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PROJECT MANAGEMENT OF TRANSFER FROM SPACE TO THE EARTH: SUPPORTING OPEN-COLLABORATIVE PROJECTS in the Canadian Space Agency

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ABSTRACT

This paper proposes a methodology to support the management of collaborative projects between the Canadian Space Agency (CSA) and industrial partners (particularly small-size or start-up enterprises), and exploring how the technology transfer should be boosted using new media tools. Particular emphasis was placed on crowdsourcing platforms and familiar tools used by enterprises. Results show that the process of developing collaborative projects was not sufficiently supported by current ICT tools. The data also revealed the important role played by social dynamics in the first stages of product conceptualization to harness open collaboration in further development of projects.

INTRODUCTION

This proposal is elaborated according to the extracted guidelines from research about open collaborative projects and the modeling of a platform based on Information and Communication Technologies *(ICTs)* of the project: "Measure of the Impacts for the Economy and Society of the Investments in the Expertise in Space in Canada" *(M(IES)*2C) directed by Patrick Cohendet. The ÉTS research team proposes the support of CSA experts to generate a new ecosystem of open-collaborative projects. This project was supported by the Capacity Building in Space Science and Technology programme *(SS&T)* – Clusters Pilots Results of CSA.

This paper summarized the first stage of the methodology analysis to model a new technology transfer platform. This platform reduces the time of documentation and also enables exchanges among agents involved in the process of new product design, particularly the transfer of spatial technology to be applied on the earth market and community. This paper is divided into three sections: first a literature review about TT Platforms and methodologies, second the research undertaken and finally, the testing phase by expert validation and some recommendations derived from these results.

1. Technology transfer: Methods and tools

A Technology Transfer *(TT)* is a process for the introduction of a technology developed by a team or an organization to another organization. The authors Kingsley, Bozeman and Coker **[1]** mention that TT is "the use by an external party of technology or technical information developed by a publicly sponsored contract". This process occurs in two phases: when the technology is transferred "Spin-out" and how technology is absorbed and implanted in the organisation "Spin-in" **[2]**. According to Coccia **[3]**, TT "may be considered as the flow of information from the source *(public and private research institutes, universities, etc.)* to the users *(firms and companies)*, over a given period of time, through the appropriate channels *(communications, logistics and distribution)*". Thus, the TT implies a Knowledge Transfer *(KT)* represented or already explicit in machines or products as hard technology and tacit knowledge or know-how as soft technology **[4]**. Bell and Pavitt **[5]** explain that the technological changes are introduced by a process of TT, there is also an alternated evolution into new skills for the receiving companies. During the process of KT, explicit knowledge *(goods)* is easier and cheaper to transfer than the tacit knowledge *(management strategies)* which is hard to transmit and expensive **[6, 7]**.

Current Technology Transfer Platforms

For the National Aeronautics and Space Administration *(NASA)*, TT is one of their main strategic issues. Since 1958, NASA has had the mandate of developing mechanisms to put in place TT. However, C. Morgan Kinghorn, President of the National Academy of Public Administration **[in: 2]** declares: "despite these past contributions, NASA has not been as successful with its recent technology transfer efforts due to organizational changes, budget difficulties, and a lack of program focus. Equally important, private industry and universities often are the leaders in many technologies that NASA needs for its missions, which is a fundamental change from prior decades. Managing effectively in this new environment requires a different approach to technology transfer and a different set of skills" *(p. v)*

In the study about six big space agencies presented by Petroni, Venturini, Verbano and Cantarello **[8]**, TT is considered as an "implicit strategy" of the strategy orientation for all these agencies: European Space Agency *(ESA)*, the Japanese Space Agency *(JAXA)*, the Russian Space Agency *(ROSCOSMOS)*, the Indian Space Agency *(ISRO)*, the French Space Agency *(CNES)* and the Brazilian Space Agency *(AEB)*. According to authors, "a clear strategic orientation of this type can be particularly noted in the behavior of CNES, ESA and JAXA. In all three cases there exist well-organized structures for research and for the design of missions and space instruments. In addition, shared initiatives have been launched with universities and public and private research centers" *(p. 58.)*. The implemented strategies that encourage TT between agencies and enterprises are mainly supporting Spin-off developments and contracts between others government entities. As the case of ESA, it "has recently promoted the establishment of a fund to finance programs of early-stage innovations" *(idem)*, or JAXA shares initiatives with METI *(Ministry of Economy, Trade and Industry) (ibid)*. Other agencies, such as ISRO, "possess excellent technical corps, but do not yet have a broad, space-related industrial system" *(idem)*.

