaining CoP							Follow on project matured technology and fieldable kits produced
CRTI 06-0234TA	4) transition, operationalization, commercialization							
CRTI 06-0236TA	5) support to ops							
CRTI 06-0252RD	2)building/sustaining CoP							follow on project operationalized it
CRTI 06-0255TA	4) transition, operationalization, commercialization							
CRTI 06-0259TD	2)building/sustaining CoP							Lack of control of IP prevents realization of value
CRTI 06-0275TD	5)support to ops							
CRTI 06-0283RD	4) transition, operationalization, commercialization							Project stopped
CRTI 06-0299TA	4) transition, operationalization, commercialization							not progressed to high enough TRL
CRTI 06-0301TD	3)maturing technology							potentially very important but still in early development stage

Project #	Types of Value Created: 1) Advice, 2) Build CoP, 3) Mature Tech, 4) Transition, 5) Support to Ops	Value Assessment through some Measures of Impact (Good=Green, Improve=Yellow, Not so Good=Red)					Degrees of Value: Realized (Green), Potential (Yellow), Lost (Red)	Summary of key Statement Actions/Activities to Increase Realized Value
		Operational impact (degree)	Stakeholder /end user support (degree)	Realistic Exploitation plan	Communication (was advice or tech formally given & communicated)	Impact Relative to Level of Investment		
CRTI 06-0317TD	3)maturing technology							led to follow on project - 07-216TA which completed transition and operationalization
CRTI 06-0318TD	5)support to ops							Community development to expand usage across Canada through self-funding by universities
CRTI 06-0319TD	5)support to ops							Project stopped
CRTI 06-0320TD	5) support to Ops							Classified; producing unique value; is uniquely exploited
CRTI 07-0103RD	1)knowledge, advice							When it changes a RN CONOPS, it will also impact support to ops., #5
CRTI 07-0104TD	3) maturing technology							need to look at how to take it to the next step
CRTI 07-0109RD	2)building/sustaining CoP							should brag about this one
CRTI07-0113TD	4) Transitioning, operationalizing. Support to ops							Needs a business/exploitation plan
CRTI07-0121RD	1)knowledge/advice							too costly to commercialize, economic roadblock, but did improve on other aspects of next generation suit (-weight)
CRTI 07-0123TA	5) support to ops							being offered in next generation suit
CRTI07-0132TA	3) maturing technology							need to know the commercial status
CRTI 07-0135RD	2)building/sustaining CoP							
CRTI 07-0148TD	5) support to ops							

Project #	Types of Value Created: 1) Advice, 2) Build CoP, 3) Mature Tech, 4) Transition, 5) Support to Ops	Value Assessment through some Measures of Impact (Good=Green, Improve=Yellow, Not so Good=Red)					Degrees of Value: Realized (Green), Potential (Yellow), Lost (Red)	Summary of key Statement Actions/Activities to Increase Realized Value
		Operational impact (degree)	Stakeholder /end user support (degree)	Realistic Exploitation plan	Communication (was advice or tech formally given & communicated)	Impact Relative to Level of Investment		
CRTI 07-0150TD	5) support to ops	Incomplete						
CRTI 07-0153RD	1) knowledge/advice							
CRTI 07-0176TD	5) support to ops							Should brag about this. Standard developed with CSA participation
CRTI07-0179RD	3)maturing technology							
CRTI 07-0186RD	5)support to ops	Incomplete						
CRTI07-0190TA	3) maturing technology							Lack of operationalization or commercialization is an issue for impact. Need a commercialization assessment
CRTI07-0193RD	3) maturing technology							project exceeded plan and matured technology to w here a more comprehensive exploitation plan is warranted
CRTI 07-0196TD	1) knowledge/advice							operationalized and advice provided by CMC-environment Canada
CRTI07-0216TA	3) maturing technology							find out options for commercializing this
CRTI07-0217TA	4) transition, operationalization, commercialization							Customer deployed to Ops; great Ops T&D data; customer not motivated to continue, due to privacy issues of secondary video
CRTI 07-0219RD	5) support to ops							one to brag about
CRTI 07-0234RD	1) knowledge/advice							outcome needs to progress further in order to determine potential and real value more accurately
CRTI08-104TA	3) maturing technology							not mature enough to be deployed, need follow-up to get commercially ready
CRTI 08-0105RD	5) support to ops							still underway but expect to deploy output and brag about it

