From Program Strategic Planning to Program Initiation: Lessons learned from a collaborative University-Industry R&D case study

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***Abstract*— This paper aims to contribute to knowledge by presenting the lessons learned resultant from a large case study composed by three collaborative University-Industry R&D funded programs between the University of Minho (UMinho) and Bosch Car Multimedia Portugal (Bosch). The three programs selected amount to a total investment of above €109 million, over the period between 2013 and 2021, involving more than one thousand University researchers and Industry collaborators. The lessons learned are limited to the time span from Program Strategic Planning, where new project ideas/ innovation opportunities are identified and developed for the preparation of the 'Funding Application', to Program Initiation, where the program effectively initiates after the negotiation of the 'Funding Contract'. The collection, analysis and implementation of lessons learned allowed the development of a structured process to guide University-Industry partners on the path to transform some newly identified project ideas into the initiation of a large R&D funded program. The proposed process is currently adopted by the governance structure of Bosch and UMinho partnership and other UMinho partnerships with Industry.**

Keywords—Program and project management, University-Industry collaboration, lessons learned.

I. INTRODUCTION

Due to the current political and economic situation in Europe, which resulted from a profound and severe economic crisis in the first decade of the 21st century, new financial stimuli from the European structural programs were provided to foster economic development. It has emerged the necessity of responding to these stimuli towards addressing the new challenges that follow the crisis period [1]. Therefore, in line with the European innovation policies the Portuguese government decision-makers have been encouraging the partnerships between universities and industries, towards enhancing the competitiveness level of the ecosystem of collaboration among the University and Industry players [2], [3].

One of the major barriers for an effective management of the University-Industry partnerships is that both entities are driven by different types of benefits [4], based on their motivations and values, which might lead, somehow, to a conflict of interests, over time. Nomakuchi and Takahashi [5] suggest some examples of these differences, such as the concept of Intentionality: the Industry focus in short-term profit, whereas the University focus in long-term profit; motivation: the Industry seeks remunerations and promotions opportunities, the University seeks for self-fulfillment; and, responsibility: the Industry establishes their own profit' targets, instead of the University that is more concerned with social responsibility.

Universities are called upon to actively contribute to the development of new products, technologies and processes. Collaborating with industries through appropriate knowledge transfer mechanisms. Universities make use of University-Industry partnerships as an effective tool to address the technological outputs that are suitable to the Industry, instead of solely producing theoretical knowledge left at a stage yet far from the market uptake, corresponding to very low Technology Readiness Levels (TRL) [3]. This call also allows the expansion of the Universities traditional role of education/ research and their mission within the society [2]. Therefore, the academic research plays a central and crucial role in the economic development through the enhancement of innovation and technology transfer driven by the needs of Industry and their sustainability aims, and, as such, universities and industries should reinforce collaborative research and development (R&D) partnerships, so that the knowledge created might be accessible to the society [5], [6].

The reasons that motivated Industry to join/ establish University-Industry collaborative R&D partnerships are mainly related to its effectiveness: the adoption of innovative solutions for real problems with market broad applications, the promotion of the business growth, as well as the access to the state-of-the-art within specific scientific knowledge areas. Other important aspect is related with the possibility of having access to funds and resources for the deployment of the organizational strategy.

Collaborative University-Industry R&D initiatives are usually funded and named as projects by the funding entities, but often are organized as programs by partners. A program is a set of projects that are, somehow, related and aimed at achieving a set of major benefits that are more than just the sum of the projects they consist of [7]. A collaborative University-Industry R&D program is here defined as a

temporary organization with a project based collaborative work environment, within a specific context, with heterogeneous partners, collective responsibilities and, in most cases, with competitive public funding support [8].

Programs have more complexity and uncertainty than projects. They require a specific way of thinking, more uncertainty-tolerant, closer to change, and more aware of the business influence. The time of a program completion is generally longer than that of a project [7]. Program management is the application of knowledge, skills, tools and techniques to a program, in order to fulfill all its requirements and obtain benefits that would not be obtained in the case of solely managing individual projects [9]. One of the important tools and techniques to be applied in program and project management is the lessons learned collected during program's lifecycle [10]. The ability to capture lessons learned will help the identification of a set of rules or guidelines that might improve the program and project's performance and avoid repeating mistakes [11].