Towards new management in Open-collaborative Projects

Firstly, we would like to introduce the concept of Open-collaborative In-

FIGURE 1. Screen shot of Nasa Pavillon at Innocentive from https://www.innocentive.com *Accessed 15 January 2013*

novation Projects *(OCIP)*. For Baldwin and Von Hippel **[9]**, "an open collaborative innovation project involves contributors who share the work of generating a design and also reveal the outputs from their individual and collective design efforts openly for anyone to use. The defining properties of this approach are twofold: *(1)* the participants are not rivals with respect to the innovative design *(otherwise they would not collaborate)*; and *(2)* they do not individually or collectively plan to sell products or services incorporating the innovation or intellectual property rights related to it" *(p. 9)*. The open collaboration implies certain challenges for all actors involved, particularly enterprises, to open their brief of the design and integrate an external team early in the process. For designers, it is not easy to develop confidence in a process, where there is a high degree of uncertainty about intellectual property or role definition in the project **[10]**.

This kind of collaboration has some similarities with crowdsourcing platforms; one well-known case is the use of InnoCentive, a crowdsourcing platform for NASA *(see* **Figure 1**, *available at: https://www.innocentive.com/pavilion/NASA)*. From 2008 to 2010, "14 external problems or challenges were posted through three different vendors: InnoCentive, http://www.yet2.com/ and TopCoder. The 20 internal challenges were conducted using the InnoCentive crowdsourcing platform designed for internal use in an organization and customized for NASA use, and promoted as NASA@Work" *(idem)*. NASA@Work is also used to integrate 10 research centers of NASA, that are distributed throughout the nation. This platform is a good example of the need of integration of large research centers that have their creative/innovation resources delocalised geographically.

The context of Open Innovation *(OI)* challenges substantially the variables and the factors of TT. Particularly, OI generates a new interaction among actors involved in Open Projects and society. As mentioned by Jolly **[11]**, OI provides direct benefits and drawbacks to aerospace sectors, in the following aspects shown in **Table 1**.

More of the drawbacks mentioned by Jolly *(2012)* in some cases, mitigate for the quick absorption of the technology generated by the spatial sector that is useful for the human being as the first needs in health and sciences for life **[12]**. There are also potential benefits for the small technological enterprises that will be able to absorb R&D expenses and risk the commercialization of new products and services, in a strength innovation ecosystem **[13]**, as presented in policies of Small Business Innovation Research Program *(SBIR)* that reported satisfactory results **[14]**. It should be noted that the implementation of Open-collaborative methodologies have been developed in parallel with the ICT platform. ICT enables and outlines the collaboration that is already setting up, as we will explain in Section 2.2.

Open Innovation	
Main Benefits	**Main Drawbacks**
Ability to leverage R&D which was developed outside; Extended reach and capability for new ideas and technologies; Opportunity to refocus some internal resources on finding, screening and managing implementation; Improved payback on internal R&D through sales or licensing of otherwise unused intellectual property; Greater sense of urgency for internal groups to act on ideas or technology; Ability to conduct strategic experiments with less risk and fewer resources in order to extend core business and create new sources of growth; Over time, the opportunity to create a more innovative culture from the "outside in" through continued exposure and relationships with external innovators.	Ability to leverage R&D which was developed outside; Management and oversight of innovation is more complex; Extra costs of managing co-operation with external partners; Overdependence on external parties, with potentially opportunistic behaviour of partners (future competitors); Loss of (some) technological competencies; Increased risk of leakage of proprietary knowledge and involuntary spillovers.