Project #	Types of Value Created: 1) Advice, 2) Build CoP, 3) Mature Tech, 4) Transition, 5) Support to Ops	Value Assessment through some Measures of Impact (Good=Green, Improve=Yellow, Not so Good=Red)					Degrees of Value: Realized (Green), Potential (Yellow), Lost (Red)	Summary of key Statement Actions/Activities to Increase Realized Value
		Operational impact (degree)	Stakeholder /end user support (degree)	Realistic Exploitation plan	Communication (was advice or tech formally given & communicated)	Impact Relative to Level of Investment		
CRTI 08-0112TA	3) maturing technology							need to support finding commercial partner
CRTI 08-0116RD	5) support to ops	Incomplete						
CRTI 08-0122TD	5) support to ops	Incomplete						
CRTI 08-0131TD	5) support to ops							maybe brag about this
CRTI 08-0142RD	3) maturing technology							too new to determine if able to commercialize or operationalize
CRTI 08-0173TD	1) knowledge/advice							led to follow on TI project to operationalize the output
CRTI 08-0176RD	2)building/sustaining CoP							one to brag about
CRTI 08-0180TD	5)support to ops	Incomplete						
CRTI 08-0181TD	5) support to ops	Incomplete						
CRTI 08-0190RD	5)support to ops							
CRTI 08-0192TD	2) community/ capacity building							big cities did not want to disclose inventories
CRTI 08-0197TD CBP	5) support to ops	Incomplete						
CRTI08-0200RD	1) knowledge/advice							proof of concept achieved and awaiting platform development
CRTI 08-0203RD	3)maturing technology							one to brag about and communicate more broadly
CRTI08-0208TA	3) maturing technology							Project stopped

Project #	Types of Value Created: 1) Advice, 2) Build CoP, 3) Mature Tech, 4) Transition, 5) Support to Ops	Value Assessment through some Measures of Impact (Good=Green, Improve=Yellow, Not so Good=Red)					Degrees of Value: Realized (Green), Potential (Yellow), Lost (Red)	Summary of key Statement Actions/Activities to Increase Realized Value
		Operational impact (degree)	Stakeholder /end user support (degree)	Realistic Exploitation plan	Communication (was advice or tech formally given & communicated)	Impact Relative to Level of Investment		
CRTI08-0214RD	1) knowledge/advice							potential to transition to improved capability and have greater impact in the hands of AECL, follow-up with AECL warranted and nuclear forensics TI
CRTI 08-0222RD	1) knowledge/advice							project is still at R&D stage but could dramatically change detection by extending the stand-off range
CRTI 08-0225TD	1) knowledge/advice							project validated need for a national training standard but has not been exploited
CRTI 08-0226TD CBP	5) support to ops	Incomplete						
CRTI08-0233TD	3) maturing technology							product available to CF under Surgeon General waver
CRTI 08-0234TD	2)community/capacity building	Incomplete						
CRTI 08-0241TD	3) maturing technology							needs follow on effort to document and transition to operations
CRTI09-462RD	1) knowledge/advice	Incomplete						
CRTI09-566TA	4) transition, operationalization, commercialization							intellectual property dispute over licensing to BTI from DRDC Ottawa
CRTI09-403TA	3) maturing technology							
CRTI09-606TA	3) maturing technology							beyond the current 10 being built there is no exploitation plan
CRTI09-481TD	3) maturing technology	Incomplete						
CRTI09-453TD	3) maturing technology	Incomplete						
CRTI 09-531TD	1) knowledge/advice							one to brag about
CRTI09-509TD	1) maturing technology							still being developed, need more end user support

4 Summary and Recommendations

4.1 Key Findings from using the present Value Framework.

The results of this study have documented and verified a powerful yet generic value framework to assess VALUE derived from outputs of S&T projects. Further, the study was able to validate the framework from almost 100 projects of the Case study. It can therefore be used to measure success more generally, and to realize greater value from many government investments in S&T. It describes a process to combine the roles, mandate and strategy of the agency undertaking the S&T with measures of the success of the outputs of the projects and activities. It also considers the whole of government goals and broadly-based policy to enhance Canada's competitiveness and productivity by stimulating industry-led innovation, particularly among SMEs.

