A Technology Transfer Framework: A Case Study from the Energy Sector

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***Abstract*—The technology transfer concept is not consensual throughout the literature and encompasses several different facets and nuances. In spite of the apparent confusion regarding its definition, researchers and practitioners are unanimous when it comes to its importance – especially for organizations that depend on technological development. The literature has brought a myriad of taxonomies, frameworks and guides trying to make sense and formalize the transfer process. However, few are the real cases analyzed in the current body of knowledge. This paper brings a case from an organization that is trying to overcome the obstacles of technology transfer by creating its own framework. The framework – still in its preliminary form – is presented and analyzed, its reasoning, components and criteria are depicted and discussed, and its limitations and future directions are pointed out. This paper contributes to the literature by enriching the body of knowledge with a real-life case and contributes to the practice by informing technology managers of how an organization is dealing with its R&D management and technology transfer issues.**

***Index Terms*—Energy, R&D management, technology management, technology transfer.**

I. Introduction

The technology transfer concept, as it will be further discussed later in this paper, is not consensual and several different definitions emerge in the literature body. However, most of the definitions are slightly different from each other. As defined in [1], "Technology transfer can be defined as the process of transferring knowledge or expertise related to some aspect of technology from one user to another". Although the definition of technology transfer is not consensual, its importance and complexity is. According to [2], "technology transfer encompasses a complicated process involving the complexity of the technology, the owner`s capability of teaching, the acquirer`s capability of learning and the complex interaction between the two parties". Such is the complexity of technology transfer that Reisman [3] decided to create a taxonomy, describing the most recurrent players and factors that could play a role during a tech transfer process. The author argued that the subject is incredibly complex and the literature is too chaotic, therefore his taxonomy would help in organizing and understanding the process. Also, later in 2013, Estep and Daim [4] published a research work trying to make sense of the vast literature on technology transfer, showing, once again, that although the subject has been extensively researched, it is still difficult to have a holistic view and find common ground on which to base the implementation of transfer projects.

This paper has the intention of shedding some more light on how organizations are trying to deal with their technology transfer problems, through the analysis of a case. The initial framework for a technology transfer process, as it is being developed and implemented in the Technology Innovation Office at the Bonneville Power Administration, will be presented and hopefully will serve as a small contribution to both researchers and practitioners on how to face technology transfer challenges. Although the framework is still in its preliminary phase, the contribution will be materialized by adding another "brick" in the "wall of knowledge" represented by the technology transfer literature. Theory-wise, it contributes by presenting a new framework, a new way of analyzing R&D projects regarding technology transfer issues. Practice-wise, it contributes by depicting how this framework is being implemented/planned to be implemented in a real organization.

The rest of the paper is organized as follows: a literature review, some research method remarks, the presentation of the initial technology transfer framework, a discussion, conclusion and finally some comments on the limitations of this work and potential ideas for future research.

II. Literature Review

Technology transfer has been a subject of study for many different fields throughout the years, yet it still presents numerous research opportunities, given its importance and its management challenges. The complexity of technology transfer starts with its very definition, which could vary significantly depending on the field of study or the application. There are technology transfers within the same organization in the same location and there are those within the same organization but involving different locations and personnel. There are technology transfers involving different players (e.g. a university and a company) in the same location/region and there are technology transfers involving different players in completely different locations/settings (e.g. an American company licensing a technology to an Indian company). Each of these different modes of technology transfer will present donors and recipients with specific characteristics and problems to solve. Nonetheless, some of the characteristics, challenges, key questions and success factors are common, regardless of the type of technology transfer being dealt with.

According to [5], "When scientific or technological

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information generated and/or used in one context is re-evaluated and/or implemented in a different context, the process is called technology transfer". As aforementioned, several fields of study have been researching technology transfer, and each of those have their own definitions – which slightly or substantially differ from each other. As [6] notes, economists, sociologists and anthropologists all have different visions on tech transfer. Adding to this point of view, Cormican and O`Connor [7] state that "It seems that technology transfer can be defined in many different ways depending on the discipline of the researcher and the purpose of the research. It is also clear that technology transfer has been used by many disciplines to analyze a wide range of technology issues" [1]. Other definitions can be found across the literature, as in [7]–[11] Notwithstanding the initial confusion provoked by the myriad of definitions provided by the literature, it is not difficult to understand the importance that such a process has for innovative organizations and technology developers.

While scholars debate on the definition of technology transfer and their different modes and characteristics, there is a consensus when it comes to the importance of such a process to organizations, especially in highly competitive environments. Technology transfer has become a strategic "feature" any organization should master in order to thrive in highly competitive and high tech markets. As [12] states, "thinking a strategy is necessary for handing off a technology from developer to user". Following the same line, Cormican and O`Connor [1] argue that "technology transfer has become part of many organizations` business strategy and the ability to manage the transfer process has become a critical competence". Bringing a broader point of view, Franza and Grant state that "Technology transfer has become an increasingly important mission of federal laboratories in the United States, with results that benefit the government, private companies and the U.S. economy" [13]. Technology transfer is also noted in the literature as being effective and beneficial to specific sectors, such as implementing energy efficiency initiatives [14] and decreasing green house gas emissions [15]–[20].The advantages derived from a good technology transfer management go beyond what some may imagine. It can really be a game changer for organizations on highly competitive environments. As [2] explains, a proper tech transfer management will increase the organization productivity, enhance its alliances quality and most importantly, create sustainable competitive advantage. Many are the studies which tried to identify the potential challenges for organizations to be successful at transferring technologies and many are the studies which communicated the importance of such a process to the success of any given organization. Among those, one can highlight the work done in [2], [3], [21]–[31].