TABLE 1. *Main Benefits and Drawbacks of Open Innovation for space sector, by Jolly (2012, p. 9-10)*

2. Research Overview

This research follows a "Research-oriented Design" method **[15]**, in which a "design situation", in our case, the design of a collaborative platform, "is employed as a means of generating insights that will feed into the design of a product" *(Idem)*. This method is also defined as "Research through Design"**[16, 17]**, in which the "design artifact became design exemplars, providing an appropriate conduit for research finding" **[18]**. This methodology is particularly useful in the design of systems, methodologies, or Human Computing Interfaces *(HCI)* that needs interactive research between technical opportunities and theory model gaps *(ibid)*.

Overall, this research is composed of the following studies:

1. The validation of data collected comparing the theoretical studies with the needs of enterprises
2. Comparing the main methodologies of current collaborative platforms based in crowdsourcing
3. Proposing a methodology of work to use the spatial technology in the current market, in a technology transfer approach and community needs.

R&D enterprises need to collaborate

At the networking level, R&D enterprises contribute to innovation activities through networking and the data exchanged between them. The small size of these enterprises leads them to interact easily within their immediate context, which includes their clients, manufacturing industries, and their internal personnel, such as sales managers and R&D staff. Finally, the independence and free association of these enterprises facilitates knowledge exchange for their innovative activities. We compare the needs of knowledge and information of these enterprises with the needs of big enterprises in the Satellite and Communication *(ST)* sector. We use a specific collaboration part of the Survey of Innovation **[19]**, which shows us the kind of network and partners that R&D and ST enterprises interact with in innovation *(these statistics are based only on innovative enterprises)* in the Survey of Innovation *(Statistics Canada, 2005)*, as shown in **Figure 2**.

Networking details are shown in **Figure 3**, which presents a percentage summary of the professional interactions of engineering, industrial design and scientific services, and classify the importance of information provided by other stakeholders, ranging from high to low significance. In **Figure 3**, we observe mainly collaborators and the actions involved at the internal and external networking levels; at the internal level, we observe R&D personnel, sales and marketing staff, production staff, personnel management, software, hardware, materials or equipment. At the external networking level, we find customers, consulting companies, competitors and other companies in the sector, universities or other higher education institutions, professional conferences, meetings, regular publications, participation in fairs and exhibitions, professional associations and the Internet, and exchange providers.

Expert knowledge is the main need of R&D enterprises, according to Canadian statistics and the Department for Culture, Media and Sport of Great Britain's report **[20]**. The expert in a given subject matter or the R&D domain is a key player in R&D activities. The need for expert thinking among R&D enterprises is demonstrated in the Survey of Innovation *(2005)* collaboration study. In **Figure 3**, we show the responses in percent respecting the most important collaborative exchanges for achieving innovation. We found that access to expert knowledge is effectively one of the main reasons to collaborate with these R&D enterprises: on average, 66% of the reasons provided for collaborating involve having access to critical expertise. In **Figure 3**, we also highlight other reasons behind collaboration, including sharing high costs of R&D activities *(58%)*, improved access to R&D *(54%)*, development of prototypes *(51%)*, access to new markets *(extension to other localities) (49%)*, risk sharing *(especially in the case of engineering companies) (37%)*, access to new distribution channels *(26%)* and increased scale of operations *(20%)*.