This research involved the analysis of a large case study composed by three collaborative University-Industry R&D programs, between University of Minho and Bosch Car Multimedia, named as HMIExcel, Innovative Car HMI and Sensible Car. These three programs adopted the Program and Project Management (PgPM) approach, developed from an exploratory study [12]. The PgPM approach is dedicated to support R&D projects and programs on University-Industry collaborations, and it is divided into four phases: Program Preparation (Program Strategic Planning), Program Initiation, Program Benefits Delivery and Program Closure [12].

This research study aims to gather lessons learned in the two first phases of the PgPM lifecycle adopted, Program Strategic Planning and Program Initiation. The intent is to provide new inputs that will allow to mitigate risks or to eliminate issues that may occur in future collaborative R&D University-Industry programs.

The remaining of this paper follows a commonly used structure. The second section presents the theoretical background, namely the University-Industry R&D collaborations and the importance of developing a culture of learning in organizations and of lessons learned collection, for program and project management improvement. The third section presents the case study background and the methods used to collect the lessons learned in this research. The fourth section provides the description of the two phases contemplated and the lessons learned that were collected. Finally, the main reflections and conclusions that emerged from this research, as well as the suggestions for future work are presented.

II. THEORETICAL BACKGROUND

A. University-Industry R&D Collaborations

University-Industry R&D collaborations are very important in the context of future success of organizations, as well as national economies [2]. These collaborations fit into the principle of symbiosis. It means that this is a beneficial relationship for both parties, they will only survive as a collaborative entity if each partner satisfies the needs of the other. Using a questionnaire survey involving industries from different sectors of activity and universities, the motivations of universities and industries to be part of a R&D collaboration [5] were studied. Table I summarizes in a hierarchical representation, the underlying motivations of each partner.

The PgPM approach developed previously [12], [13] to manage collaborative University Industry R&D programs, took into account the specificities of such entity composed of two quite different partners. The PgPM approach is easily comprehensible and applicable, and is proven to deliver successful results [14]. PgPM distinguishes between programs and projects. In programs covering a group of related projects, their management must be coordinated, and synergies must be created, so that projects can generate greater benefits than they would if managed individually [9]. Nevertheless, the management of a program encompassing several projects requires the management of them all. Thus, PgPM establishes a project management layer bellow the program management layer [12].

The lifecycle of the program management layer is divided into four phases: 1) Program Strategic Planning: to align a common strategy for the Consortium (partner) Members, to identify the program scope, and to strive for the necessary resources to support new R&D projects, namely the financial support for the program; 2) Program Initiation: to guarantee the initial planning of the program and the alignment of the program objectives and outcomes with the stakeholders that will effectively get involved into the program execution; 3) Program Benefits Delivery: throughout this iterative phase, the projects of the program are planned, integrated and managed to facilitate the delivery of the intended program benefits; 4) Program Closure: to execute a controlled closure of the program and determine if the collaboration can be sustained [12]. The life-cycle of the project management layer is also divided into four phases: 1) Project Initiation: to kick-off each project, through the formal acceptance of the "project charter", 2) Project Initial Planning: to develop the initial Project plan by reaching a compromise between the Program Coordination and each Project team; 3) Project Execution, Monitoring and Controlling, and Replanning: to execute the Project work, to monitor and take the necessary control actions to pursue Projects success; and 4) Project Closure: to obtain formal acceptance of the results by stakeholders.