As clear as the importance of technology transfer is its challenges and difficulties in being managed. Bozeman [6] says that "First, putting a boundary on the technology is not so easy. Second, outlining the technology transfer process is virtually impossible because there are so many concurrent processes". Moreover, according to [1], the process of transferring technologies is intricate and contains several challenges. Still according to [1], tech transfer "…is a complex activity and companies face many problems in this regard". In [19], the authors argue that, given the complexity of technology transfer, it is necessary the evaluation of several case studies in order to solid conclusions. The specific challenges and obstacles that hinder transferring a technology successfully are discussed in the literature and would depend on each specific situation. Trying to identify general barrier categories for technology transfer, the authors in [32] list the major barriers for technology transfer in the steel sector in Japan: economic factors, inadequate policies and regulations in place and technical factors.

When it comes to knowing what should be considered and what conditions should be in place in order to conduct a successful technology transfer process, scholars have been trying to identify success factors – desired conditions and *sine qua non* conditions for a successful transfer. As stated in [5], for a technology transfer process to achieve its objectives, both players (the recipient part and the donor part) should possess very strong analysis skills. This is true due to the fact that, regardless of how good of a model one uses or how experienced one is, technology transfer processes are always one of a kind – its full repeatability is nearly impossible – therefore both recipient and donor should be aware of the conditions (should analyze it thoroughly) in order to plan and execute the transfer. Estep [33] identified success criteria perspectives related to technology transfer, separated into four major groups, namely research domain (the donor); technology recipient domain; technology characteristics; interface strategy. Another interesting work by Lai and Tsai [34] has found factors and sub-factors that play a major role in technology transfer projects. Most of the frameworks and success factors listed in the literature concern technology transfer as a whole. However, some authors also try to narrow down the type of transfer in order to identify more specific factors. For instance, in [30], Siegel et. al consider the UITT (University-Industry technology transfer) process, and they conclude that, for that particular type of transfer, these are the most important factors to be considered: reward systems for UITT; staffing practices in the TTO (Technology Transfer Office); flexible university policies on technology transfer; devoting additional resources to UITT; elimination of cultural and informational obstacles that hinder UITTs.

The literature on technology transfer is vast and there has been numerous efforts from researchers in order to devise models that could ameliorate an organization`s understanding of the process, its features and requirements, ultimately (and hopefully) leading to increased transfer capabilities. In [12], Bandarian develops a model to determine the commercial application of a technology. It is based on multiple perspectives – the STEP methodology, strategic technology evaluation program – and it considers factors such as financial, legal, regulatory and market-related issues, rather than just focusing on the technical aspects of the technology.

The work conducted by Bar-Zakay in the early 70`s resulted in a very comprehensive technology transfer model, that regards it as a country to country process and identifies and divides activities, milestones and decision points between recipients and donors. The work done by Bozeman [6] also resulted in a framework or model for tech transfer. The author considered tech transfer as a domestic process, e.g. from government labs to private companies, and his model highlights different perspectives and factors that should be taken into consideration when transferring a technology. Cormican and O`Connor [1] put together a model that is focused on external product technology transfer. It is a step-by-step process that aims to set general guidelines for organizations to transfer their products manufacturing processes to another organization or another location within the same organization. The technology transfer process can also be identified in the relation between research teams (organizations that develop the technology) and users (organizations that adopt the technology). In [33], the author studied that relation and developed a model based on hierarchical decision modeling (HDM) to create a technology transfer score. The work done by Ramanathan [36] brings a good summary of diversified models for technology transfer, and also introduced the idea of planning and implementing a technology transfer project by adopting a life cycle approach.

III. Research Method

This paper intends to present the preliminary version of a framework designed to ameliorate an organization`s technology transfer capabilities. The method utilized was action research. The authors participated in the development of this initial version from March 2015 to December 2015, period during which he maintained close contact with the organization, its staff and some of its research and development projects, being able to acquire enough information and expertise to depict the referred framework.

IV. Technology Transfer Framework

A. BPA Background

The Bonneville Power Administration (BPA) is a federal organization, part of the Department of Energy (DoE), that manages electricity marketing and owns and operates transmission lines in the Pacific Northwest (Washington, Oregon, Idaho and parts of Montana, Utah, Nevada, California and Wyoming). According to [37], BPA markets power from several tens of power plants (the vast majority being hydroelectric power plants), being responsible for providing nearly 28% of the whole Northwest electricity and operating nearly 75% of all transmission lines in the region. The organization is 75 years old and is known for its strong investments in diversified technologies and for sponsoring new concepts and paradigms in the electric sector, such as energy efficiency and demand-side management, for instance.

The Technology Innovation Office (TI) is the group within BPA that manages its portfolio of investments in technology development. Stated in [38] is the following: “Since 2005, BPA's Technology Innovation Office has implemented a disciplined research management approach that has led to an unprecedented level of success, including the build out of the largest synchrophasor network in North America; the helical connector shunt innovation, a BPA-engineered technology that can up-rate and extend the life of aging transmission lines; the support of a pilot program that boosted the adoption of ductless heat pumps in the region; and an industry-leading seismic mitigation program”.