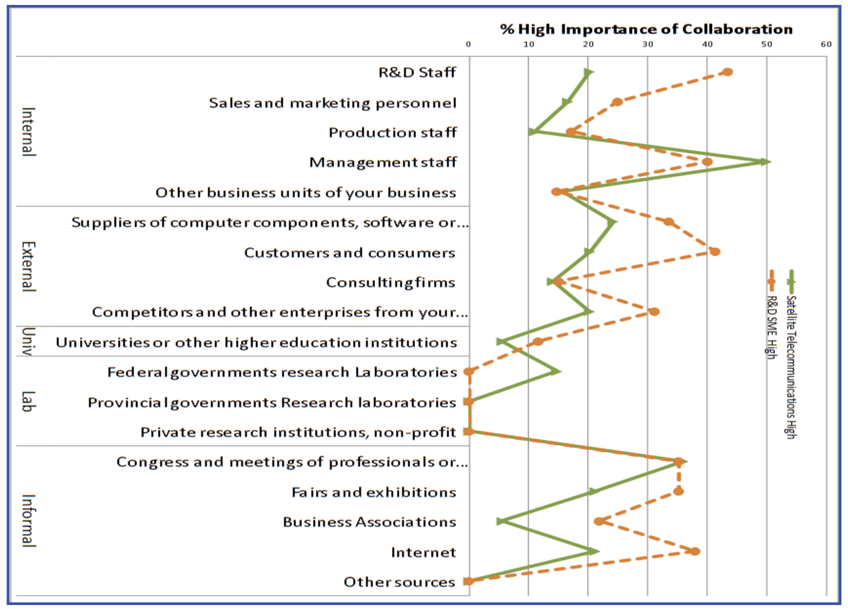

FIGURE 2. *Sources of information for innovation in R&D enterprises in Canada (Adapted from Table 358-0048 Statistics Canada. - Survey of innovation)*

Reasons to collaborate	Operational	Tactical	Strategic Increasing complexity
Sharing cost		•	
Spreading risks			•
Accessing R&D			•
Prototype developement	•		
Scaling-up production process		•	
Accessing critical expertise			•••
Accessing new markets		•	
Accessing new distribution channels		•	
	Technical integration (Mainly objective)		Negotiation (Mainly subjective)

FIGURE 3. *Top reasons for collaboration by SMEs in R&D and ST enterprises.*

In addition, the other "informal networking" with their Associations, Internet and business community of knowledge capture identified in **Figure 2**, we notice in **Figure 3** that collaboration activities among experts are indispensable for innovation; that shows the importance of activities related to strategic development of business activities – a model of "shared expertise" that is "proprietary knowledge assets that are exclusively held by knowledge workers and shared in their work or embedded in technology" *(Wiig Knowledge Management Model, 1993 cited by Dalkir* [21], *p. 79)*. **Figure 4** shows the intrinsic product-result development approach to innovation. We note that the collaboration relationships are based on acquiring expert knowledge of partners and developing strategic activities.

Another element presented by Tödtling, Lehner and Kaufmann **[22]** demonstrates that the business-university relationship can be connected to company size, because larger companies and monopolies are more prone to work with research centers and government laboratories. Consequently, in large enterprises which employed scientific researchers, they maintain projects based on experimental activities and they work in the context of a relationship that is more closely tied to a scientific system, and share both academic language and concepts *(p. 69)*. These results lead us to propose a different methodology of networking based on social interactions and knowledge flow.

Project Platforms comparison

Web based and Database Platforms

Some Technology Transfer programs were implemented using ICT as a main strategy of sharing information. These platforms are divided in two categories: Spin-in when agencies need service from providers, and Spin-out, when agencies propose work subjects to external partners and community. In **Table 2**, we show a review of TT platforms used by the main space agencies; this data was provided by the enterprise Turquoise *(personal communication with CEO of Turquoise Ozgur Gurtuna, 2012)*.

We observe in **Table 2**, a common aspect in the use of these web-based platforms, the use of HyperText Markup Language *(HTML)* pages and Extensible Markup Language *(XML)* to encode and to read databases. In the Canadian Platform, the use of Active Service Pages *(ASP)*, a Web Application framework developed by Microsoft. In the European Platform, we find programming languages such as C++ and Practical Extraction and Reporting Language *(PERL)*. In these kinds of Web services, external enterprises have the possibility of being informed and knowing about some future projects. In other ways, for agencies, these platforms had the advantage of obtaining and tracking information about the possible providers or contractors, and adapting to an active database.