TABLE I. HYERARCHICAL UNDERLYING MOTIVATIONS OF UNIVERSITIES AND COMPANIES IN COLLABORATIVE RESEARCH FROM LEE [6]

Rank	What companies seek from universities	What universities look for in companies
1	Product Development Research	Ensure funds for graduate assistants and lab equipment
2	Conduct "blue sky" in search for new technology	Get insight into their own research
3	Solve technical issues	Field- test application of their own theory
4	Design prototypes	Supplement funds for their own research
5	Provide seminars and workshops	Aid University in their extension mission
6	Conduct fundamental research	Create jobs and internships for students
7	Support universities	Gain useful knowledge for teaching
8	Develop software	Search for business opportunity

The program lifecycle is designed not only to meet the needs of corporate governance (set of processes, rules, decisions, customs and ideas that show the way a company is

managed) but also to ensure that the expected benefits are realized in a predictable and coordinated way [15].

Biesenthal and Wilden [16] suggest that several existing definitions of project governance share the view that governance is mainly concerned with the alignment of project objectives with the organizational strategy, and therefore, it aims to create values for different stakeholders across different organizational levels. Therefore, one main purpose of governance is the balance of goals (Müller, 2009). How University, Industry and government balance their respective goals by exchanging values to support the achievement of the overall University-Industry collaboration goals, from the Program Strategic Planning phase (Program Preparation) to the Program Initiation and Benefits Delivery (execution and delivery phase of the program life cycle) is presented in the following paragraphs.

During the Program Strategic Planning phase the main values that the University partner exchange with the Industry partner are the access to new knowledge (state-of-art), namely by a wide network of international experts [17] and the design of innovative ideas to solve the Industry problems, leading to the competitive market advantage of the Industry [18], [19]. These allow Industry to improve in terms of reputation growth among clients, partners, suppliers, collaborators during the execution and delivery phase [17], [20]. Knowledge is seen as a potential source of competitive advantage, which means that universities are central to the science and technology ecosystem as a limitless source of knowledge and technological resources [2].

Additionally, universities lead to the improvement of the innovation ability and ongoing follow up of technological changes [21], the acceleration of commercialization of new technologies and products [17], [18], therefore, allowing the Industry's product portfolio diversification [22], increasing economic growth and wealth creation, namely by the creation of new business opportunities (e.g., spin-offs) [17], and simultaneously benefiting from a cost-effective research [23].

On the other side, the main values that Industry partner exchange with the University partner during Program Strategic Planning are the reinforcement of the University know-how, in certain subjects, due to the intrinsic Industry's characteristics [18]. In fact, the exchange of knowledge is bilateral between University and Industry partners, as well as the University affiliation with a real and safe environment to receive feedback on ideas and theories, and the identification of new R&D opportunities [17].

Furthermore, the collaboration with Industry allows University, during the execution and delivery phase, to increase the capacity to attract new students, namely PhD students, in order to support the Industry needs [19]. Students will be able to access real world experience, bringing positive impact to their curricula, opportunity to interact with practical problems and new ideas [24]. Industries also potentially allow to generate financial benefits for researchers (e.g., royalties, awards), as well as to increase the researchers' capacity of scientific production [25], namely through Industry and academic joint publications, increasing the recognition in the academic community [20], [23].

During the Program Strategic Planning phase the main value that government exchanges with both University and Industry partners are the access to funds to hire human resources and purchase cutting-edge equipment and materials [18], [3]. As such industry is enabled to increase its R&D investments in order to achieve better performance in innovation initiatives, share risks and uncertainties, reduce costs and increase resource capacities and skills in order to overcome competition in the global market. Government will then be helping in the reinforcement of the scientific and technological knowledge [18] during the execution and delivery phase.

Therefore during the Program Strategic Planning phase University makes the reorientation of the research agenda to the Industry real needs [3], [26], complying with a relevant universities' mission, which is the proximity to industries, in order to support economic, social and environment sustainability, an important value to government. During the execution and delivery phase University and Industry partners, comply with the government agreement in terms of recruitment of new researchers and collaborators [26] creating employment, an important value to government, as well as by enhancing the learning and continuous professional development of researchers and collaborators [19], [26], leading to regional and local economic development [17].