B. Framework

The technology innovation office at BPA has an annual cycle that is comprised of planning to request for new proposals (new research ideas with technologies that would serve the needs of the organization, according to the strategic management guidelines and the technology roadmaps), receiving and analyzing the proposals submitted and accepting the best proposals. The office is also involved in the agency`s summits, which are events in which research projects are evaluated by a multidisciplinary body of analysts, who analyze if the projects should continue or if they should be pruned – all in consistency with the organization`s internal policies and with the effort of keeping the research portfolio balanced. In parallel, the office also manages the on-going projects and facilitates the transfer process of those projects coming to an end. The management of the ongoing projects is done through regular meetings and reports from the research team representatives and internal project managers, and also through regular stage-gates, pre-established in the agreement between the research team and the organization. The management of the transfer process, however, was very unstructured and no formal process was in place. Thus, the organization felt the need to create and implement a technology transfer process to aid in the implementation of technologies from closing technology development projects.

The objective of the framework is to create a general process, applicable to all technology development projects at BPA, aiming to improve the organization`s technology transfer capabilities, i.e. to help the organization to maximize the benefits derived from new technologies, within less time and spending less resources. Fig. 1 shows the technology transfer process map, created to guide the development of the framework.

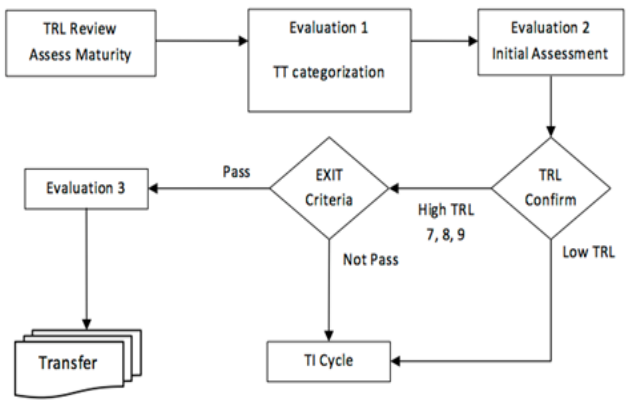

Fig. 1. Technology transfer process map.

A very important observation can be made at this point. Instead of dealing and planning the technology transfer only when the development project is close to be finalized, this process map indicates that the technology transfer process starts when the technology development project starts. All these steps occur in parallel with the regular project control systems in place (stage-gates; performance reports; etc.). The first box – TRL review – takes place at the very early stage of the R&D project and the following steps take place throughout the project life cycle, ultimately culminating with the actual transfer of the developed technology, right after the R&D project is finalized.

The first step of the map is the technology maturity assessment through the application of the famous NASA scale technology readiness levels (TRL). Even before the project starts, the research team is responsible for determining the current TRL (it might be 1 if the technology is being developed from scratch or it might be higher if the research is a "follow-on" type, when the starting point of one project is the ending point of a previous project) and also the expected TRL when the project is done. That kind of information is useful because the recipient, knowing how mature the technology will be at the end of the project, can plan its efforts and how to benefit from the outcome of the project accordingly. The second step is the evaluation 1 (EV1), when initial and basic information concerning the project and the technology are gathered, as well as the categorization of the project. Following EV1, the evaluation 2 is performed (EV2), when more specific information about the project and the technology are gathered and initial assessments of feasibility are conducted. After EV2, later on the technology development process, a confirmation of the TRL is conducted. The first step mandates the determination of the current and the expected TRLs. However, changes are likely to occur during the project, resulting in changes in the expected TRL. Therefore, it is important to re-assess (or confirm) the TRL in the middle of the project. After the TRL is confirmed, there is a decision point. For those projects which will result in technologies with low TRLs (six or below), there will be no transfer activities. In those cases, the outcome of the project will be fed back into the normal office innovation cycle – certainly those technologies will need to be further developed through new projects – and a new project is likely to start where the previous one has ended (this process goes on until the technology is mature enough to be transferred). For those projects which will result in technologies with high TRLs (seven or higher), there is another scrutiny step through which the technology is analyzed against some exit criteria (mostly related to cost, technical feasibility and regulatory issues). If the technology does not pass the exit criteria, it will also be fed back into the normal cycle – waiting for new solutions to come for the problems encountered. If, however, the technology passes the exit criteria, the development process continues and the last evaluation point (EV3) is conducted. On EV3, specific questions are addressed, concerning the value of the technology for the organization, the feasibility (considering multiple perspectives) and the risk of implementing the technology. After the last evaluation point, enough information about the technology has been gathered, making it possible for the organization to properly plan and execute the transfer.

The most important components of the framework are the EVs. These evaluation points gather information about the project, the technology and the research team (technology donors), educating the recipient with regards to what to expect from that technology development project, when and how. Without such an understanding, it is very difficult to devise a plan to transfer the technology. Following is a more detailed explanation of the three evaluation points.