For the paradigm of "database" approach of the use of these Platforms, we observe the following drawbacks:

- Limited information about projects
- Non collaborative spaces
- No workspaces
- Competition oriented
- Non-contact with sponsor, partners or experts

On the other hand, these platforms are also limited to completing a process of collaboration, because the used technology does not allow convenient visualization among participants in either of the following projects.

Agencies	**Spin-in** (Contracts)	**Spin-out** (Sharing projects)
CSA	MERX https://www.merx.com/	Technology Transfer Federal Partners in Technology Transfer FPTT http://www.fptt-pftt.gc.ca/eng/about/partners/space.html
ESA	EMITS http://emits.esa.int/emits/owa/emits.main EUMITS https://eumits.eumetsat.int/	Technology Transfer http://www.esa.int/SPECIALS/TTP2/
NASA	Multiple RFP Systems http://prod.nais.nasa.gov/cgi-bin/nais/index.cg	Knowledge Management http://km.nasa.gov/whatis/index.html Technology Transfer http://technology.nasa.gov/ Early-stage of innovation Program http://www.nasa.gov/offices/oct/early_stage_innovation/early_stage_programs_chart.html

TABLE 2. *TT Web Platforms at Space Agencies*

Crowdsourcing Platforms

Figure 4 provides a comparison and an explanation of main functionalities found in different platforms of crowdsourcing: Innokiz *(prototype ETS-Montreal)*, InnoCentive.com, OpenIdeo, Challengepost, y2.com, Topcoder, idea.me, and 10000Ideas. We compared these crowdsourcing platforms using 10 criteria-functionalities **[23]**:

1. Price
2. Visualizing new ideas
3. Innovation Management
4. Communication tools
5. Recruitment of staff
6. Collaboration, Professional networking
7. Tools/Workflow/ Process
8. Challenges proposed
9. Public participation
10. Public Poll

These elements are essential to support collaboration for exchanging ideas in a Spin-out technology transfer from large enterprises or public administration to SMEs. Also, InnoCentive supports Spin-in technology transfer, in a virtual Pavilion dedicated to a NASA internal challenges **[24]**.

Into the paradigm of "Crowdsourcing" Platforms, the Platforms have some advantages compared to "database" Platforms. Crowdsourcing allows the connection among sponsors and contributors to the project. We observe the following drawbacks in the use of crowdsourcing platforms to be oriented to technology transfer among SME enterprises and the CSA agency:

- Result-oriented and not process-oriented
- Non collaborative activities proposed among participants
- Competition oriented
- No contact with sponsor, partners, experts, community of practice
- No Networking generation

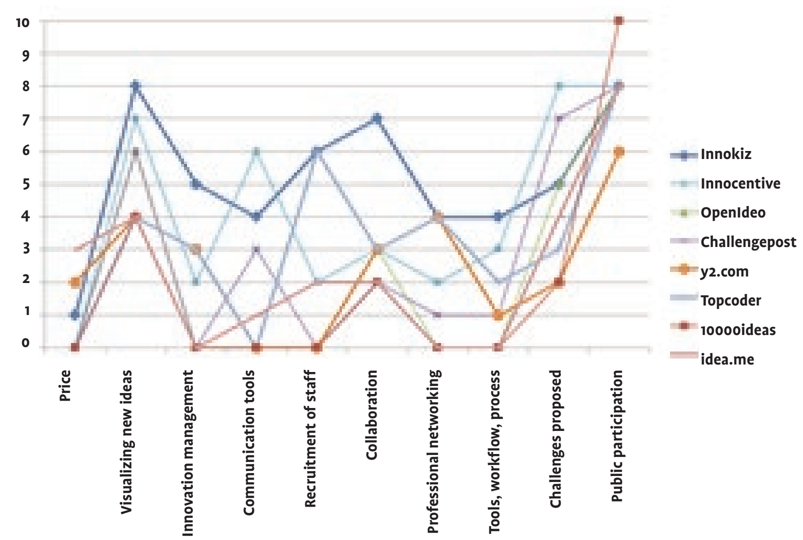

FIGURE 4. *Comparative of crowdsourcing platforms used to knowledge and ideas transfer*