The premise that S&T projects can be mapped and assessed for VALUE using the present Value Framework approach was verified. This would clearly suggest that the VALUE of Outputs (from S&T projects) in the hands of end-users is more related to "Measures of Impact". Based on the recent Reports from Jenkins and the NRC (Jenkins , 2011, Jenkins 2013, NRC, 2013) , it does appear prudent and highly desirable that S&T programs continue to cater to their clients, stakeholder and partners while ensuring that a high degree of value is derived from the related investments. This would ensure the right posture so that value-driven innovations continue to take place, binding operators to S&T performers, together with industry experts to ensure that the realized value of the clients also contributes to some degree to "wealth in the nation", through industrial partners involved in commercialization. Advancing knowledge *per se*, maturing technology per se may become a risky investment in and or by itself in government at large, unless it maps to a broader strategy or plan or acquisition or Operation that holds value to the end user.

The framework describes ontology of specific types of value that can be applied to government sponsored S&T programs where the intent is to deliver advice and expertise, support, technology, operational capability and capacity to external groups of national importance. Development of objective and subjective measurements of each type of value then enable executive teams to assess the performance of each program with respect to value. As a result five types of value are identified and a common set of measures is described to assess all of them.

The study also describes in some detail how to convert *potential* value created through S&T projects and activities (technology push) into *realized* value through exploitation of the outcomes and outputs of those projects and activities (technology pull). The degrees of realized value are dependent on whether the outputs are delivered to stakeholders (leave-behind reports, technology and capabilities), and whether they are effectively exploited and sustained by operators or end users (transitioned, operationalized, commercialized).

The study then "validated" the framework and measures against a significant number of the projects that were delivered through the CRTI program Case Study, and showed that the ability to create potential value can be effectively measured against five key criteria. The preliminary assessment indicated that there are common characteristics of highly successful projects and activities, and that weaknesses in key measurements usually led to lower degrees of realized

value. This assessment framework is quite generic so that it can be easily adapted to other government-led S&T efforts.

The assessment also indicated that the realized value can be increased through more effective reporting, communication and engagement with key stakeholder groups, along with a greater focus on follow-on activities for outputs during the close-out process of projects and activities. Further, a communication strategy that reports and communicates important information before, during and at the end of the project is a critical component of a successful project or activity. A value spreadsheet to collect the measurements for all projects and activities can provide a useful set of tools to support the value framework.

4.2 Reports and Communications to Increase Realized Value

Reporting and Communicating progress and influence correctly to all stakeholders and operators is a key element of realizing the full value from projects and activities because it makes them aware of the availability, maturity and impact of the project or activity. Further, effective reporting and communications allow stakeholders and operators to provide feed-back that could increase the value of the project or activity by considering operational needs that may have been overlooked when the project or activity was begun. However, if the advice behind a 300 page report is not singled out and properly reported and communicated, the value behind the effort may remain potential value only, particularly if the large document is never read. There are at least six different types of stakeholder groups that require visibility to specific reports and communications products to ensure that they realize the value from projects and activities. They are:

- The lead and primary customer of the project or activity;
- The operators, policy and/or doctrine developers who are the target consumers of the outputs;
- The Communities of Practice who can adopt or help operationalize the outputs;
- External industry partners who may want to license and/or commercialize program outputs;
- The international technical community; and
- Senior government officials and the general public who support/fund the program.

Along with identifying the target audiences for communications, the timing of communications is also an important part of the strategy since many operational organizations have defined acquisition cycles that must be followed to transition and/or acquire new technologies and capabilities, or implement new policies and doctrine. Thus they must be aware of the availability of an output of a project or activity in order to plan for acquiring it.