1) EV1

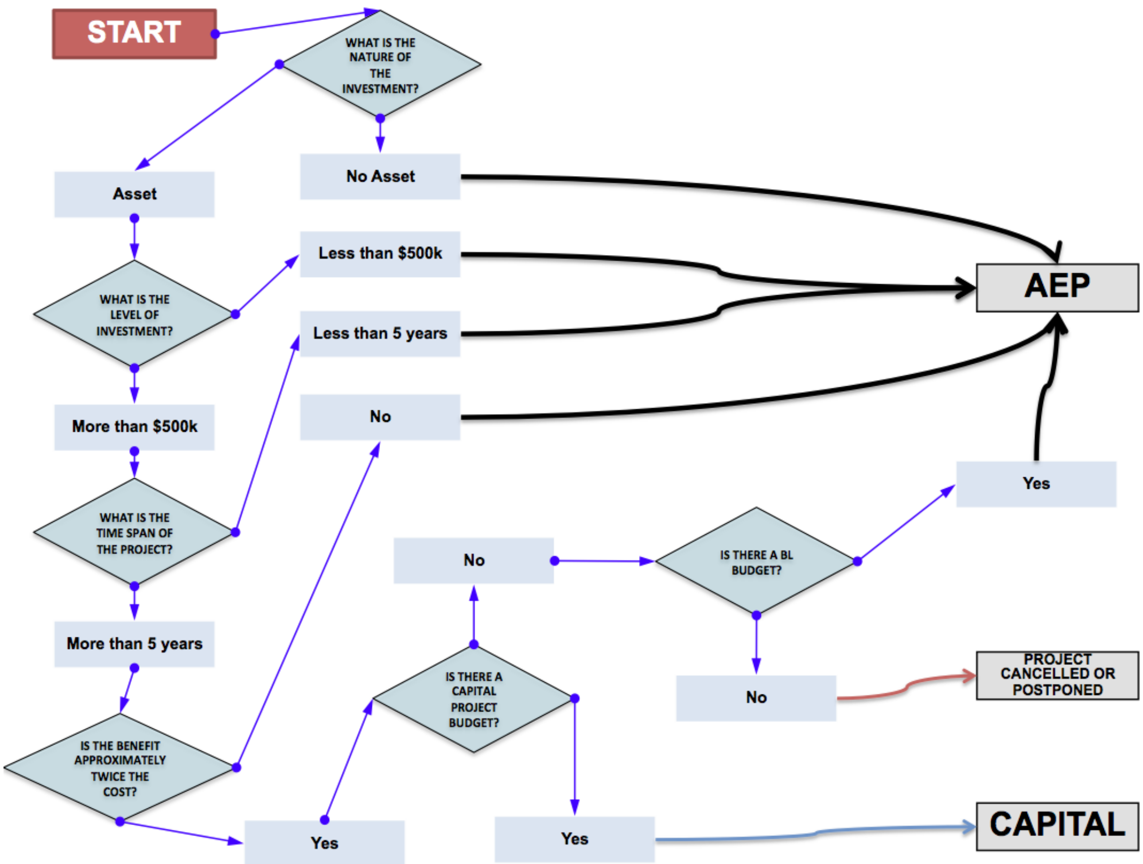

Fig. 2. Categorization chart on EV1.

The objective of the evaluation point 1 is to categorize the project and gather basic and high level information. This evaluation instrument is applied in the very early stages of the technology development project and the respondents are staff members from the Technology Innovation Office – they should do so by learning from project-related documents (project proposal, for instance) and also from interviews with the research team and the internal project manager (when necessary). The instrument is divided into three sections: categorization; project outcomes; project benefits. The categorization starts with the flow chart depicted in Fig. 2.

The categorization is important to know the size and scope of the project. The two possible categories are capital projects and applied expense projects (AEP). Capital are those projects that involve the development of assets to the organizations, and also are bigger in time spam and investment volumes. Conversely, AEPs may not involve asset development, e.g. the development of a new practice or process – a knowledge diffusion-type project, and AEPs are less extensive when it comes to development time and investments required. The flow chart starts by asking about the existence of assets, then moves on to ask about the level of investment and the time spam of the project. It also asks about the ratio between investment and expected benefits, and asks about the origin of the investment – if there is a dedicated capital budget line or of there is a normal business line budget. Being done with the categorization, EV1 moves on to investigate the expected outcomes of the project. Product and service, knowledge diffusion and follow-on research are the possible categories for outcomes, and the respondent has the option to list the primary and the secondary (if any) type of outcome. For example, a project might develop a new device (therefore its primary outcome will be a product) and also a process to install the device (therefore its secondary outcome will be knowledge diffusion). The third and last section of EV1 is "project benefits". This section aims to categorize and briefly describe the expected benefits – that could be interim or end benefits. An end benefit exists when the project delivers a "fully applicable" outcome, e.g. if a project develops a device that will be tested and applied in the field without further adaptations or research needed. An interim benefit exists when the project does not deliver a fully applicable outcome, but rather contributes to the future delivery of a fully applicable outcome, e.g. a certain project creates a new device and brings it to TRL 5, thus requiring another project to bring the TRL further to applicable levels. For every question of the evaluation instrument, there are fields for the respondent to provide additional explanations if necessary.

2) EV2

The objective of the evaluation point 2 is to determine (in a high-level manner) the economic value and strategic fit of the project, as well as its applicability and the impact it will have on the organization`s operations. EV2 could also be regarded as a less detailed version of EV3. The respondents for this evaluation instrument are mainly staff members from the Technology Innovation Office. However, since there are some more specific questions about the project, the input from research team members become highly recommended at this point. EV2 should be applied around the mid-point of the project, when both donors and recipients have a clearer idea of how the project is being conducted. The instrument is divided into two sections: value and applicability. The value section is sub-divided into three sections: economic value; strategic value and impact. The economic value sub-section asks the total upfront investment range and the expected cost savings and/or revenue increases ranges derived from the outcome of the project. The strategic value section asks the respondent to classify the project outcome into one of the organization`s strategic areas of interest (pre-determined by the organization`s strategic management process). Also, it expects the respondent to rate the strategic value from low to high, according to the following definitions:

- Low: The project is related to one of the strategic areas and brings an incremental push towards the achievement of that strategic goal.
- Medium: The project is intimately related to one of the strategic areas and brings significant push towards the achievement of that strategic goal.
- High: The project is not only intimately related to one of the strategic areas, but also is critical to the achievement of that strategic goal.