Methodology Proposal to manage Open-Collaborative Projects

Considering the impact of the spatial sector in society and the high degree of knowledge protection for some special topics of development, particularly the military sector, communications, and energy, it is the main importance defining the Degree of Openness/Closeness on the communication topics of the Knowledge Transfer that there be sharing in a collaborative Platform. This degree could be measured for a strategic Committee that analyzes the impact of open or closed strategy of knowledge sharing *(coverage, scope, magnitude)*. This degree also has to be analyzed with the impact in the intellectual property and a balance with the impact in society of each discovery or invention. For example, if an invention has more impact in the society the knowledge has to be transfered "immediately" in an open strategy. In this case, the impact is measured by social demands, which have more impact on social health/ well-being.

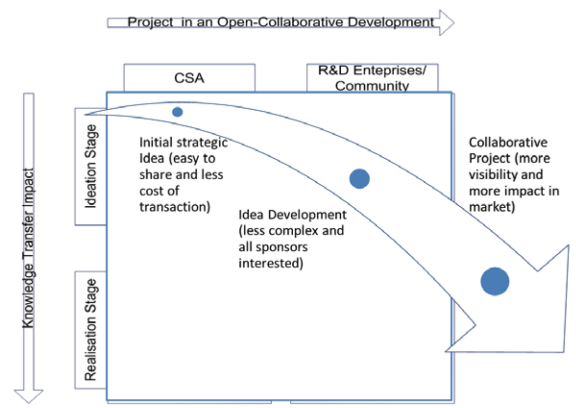

FIGURE 5. *Knowledge Transfer Proposal for CSA in an Open-Collaborative Project Development.*

The implementation of Open-collaborative strategies shall be parallel with ICT development. ICT enables and outlines the collaboration that is already setting up. As shown in **Figure 5**, we propose three strategic stages parallel to the CSA Platform:

1. 1. Definition of the strategy of Open Innovation for the project: Strategic Knowledge for Open Collaborative development, this stage is developed by Internal Staff of R&D of CSA and concerned departments;
2. 2. Definition of network to be created or to be supported: Definition of Community of Practice (or desired network) and searching of external shared expertise for Project Definition;
3. 3. Planning and implementation of co-design events (meetings, congress, summits, etc.) in co-localized or delocalized settings supported by the ICT Platform.

3. Conclusions

The economic models and policies of innovation, and especially those related to technology transfer, are designed to support scientific and technological developments in high-tech or science under policies that encourage the classic linear model. However, our research demonstrates that the innovation process is not linear; the links between research, its uses, and impacts are not necessarily direct and immediate. The innovation process is an amalgam of very diverse types of knowledge sharing and opportunities related with technology development, various principles and technologies that have emerged at different times and from different actors; products that are generated are diverse in nature and can play different roles; its realization requires other factors beyond those related to Knowledge Transfer and Open-Innovation strategies.

Apart from socio-technological conditions, there is important ICT research to bring forward open-collaborative project development. In our research, we observed that the development of ICT in the spatial sector for support Knowledge Transfer is not as technologically advanced. Sections 2 and 3 provided a summary of ICT platforms designed for Knowledge Transfer and project development. The actual platforms are compared with new propositions of crowdsourcing platforms such as: Innocentive, NASA@work, OpenIdeo, Challengepost, y2.com, Topcoder, idea.me, and 10000Ideas. Crowdsourcing ICT platforms show new functionalities coherent with Open Innovation and enabling the network creation and the easy dispersion of Technology Transfer but crowdsourcing platform lack of the support to the networking or to brought together all actors implicated. In this respect, Technology Transfer for the spatial sector, and particularly for CSA, needs to be modeled in function of communication needs and aspects such as access to the information, the intellectual property definition, the involved industrial or military secrets, and the impact of new research in the well-being of Canada.

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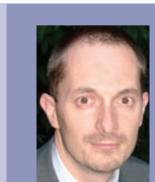

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