B. Develop a Culture of Learning

Irwin and Klenow [27] demonstrate that organizations learn three times as much from their own experience as from experience at another organization. Therefore, the authors suggest that organizational units, as a R&D collaborative University-Industry organization structure, are more likely to benefit from internal than external knowledge.

Organizational learning describes attempts by organizations to become learning organizations by promoting learning in a conscious, systematic and synergistic fashion which involves everyone in the organization [28]. How organizations create, retain, and transfer knowledge, is a subject of increasing interest for both academics and practitioners [29]. The concepts of learning organizations stem from the works of leading strategic management authors like Weick [30] and Porter [31].

Burnes et al. [29] suggest that there are two factors which seem to have moved organizational learning from being a subject of interest just for academics to also practitioners: the pace of change and the competitive threat posed by globalization. The arguments put forward by proponents of organizational learning are: change is now so fast and so prevalent that if organizations fail to keep pace with it they will not survive; and the speed and prevalence of change is such that it cannot be managed in the traditional manner by a few senior managers, but must become the responsibility of everyone in the organization.

Organizational learning can be said to occur when there is a change in the content, conditionality, or degree of belief shared by individuals who jointly act on those beliefs within an organization [32]. Gareis [33] (p. 319) argues that "Organization learning should happen continuously. It has to be integrated in defined processes, responsibilities for organizational learning should be clearly defined."

Loo [34] identified the need for organizational learning as one of the most important areas for improving project management practice. Learning and knowledge management contributes to project management in different ways, for example by the availability of repositories of data from past projects which are crucial to the quality of estimates [35].

Organizations might develop a culture of learning, for example through the development of a knowledge management system including a learning system to improve the effectiveness of the project management professionals [36]. Organizational learning requires a different organizational culture than exists in most traditional organizations, for example, it is required a proactive leadership directed towards sharing knowledge or a cross-functional communication and cooperation [29].

Sense [37] argues that activities directed towards enabling and promoting learning activity within project oriented organizations, such as University-Industry R&D collaborations, are essential, and certainly not considered 'optional' or simply as something 'nice to have/do'. In fact, projects can create barriers to organizational learning, by privileging short-term task performance over long-term knowledge accumulation [38].

C. Lessons Learned

By definition, lessons learned are documented information that reflect both positive and negative experiences throughout the project [39], [40]. Lessons learned are collected in any project, but need to be properly addressed so that they become useful. Rowe and Sikes [41] suggests a lessons learned process to successfully capture and use them (Fig.1).

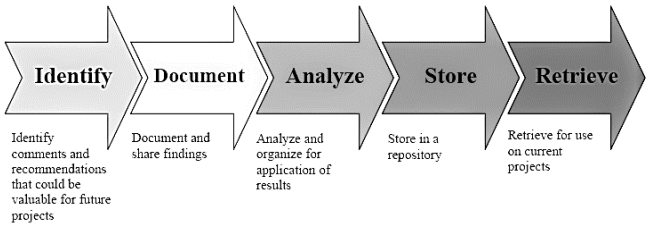

Fig.1. Lessons Learned Process from [41]

It is commonly accepted that capturing and analyzing the lessons learned is vital to improve further project success [11],[41],[42],[43]. In University-Industry R&D programs, the main purpose in collecting lessons learned is to ensure that the identified recommendations throughout the program are effectively converted into opportunities to benefit all the stakeholders with the acquired experience and, in this way, improve the performance of the current and future R&D programs.

III. Research Methodology

Case study is perceived by researchers as one of the most used research strategies when context is particularly relevant [44]. By using it, researchers can focus on a particular phenomenon and discover crucial knowledge [45].

An exploratory research was carried out, aiming to learn from the experience of the program and project stakeholders of a large case study, in order to collect and organize the lessons learned of two phases, Program Strategic Planning and Program Initiation, in the particular context of collaborative University-Industry R&D programs. The case study encompasses three programs, which amount to a total investment of about €109 million, over the period between 2013 and 2021.