The impact sub-section asks the respondent to rate the expected impact on the organization`s overall activities derived from the outcomes of the project. Some "impact criteria" were developed and the rating occurs with regards to each of these criteria. The nature of the criteria is the following:

- What are the external parties participating, e.g. research teams, consultants, experts, regulators, etc.?
- How many groups within the organization will be involved in the project?
- How many groups within the organization will be affected by the outcomes of the project?
- To what extent the outcome of the project, once implemented, will affect the organization`s operations?
- How is the result of project or application expected to affect public perceptions of core service delivery by the organization?

The rating is from low to high, according to the following definitions:

- Low: The project will bring minor changes to one or more groups within the organization.
- Medium: The project will bring significant changes to one or more groups within the organization.
- High: The project will fundamentally change the way the organization works/regards a particular matter.

The last section of EV2 is called "applicability". The section asks the respondent to rate specific applicability criteria. The criteria are the following:

- Is it technically feasible to take the technology and apply for the organization?
- Can employees and organizations easily apply and use the technologies? Does the business processes support the application?
- Does regulation or policy support the application?

The rating is from low to high, according to the following definitions:

- Low: The outcome of the project will not be applied in its entirety and some adaptations/limitations are required.
- Medium: The outcome of the project will be applied in its entirety by the organization, but some adaptations are required.
- High: The outcome of the project will be applied in its entirety by the organization, with no need for adaptations/limitations.

3) EV3

After completing Evaluation 1 and Evaluation 2, Technology Innovation Projects (TIPs) that include technologies with a TRL greater than or equal to 7 advance to Evaluation 3. The objective of evaluation point 3 is to gather detailed information about the project, leading to a better capacity of planning for and executing a successful transfer. Similarly to EV2, EV3 respondents are mainly staff members from the Technology Innovation Office, but with a strong support and input from both technology donors (research team and other partners) and technology recipients (end users and the internal project manager). The application of EV3 should be done towards the end of the technology development, as more detailed and precise information are needed. EV3 gathers detailed information pertaining to the feasibility of the technology transfer and documents the risks associated with the potential transfer. The economic value and the strategic value of the TIP are assessed as well, in a more detailed fashion than what is done in EV2. EV3 assesses the likelihood for a successful transfer, value and risk of the developed technology. Technology Transfer will plan to mitigate the identified risk and overcome the barriers. However, if the risks and/or obstacles for successful technology transfer prove to be too high, the project is either referred back into the TI cycle or held in stand-by until the impediments diminish. If no major issues are identified, the technology transfer can proceed as planned. Where manageable issues are identified, solutions are developed. For all cases, EV3 documents 'lessons learned' to systematically improve the technology transfer process. The process logic for Evaluation 3 is shown in Fig. 3, followed by its step-by-step explanation.

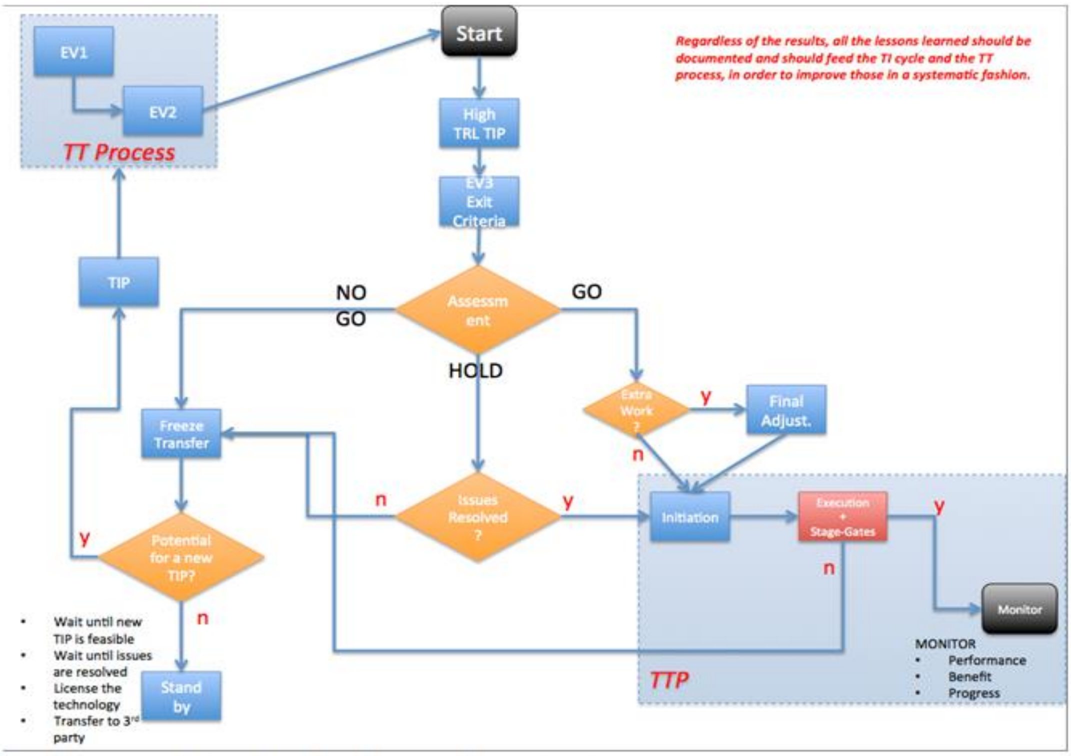

Fig. 3. EV3 flow chart.