Types of S&T contributions that contribute to higher realized value include:

- Quad charts describing the objective, potential outcomes and impact, the technology maturity, and the completion date;
- Highlight sheets describing key technical advances in terms of their operational impacts;
- Interim progress reports and testing results;

- Final reports describing how mature the output is, the availability of it and follow on activities;
- Publications that describe the technical advance and operational impact; and
- Symposium briefs to both technical and operator forums.
- Letter Reports that highlights in 2-3 pages the advice being provided (with distribution list) or the value so derived in the project, and that references the companion 100 page report, as an example.

Not all of these types of communications should be provided to all stakeholders because they are often either too detailed or irrelevant for them.

The specific measures and objective evidence that defines the degree of value support the measurement process. The evidence not only provides the "meat on the bones" of the value statement for projects and activities, but also identifies where there are missed opportunities to convert potential to realized value. For example, the lack of the right end user report or communications in a project that has a mature technology output is a red flag that can be addressed by the management team before the end of the project. Thus the process of measuring value provides key insight that, of itself, can increase the value of the projects and activities.

As described above *potential* value is created through the selection and execution of projects and activities that align with operational priorities and needs, the medium and long term strategic intent of the program, and the whole of government direction for S&T investments. In the Case Study, the outputs produce value in any of the five types of value, as described in section 2.0. Realizing value from the projects and activities, on the other hand, relies on exploiting and sustaining the outputs. This is achieved in large part by ensuring that they are delivered, understood and adopted by operators, end users and other stakeholders. Realizing value also relies on knowing when and how to report and then to communicate outputs but mainly value so derived from the outputs to the right stakeholders to enable or encourage transitioning, operationalization and commercialization, hence influence on outcomes that matter to them. Thus the process of measuring value provides key insight that, of itself, can increase the value of the projects and activities.

The study is affected by at least two limitations. First, the assessment was subjective. Though subjective, all experts in the field were very familiar with the program and the projects and had access to reports, progress reports and industry reports about the current state of affairs with a particular technology or standard or report. Secondly, the study had set its "arcs of fire" in line with a certain number of manageable projects, namely those from CRTI Calls #5-9. It would be desirable to further validate the current framework by end users, who could be using a larger data set of projects, additional projects from different programs, and looking at different problem spaces projecting value across different solution spaces. Currently this is a planned effort to extend the present preliminary analysis to such a deeper analysis.

In conclusion, a value framework for S&T projects has been elaborated. The following ontology was used: 5 types of value were documented, 5 measures of Impact were used and each measure was assessed on a 3 point scale. Any type of value was considered potential, realized or lost depending on the data. Finally, to generate value, S&T projects must have or must produce Outputs and these outputs can only take two forms: Documents or Technologies. The following

recommendations are proposed for many government-led S&T programs that intend to transform from a Technology-focus to client outcomes-driven approach, in order to increase the realized value from projects and activities.

Adopt a value framework such as the one described above;

Implement an annual assessment of projects and activities, particularly those nearing completion to ensure that potential value is being converted to realized value;

Implement a communications strategy to increase the knowledge among stakeholders of the importance of the outputs of individual projects and activities; and

Use feed-back from the value assessment to adjust governance, processes and behaviors to continue to increase the value that is being realized from the program.

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A framework to describe and assess "Value" has been elaborated. Value is taken as associated with "Measures of Impact", measures that many S&T programs wish to be in a position to document from their outputs. Strategically, the framework also distinguishes between *potential value* (available but not exploited and sustained) and *realized value* (exploited by operators or end users) or even *lost value*. To verify and validate this value-based framework, existing data from a Case study, the CBRN Research Technology Initiative (CRTI) Call for Proposals #5-#9 projects have been used. To simplify the task, "Measures of Performance" normally associated with schedule, budget and scope of the project were not included in the assessment to encourage a specific focus on value and the "Impact" related measures: the logic that has been applied here is that although a well-managed project is important, if it generates no impact, it provides little value to clients. The premise of this effort is that S&T projects can be not only mapped but assessed for Value based on various measures of "impact" using the present Value Framework approach. Preliminary data from a Case Study of Call for Proposals #5-9 Projects (N=98) of the CRTI program indicate that all of them easily map first and foremost to the 2 types of S&T *Outputs*: documents (i.e. advice) or technology (i.e. sensor). Further, all of the outputs of the above projects easily mapped to one of the 5 Types of Value by considering the following *ontology*: 1) Knowledge/Advice, 2) Building the related Community of Practice, 3) Maturing Innovative Concepts/Technology, 4) Transitioning/Exploiting Innovative Concepts/ Technology, and 5) Support to Special Ops or Major Events with Concepts/Technology. The data analysis also validates the current value framework as a very useful framework to document Value in terms of influence or impact, vis a vis clients and their desired outcomes, regardless if output of the projects was a document or a technology. It is recommended that, as S&T organizations shift their focus from being technology-focused to (client) outcomes-driven, the concept of value and related measures of impact for Projects align well with the documentation of influencing outcomes that matter to client, stakeholder or partner. Finally, it is suggested that the framework is broadly applicable to many government-led S&T programs, provided it reflects the strategic goals of the program, the needs of client, stakeholder or partner and the guidance for S&T investments.