A. Case Study Background

The case study reported here resulted from a strategic partnership established between University of Minho (UMinho) and Bosch Car Multimedia in Portugal (Bosch) in July 2012, regarding the development and production of advanced car multimedia solutions. This partnership already encompasses three programs, sponsored by the Portuguese Government, through competitive public funds, with an average funding rate of 50% for the industrial partner, and 75% for the university. The technological challenges addressed in these programs ensure the development of technologies and methodologies whose technological maturity lies in Technology Readiness Level between 4 and 5.

UMinho is positioned in the top 150 of the youngest higher education institutions (aged 50 and under) worldwide, in the 2018 ranking of Times Higher Education (THE) and stands out for the high level of collaboration with Industry, with around 250 R&D contracts signed annually with Industry players. Bosch has become one of the largest suppliers in the automotive Industry, producing a broad portfolio of products such as navigation systems, instrumentation systems, automotive radios, steering angle sensors and electronic controllers. Bosch attributes about 12% of sales volume to R&D activities.

The HMIExcel was the first program of the partnership between UMinho and Bosch. The aim of this program was to develop and produce new car multimedia solutions based on advanced human-machine interaction (HMI) systems. This program included 14 projects from May 2013 to June 2015, embraced an investment of €19.3 million, involving around 300 UMinho researchers and Bosch collaborators. HMIExcel program obtained 174 deliverables, the submission of 12 patent applications until June 2015 and 32 technical and scientific publications until June 2018.

The Innovative Car HMI (IC-HMI) program comprised 30 multidisciplinary R&D projects, targeting product development, quality control, and production management. The IC-HMI program, with 30 projects running at the same time from July 2015 to July 2018, embraced an investment of €54.7 million, involving around 500 UMinho researchers and Bosch collaborators, including the admission of 94 new staff dedicated to R&D in Bosch and 173 new researchers in UMinho. The IC-HMI program obtained 417 deliverables, the submission of 22 patent applications until July 2018 and 72 technical and scientific publications until July 2021. The IC-HMI program set of benefits resultant from the different interrelated projects' outputs, was reported on Fernandes, Pinto, Araújo and Machado [46].

The Sensible Car (SC) program foresees the development of intelligent sensors that are critical to the capacities required in the context of autonomous driving. The SC program includes 17 projects from July 2018 to June 2021, with an expected investment of €34.7 million, involving around 380 UMinho researchers and Bosch collaborators, including the admission of 136 new staff by both parties. The SC program has planned 205 deliverables and the submission of 15 patents until the end of June 2021, and 30 technical and scientific publications until June 2024.

UMinho and Bosch have perceived the value of project management to support the management of such collaboration; and therefore, have established a governance model based on a purposely developed approach especially devoted to program and project management of collaborative University-Industry R&D funded contracts, named PgPM approach [12]. UMinho and Bosch have also invested in a

dedicated infrastructure of the type Project Management Office – named Program and Project Management Office (PgPMO). The PgPMO has a serving role [47], since its main objective is to support both the Program Coordination and Project Teams during the program and project management life cycle. Fig. 2 presents the program organization adopted in the three programs.

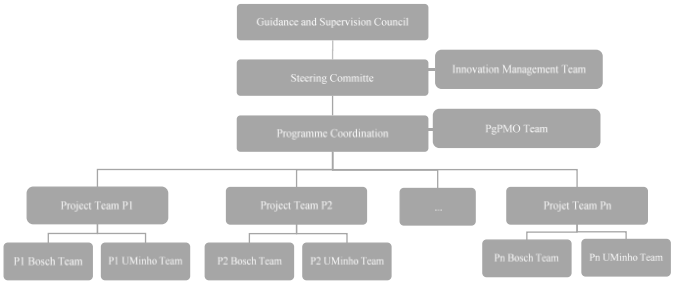

Fig. 2. University-Industry R&D program organization.