As aforementioned, technology development projects go through EV1 and EV2, then (if the TRL is greater than six) they go through the final evaluation, EV3. An assessment is done based on criteria grouped into three groups: value; feasibility; risk (criteria further explained later in this section). After the assessment is done, if no major issues are identified, the project receives a "go" sign for transfer. Before actually starting the transfer, the necessity of extra work is checked (these would be final and small adjustments and adaptations, mostly on the recipient side). If there is such a necessity, the extra work is conducted and then the transfer is initiated. If not, the transfer is initiated immediately. The technology transfer project (TTP) consists of summarizing all the information gathered in the transfer planning (EV1, EV2 and EV3) and preparing the recipient and donor teams for the execution. Depending on the type of technology to be transferred, different paths, methods and time spams will be used, e.g. for knowledge diffusion, simple reports and exhibitions might be enough, and for new devices and/or equipment, several hours of training and demonstration might be necessary, with a transition period including research team staff being present in the field for support. Regardless of the type of transfer, after the execution is done, a final assessment is conducted in the recipient side. If the transfer was considered successful, a monitoring period starts, keeping track of the progress of the technology (if a ramp-up period is necessary), the benefits that were supposed to surge and also the performance of the technology (if the benefits are being achieved within the expected timeframe and within the expected magnitudes). If, however, the transfer is considered to be unsuccessful, the transfer is frozen. Back to the EV3 criteria assessment step, if there are major issues identified but those are considered to be manageable, e.g. a new regulation must be in place in order to a technology to be used and such regulation is about to be enacted, then a "hold" sign is given to the transfer. At this point the issues are given a certain amount of time to be taken care of. If, at the end of the period, the issues were resolved, the transfer is initiated. If, however, the issues are still present, the transfer is frozen. In the case where, during the EV3 criteria assessment stage, major issues are identified and are not considered to be easily manageable, then a "no go" sign is given to the transfer, e.g., if a technical issue is discovered, seriously compromising the performance of the technology and therefore significantly reducing the expected benefits, and the transfer is frozen. In all cases where the transfer is frozen, a post-mortem assessment is conducted, trying to identify potential opportunities for further research, aiming to solve the issues that compromised the transfer. If there is a potential for further research, the outcome of the "frozen transfer" project will be fed back into the regular innovation cycle, waiting for new project proposals. As mentioned before, these new projects would address the technology issues and will make it possible for the technology to be successfully transferred. If, on the other hand, no potential for further research is identified, the organization shifts its attention towards licensing or transferring the technology to other parties that may benefit from the technology. Regardless of the result of the project (if it was successfully transferred or not), a "lessons learned" report should be written, in which all the interesting details and potential improvement points in the framework are listed, later to be taken care of. By adopting this practice, the organization makes sure to have a "living" technology transfer framework, always being updated and changing to serve the needs of the organization.

EV3 has three distinct sections, namely value, feasibility and risk. The value section is sub-divided into two sections: economic value and strategic value. The strategic value sub-section is identical to the one in EV2, and its purpose is to check if the purpose and application of the technology remain the same (in some cases, during the technological development, the application shifts considerably, leading to a purpose shift as well). The economic value sub-section is a more detailed and precise assessment than that from EV2. It asks the respondents to provide specific monetary values for implementation and maintenance costs, as well as costs savings and revenue increases, with its respective sources, e.g. decrease costs of $100,000.00 per year due to decreased congestion in transmission lines (other project instruments should define and better explain the nature and details of benefits). The feasibility section lists criteria and asks the respondent to rate the project regarding each criterion. Following are the criteria (please see Appendix A for details):

- Absorptive capacity
- Facilitators
- Stakeholder engagement
- Regulatory issues (known beforehand)
- Technology complexity
- Technology adaptation and integration

The risk section in EV3 works in the same way as the feasibility section. Criteria are listed and the respondents have to rate them. Following are the criteria (please see Appendix B for details):

- Cultural Differences
- Geographical Distance
- Partner Engagement
- Technical Excellence
- IP issues
- Engineering risks
- Potential Regulatory Issues
- Cost Projections vs. Actual Costs

4) *Next steps*

As indicated earlier, the framework depicted in this paper is a preliminary version, lacking completeness yet. The next steps toward its completion are the clear definition of the exit criteria after the TRL confirmation and extensively testing the evaluation point instruments. A few pilot projects were followed up in order to get insights about how useful the EVs would be, resulting in great ideas and the development of more mature instruments. Nonetheless, more testing is needed and more feedback is needed in order to ameliorate the EVs, so it can extract the most important information from technology development projects aiming for a better technology transfer and execution. Other improvement points are analyzed in the discussion section.

V. Discussion

As seen in the literature review section, there are a lot of different definitions and frameworks designed to structure the technology transfer process. And however not consensual and disparate these definitions and frameworks may be, it is clear that, in order to succeed in transferring technologies, the organization needs to structure the process, understand the importance of managing it and deeply understand both sides involved in the process: donors and recipients. That is the main purpose of the framework depicted in this paper. All the evaluation points aim to gather information that will increase the understanding concerning the project, the technology and the parties involved. Furthermore, by establishing a formal and structured process, it increases the awareness about the subject in the organization.