Un cadre visant à décrire et à mesurer la « valeur » a été conçu. La valeur est considérée comme étant liée aux « mesures d'incidence », que de nombreux programmes de S et T souhaitent être en mesure de documenter d'après leurs extrants. À des fins stratégiques, le cadre fait également la distinction entre la valeur potentielle (accessible, mais non exploitée ou soutenue) et la valeur réalisée (exploitée par les opérateurs ou les utilisateurs finaux), voire la valeur perdue. Pour vérifier et valider ce cadre axé sur la valeur, les données existantes tirées d'une étude de cas, soit les projets des appels de propositions 5 à 9 de l'Initiative de recherche et de technologie CBRN, ont été retenues. Par souci de simplification, les « mesures de rendement » généralement associées à l'échéancier, au budget et à la portée des projets n'ont pas été incluses dans l'évaluation, afin que l'accent puisse surtout être mis sur la valeur et sur les mesures liées à l'« incidence » : selon le raisonnement retenu ici, si la bonne gestion des projets est importante, les projets qui n'ont pas d'incidence ont peu de valeur pour les clients. Cette approche repose sur la prémisse selon laquelle les projets de S et T peuvent non seulement être mis en correspondance, mais aussi évalués en fonction de la valeur, à la lumière de différentes mesures de l'« incidence » et selon l'approche actuelle du cadre de valeur. Les données préliminaires tirées d'une étude

de cas englobant les projets des appels de propositions 5 à 9 (N = 98) du programme de l'IRTC donnent à penser que les projets peuvent tous facilement être classés d'abord et avant tout dans l'une ou l'autre des catégories d'extrants suivants en S et T : documents (p. ex. conseils) et technologie (p. ex. capteur). En outre, tous les extrants des projets susmentionnés peuvent facilement être classés dans l'une ou l'autre des cinq catégories de valeur de l'ontologie suivante : 1) savoir/conseils; 2) établissement de la communauté de pratique connexe; 3) développement de concepts nouveaux ou d'une technologie novatrice; 4) passage à une autre étape ou exploitation des nouveaux concepts ou de la technologie novatrice; 5) soutien des activités spéciales ou d'envergure grâce aux concepts ou à la technologie. L'analyse des données valide le cadre de valeur actuel, confirmant qu'il est grandement utile pour documenter la valeur mesurée, en termes d'influence ou d'incidence pour les clients ou eu égard aux résultats attendus par ces derniers, que le résultat du projet soit un document ou une technologie. À mesure que les organismes de S et T deviennent moins centrés sur la technologie et misent davantage sur les résultats (pour les clients), il est recommandé que le concept de valeur et les mesures d'incidence des projets qui y sont liées cadrent bien avec la documentation des résultats déterminants auxquels les clients, les parties prenantes et les partenaires accordent de l'importance. Enfin, il semble que le cadre soit largement applicable à un grand nombre de programmes gouvernementaux de S et T, étant donné qu'il tient compte des objectifs stratégiques des programmes, des besoins des clients, des parties prenantes et des partenaires, ainsi que de l'orientation des investissements en S et T.

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Performance Measurement; Value Added; Impact on Outcomes; Programme Evaluation