The Program Coordination is composed of four people: two Program Directors, one from UMinho and another from Bosch, and two Program Managers, one of each institution, as well. In fact, each program organization role has always a representative from Bosch and another from UMinho. The Program Coordination is the organism responsible to guarantee the program benefits realization. Above Program Coordination is the Steering Committee, supported by an Innovation Management Team, and the Guidance and Supervision Council. The Guidance and Supervision Council involves a third party beyond a representative from UMinho and Bosch, which has as main function to solve potential conflicts that might arise, and that both members are not able to solve alone due to potential conflicts of interests

B. Research Methods

Three research methods were used for lessons learned collection: participant observation, document analysis and unstructured focus groups. Observation is a complex research method and played an important role in the context of this research by driving the researchers to have a closer contact with the object of study in its native environment [45]. Observation is characterized by being participative, since the researchers are inserted in the group and participate in the observed activities [45]. Researchers observed HMIExcel, IC-HMI and SC stakeholders, since the beginning of programs, in naturally occurring situations, namely during regular management and technical meetings. Therefore, through participative and systematic observation, it was possible to collect lessons learned, here reported during Program Strategic Planning and Program Initiation.

Regarding document analysis, several HMIExcel, IC-HMI and SC documents, namely status reports, performance reports, lessons learned register, and even deliverables, were analyzed to better understand the case study context, and be able to collect lessons learned. Also, the governance model established in IC-HMI program was analyzed, which also includes the process from Program Strategic Planning to Program Initiation phase adopted.

The unstructured focus groups were conducted without a strict structure, allowing free-flowing discussions, with the researcher's moderation, in order to discuss the lessons learned from the Program Strategic Planning and Program Initiation phases. Three focus group were conducted closely to the end of HMIExcel program, one with the PgPMO team and the directors and program managers, and two others with two of the fourteen R&D project teams in the HMIExcel Program. Additionally, a total of 27 focus groups were conducted closely to the end of IC-HMI program, one with the PgPMO team, one with the directors and program managers, and 25 with 26 of the 30 project teams of the program. A focus group was conducted for each project team, however two project teams participated in the same focus group, because most of the project team members coincided. The discussion was observed and summarized.

A set of good practices were applied to ensure that the main lessons learned are successfully captured for further analysis, such as: a) collect the lessons learned in multiple occasions throughout the program duration; b) ensure the presence of the Program Manager in the sessions; c) ask open-ended questions during the lessons learned session; d) let participants during the lesson learned sessions to speak freely without a time restriction; e) compile the lessons learned from all the program lifecycle; f) perform a root cause analysis on the raised program issues; g) categorize all lessons learned for easy future consultation. Alongside with this, all stakeholders should have the same understanding about the purpose of the lessons learned sessions and their importance for current and future R&D collaborative project or program.

After the lessons learned collection, a systematic approach was carried out in order to put all the lessons learned together for being treated in a uniform manner. Then, all the lessons learned were summarized and categorized for easier future consultation and use in future collaborative R&D programs, namely organized by the four phases of the program lifecycle. Due to the purpose of this paper, we only focus on lessons learned that were categorized to be implemented in Program Strategic Planning (Program Preparation) and Program Initiation phases of the PgPM lifecycle [12]. The lessons learned are not presented by program, since the three programs happened one after the other, and the study was being carried out all along the whole period. There is an incremental learning process that is used to the benefit of the second and third programs.

IV. RESULTS AND DISCUSSION

It is well recognized in literature the importance of the program and project management process standardization to successfully manage programs and projects [36], [48]. Therefore, based on the collection of lessons learned resulting from the three UMinho and Bosch collaboration programs, Fig. 3 presents the developed structured process to guide University-Industry partners on the path to transform some newly identified project ideas into the initiation of a large R&D funded program. The lessons learned are here presented, without any particular order of importance, by the two different phases of the program management lifecycle adopted [12], Program Strategic Planning and Program Initiation.

Several lessons learned are related to the continuous engagement of University researchers and Industry collaborators, with distinct expectations, experiences and mind-sets. In fact, continuous engagement of University researchers and Industry collaborators is of the utmost importance in all program phases [2]. However, with the case study analysis the authors perceived that the highest effort spent happens during the Program Strategic Planning and the Program Initiation phases.