Notwithstanding the fact that the framework is not yet completed, there is a strong sensation that it will significantly increase the organization`s capabilities on transferring technologies. Nevertheless, there is plenty of room for improvement in the framework. In particular, a scoring system would add a great value to the framework (especially on EV3), making it easier to classify projects and technologies and making the decision process faster and somewhat less subjective. The scoring system developed in [33] could be a good starting point in that direction.

There are also some "holes" in the framework that need to be filled and some difficulties identified throughout the framework development process. The "exit criteria" after the TRL confirmation, for instance, are still not well decided. These will be mostly related to costs aspects, technical difficulties and regulatory issues, but are not clearly determined yet. Moreover, a number of other difficulties were identified. TRL is a crucial metric in this framework, and yet the determination of the technology readiness level could be treacherous. The TRL analysis is not only subjective but it also could be compromised by biases, depending on who is responsible for making the assessment. Therefore, an "independent evaluator" should be assigned to this job. Nonetheless, the less information one has about the technology, the less accurate is the assessment, thus the evaluator has to have contact with personnel intimately involved in the project. Another problematic point is how to assign the responsible for answering the questions. On EV1, the most basic evaluation point, technology innovation (TI) staff are capable of accurately answering all the questions. However, for EV2 and EV3 they definitely need the aid of project managers, principal investigators and the research team members. To determine, for each question, who should be consulted is not an easy task, and it may have serious implications on how much time and effort has to be put into applying the framework. Although the framework should be used carefully and with attention, it is merely an instrument to ameliorate the technology transfer process – the most important is not the framework but the transfer, therefore its application should not be complex and time consuming, or else it becomes a burden for the organization and the benefits disappear. Also, to keep track of the benefits is important in order to prioritize projects and know how much effort to dedicate to a particular transfer. When projects yield end benefits, this control seems to be easy. Nevertheless, when interim benefits are involved it gets more difficult. In some cases, a technology is developed through the course of several R&D projects, each of which will contribute small portions of the overall development. In those cases, to estimate how much each project will contribute or to estimate how many projects or how much time will it take until that technology reaches a high TRL can be really complicated, and a decent method or approach is yet to be developed.

VI. Conclusion

Perhaps the biggest contribution of this paper is to bring a case, a practical case from an organization that faces technology transfer issues on a constant basis. Most of the literature dwells on defining, delimiting and understanding the process of technology transfer, and another fair share of the body of knowledge is dedicated to the creation of frameworks (based on the definition, delimitation and understanding of the problem) that would address major issues and ease the process of implementing and benefitting from the creation of new technologies. However, most of these research works do not bring "real-world" cases, or do not bring information on how organizations are trying to interpret, adapt and implement the frameworks and guidelines set forth by academicians. This paper starts to fill that gap, it depicted how an organization is trying to organize itself in order to minimize the hurdles associated with transferring knowledge and technology from research teams to the organization and in order to maximize their benefits out of the new technologies being created.

VII. Limitations and Future Research

This paper presented a preliminary framework for technology transfer. AS much as it has contributed to the organization already, it is still a first approach, an initial attempt of dealing with technology transfer issues. The framework is still incomplete and is still being piloted. Also, due to the fact that the framework is not done and it is nor fully implemented, there are no solid results from its application yet, which makes it difficult to measure its effectiveness. It is also clear that all the efforts carried out to design and implement the framework are done in such a way as to reflect the needs and requirements of one specific organization. All the reasoning and tools, criteria and evaluation points were developed taking into consideration the reality of that organization. Also due to the fact that the framework is not completed, it is not possible to infer or test if this framework would be applicable in other organizations and which adaptations would have to be done. All that being said, it seems obvious that when a framework or method is developed for a specific organization or sector, it has to be changed to be applicable in other settings. Hence, should objectives, characteristics, professional background, competitive environment and modus operandi changes, it is very likely that the technology transfer framework should change accordingly – how and to what extent remains to be determined.

The limitations discussed above present some opportunities for future research. It seems logical to wait for the completion of the framework and present it again (now in its final form), along with its first results and impressions from its users. A comparative study between what was done before the implementation of the framework and after would be very informative, comparing the results of similar technologies created and transferred with and without the aid of the framework. Moreover, trying to adapt the framework to other environments and sectors and bringing new cases from other types of organizations, from other industrial segments and with different objectives and backgrounds could be useful to tell how comprehensive or how specific a technology transfer framework should be. Furthermore, once other cases are studied, it is possible to compare the way different organizations are interpreting the work academia has been doing, compare the way different organizations are creating and implementing their technology transfer processes and compare their results.

Appendix

Appendix A – EV3 Feasibility Criteria

Feasibility Factors	Measurements	Scale Definitions (1-3)	Rate (1-3

			)
Absorptive capacity	The degree to which the recipient can absorb knowledge and techniques needed to use the technology. If the recipient already has contact with similar technologies, the transfer will be easier. According to Cormican and O'Connor (2009), sending people to undertake training at the donor's site and also choosing people with previous TT experience to participate in the process is very helpful.	1 None of its staff members has ability to incorporate it without significant support 2 Staffs have ability to incorporate it with reasonable support. 3 Staffs have ability to incorporate it with minimal support.	
Facilitators	The participation of people with previous experience in technology transfer and/or in the particular technology being transferred. These people could be consultants, internal or external experts.	1 Facilitators would be needed but none are available/participati ng 2 Facilitators are needed but are participating sporadically 3 Facilitators are not needed or are needed and are participating actively	
Stakeholder engagement	How strongly the main stakeholders support the project. For instance, if the final customers strongly support the deployment of a particular technology, the team possibly is going to have access to more resources to transfer it. Similarly, the more important the senior management thinks the project is, the more resources will be available for the project and for the transfer.	1 Neither end user nor senior management show strong support 2 Either end user or senior management show strong support 3 Both end user and senior management show strong support	
Regulatory issues (known beforehand)	Known minor regulatory issues that may partially undermine the deployment of the technology. If it is known beforehand, you have the opportunity to make a contingency plan to deal with it.	1 Some regulatory issues are foreseen and at least one may be critical 2 Some regulatory issues are foreseen, but none are critical 3 No regulatory issues are foreseen	
Technology Complexity	The nature of the technology. The more complex the technology, the more complex the transfer process, and vice-versa. According to Cormican and O'Connor (2009), the best thing to do when the technology is complex is to assign experienced technical staff to the transfer and make sure to conduct extensive training sessions at the donor`s site before the transfer.	1 Technology and application include multiple groups, technical areas which require highly experienced technical staffs and interdisciplinary teams to develop implementation plan. 2 Technology and application may include multiple groups, technical areas, which require interdisciplinary implementation plan.	
Technology adaptation and integration	The degree to which a technology has to be adapted in order to be integrated into the recipient`s business processes. The less adaptations needed, the easier the transfer. The more adaptations required, the more training needs to be done, especially at the recipient`s site.	1 Major adjustments and changes are needed to integrate the technology and business process. 2 Minor adjustments and changes are needed to integrate the technology and business process. 3 Few to no adjustments or changes are needed to integrate the technology and business process.	
Other			

APPENDIX B – EV3 RISK CRITERIA

Risk Factors	Measure Definitions	Scale Definitions (1-3)	Rate (1-3)
Cultural differences	This criterion is closely related to 'geographical distance'. The bigger the difference in culture between partners, the higher the chances of having problems during the transfer. Those differences include not only the language barrier (in the case of an international partner) but also	1 There are cultural differences and BPA staff are rarely present in the principal investigators' environment. BPA staffs don't know how to communicate and understand their norms. 2 There are cultural differences but BPA staff frequently interact with PIs' organizations. BPA	

	differences in the way of doing things and solving problems. Cormican and O'Connor (2009) state that a good way of mitigating these issues is to send people constantly to the donor`s site to observe, talk and interact with the partner.	staffs know reasonable expectations and effective communication channel. 3 Cultural differences don't impact working performance and relationship.	
Geographical distance	The further two partners are from each other, the more risky the transfer. Cormican and O'Connor (2009) mention geographical distance as one of the TT problems. However, Ahn et. Al (2009) found no relationship between geographical proximity and partnership success in the biopharmaceutical sector.	1 Partner is located overseas 2 Partner is located in the US but outside the NW region 3 Partner is located in the NW region	
Partner engagement	The risk of losing contact with the partner, especially after the project termination. If the partner is not engaged, it might just give up on the project in the middle of the development. Or, if the project was not a priority and does not represent an important source of revenue afterwards, the partner might just refuse to keep track of the outcomes – further development, maintenance, etc.	1 The project is not important to the partner and they do not show signs of future commitment 2 The project seem to be important to the partner but they do not show signs of future commitment 3 The project is important to the partner and they show signs of future commitment	
Technical excellence	This risk category relates to the chances of the partner not delivering what they promised (in a technical sense). If the partner is known to be technically excellent, the risks are lower.	1 The partner has neither excellence in the field nor in related fields 2 The partner has no excellence in the field but has in related fields 3 The partner is recognized for its technical excellence in the field	
IP issues	Although it usually does not represent a major concern for BPA, what are the chances of the partner fighting for larger IP rights after the project is done?	1 IP issues threaten the ability of BPA or desired partners to utilize the technology in the future 2 IP issues may complicate or impede the utilization of the technology in the future 3 IP issues are settled and no problems can be foreseen	
Engineering risks	Material specs, design, manufacturing – inherit risks related to the technical side of the project (regardless of the partner technical excellence). Due to the technical complexity of the system/technology/ process/product, what are the chances of it not working in the way it is expected to? At EV3 this risk category should be really low.	1 Some technical issues are present and at least one jeopardizes the benefits 2 Some technical issues are present, but none jeopardized the benefits 3 There are no engineering risks anymore. All technical issues are resolved	
Potential regulatory issues	As opposed to the regulatory issues that are known before the project starts, what are the chances of new regulations being put in force during or after the project`s completion and thus hindering or impeding the usage of the technology?	1 Regulations are likely to seriously restrict the benefits 2 New regulations are likely, but will only slightly impact the benefits 3 No regulatory issues foreseen	
Cost projections vs. actual costs	How likely it is for the costs (implementation and maintenance) to skyrocket when compared to the initial estimates. For example, if the maintenance costs turns out to be much higher than what was expected, the benefit will certainly decrease and thus the project might have been a bad choice.	1 Actual costs are much higher than expected and may compromise the benefits 2 Actual costs are slightly higher, but not bringing serious consequences 3 Actual costs are the same as the projected ones	
Other			

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