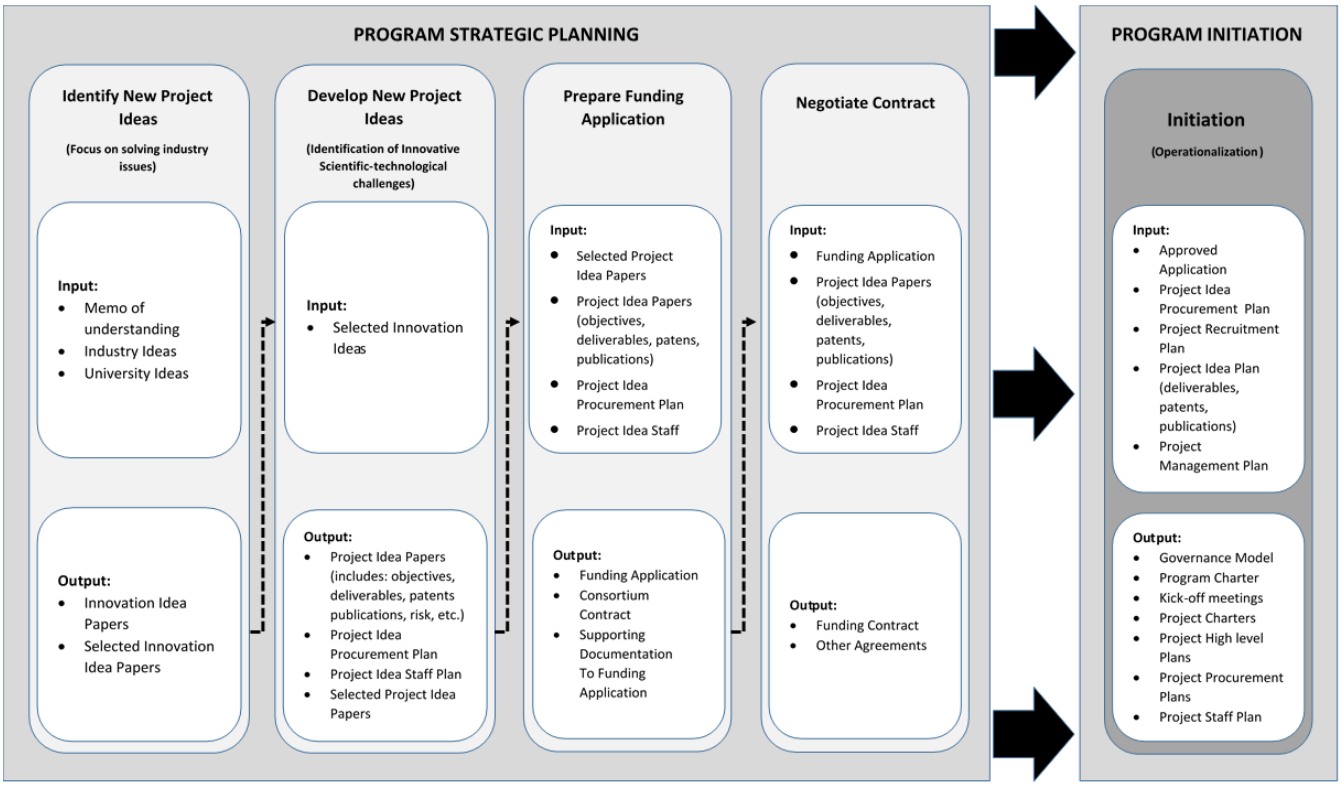

Fig.3. From new project ideas into the initiation of a large R&D funded program

A. Program Strategic Planning

The Program Strategic Planning phase occurs as a result of the University and Industry partnership, with the intention of creating a collaborative R&D program, commonly supported by competitive public funding, and therefore the preparation of a 'Funding Application' is needed. The main goals of this phase are: a) convert Ideas into a collaborative University-Industry R&D funded program; b) align a common strategy for Consortium Members (partners); c) identify the scope of the R&D program; and d) ensure the necessary resources to support the new R&D program, essentially the financial and human resources.

In order to initiate the Program Strategic Planning, it is crucial at this moment the existence of Memorandum of Understanding (MOU), or a similar document (e.g., protocol), signed between both parties to establish a framework of commitments.

Fig.3 briefly presents the main activities/ processes, inputs and outputs expected in the Program Strategic Planning phase. This phase is divided into four main activities/ processes, described below, in which the key lessons learned considered critical in each of these activities/ processes are presented. The creation of a Program Coordination and PgPMO team (see section Case Study Background) is crucial to support all the activities described below [47].

Identify New Project Ideas

The main intention of the process *Identify New Project Ideas* is to choose the set of innovation ideas that will be part of the R&D program, which will be included in the 'Funding Application'. The identified new ideas must be recorded in a document named 'Innovation Idea Paper'. The idea proponent should provide a brief description of the purpose and intent of the new project idea, in order to be later developed by a selected group, having representatives from both parties (University and Industry). These new project ideas may come from both sides of the partnership, but usually they are identified by the industrial partner, since the main purpose of the University-Industry partnership is to overcome the Industry needs. 'Innovation Idea Papers' are evaluated, prioritized and selected, to be further developed as project ideas ('Project Idea Papers'). During the process *Identify New Project Ideas* it is critical to:

- Solve/ define all 'Funding Application' settings (e.g., amount of investment, investment duration, involvement of other external R&D entities, etc.) by the top management of the consortium, as soon as possible;
- Get the sponsorship of top management of both partners, but also of the product roadmap owner (from the industrial partner);
- Align the 'innovation idea papers' selected with the industrial partner's strategy;
- Make a clear and detailed planning of the entire Program Strategic Planning phase;
- Establish clear criteria for the selection of the 'Innovation Idea Papers' and communicate it to the stakeholders involved.

Develop New Project Ideas

In the following process, *Develop New Project Ideas*, the Consortium (partner) Members should assign the selected 'Innovation Idea Papers' to Project Idea Leaders of both parties. These Project Idea Leaders are accountable to develop their respective 'Innovation Idea Paper' by using a standardized Project Idea Paper form and put together a

Project Idea team composed by members of both parties. A 'Project Idea Paper' may result from one or more 'Innovation Idea Papers', and must detail the initial proposed solution for each problem/ issue presented in the 'Innovation Idea Papers'. Additionally, to the development of the 'Project Idea Paper' the University and Industry Leaders should develop a 'Project Idea Staff Plan' and a 'Project Idea Procurement Plan', detailing, respectively, all the human resources needed and the equipment and material required to perform the project idea. The key lessons learned that were identified to perform successfully the process *Develop New Project Ideas* are:

- Define and establish a clear selection process for Project Idea Leaders of both partners. Project Idea Leaders must have technical competences in the project idea scope domain, but should have also project management competences;
- Develop, in close collaboration, the 'Project Idea Paper', detailing the problem, objectives and potential solution of each initial innovation idea, which will be later the main input to the 'Funding Application';
- Guarantee that the information contained in the 'Project Idea Paper' is close as possible to the information that is required on the application form for the R&D program 'Funding Application' submission;
- Ensure the commitment of Project Idea Leaders with 'Project Idea Paper';
- Establish a deadline for the selection of the final list of projects to be included in the 'Funding Application', by the Consortium Representatives and officially communicate it to all stakeholders; after that no further updates to the document are allowed, unless requested by the Program Coordination.

Prepare Funding Application

Based on selected 'Project Idea Papers', the 'Funding Application' is developed, detailing the R&D program proposal. Some of the 'Project Idea Papers' may be left out due to difficulties on fitting into the R&D program narrative, but can be later used in another R&D program/ 'Funding Application' which best suits its inclusion. During the construction of the 'Funding Application' narrative it may be necessary some iterations with the Project Idea Leaders in order to clarify or request additional information. This process ends up with the 'Funding Application' submission. During this activity several documents to support the development of the 'Funding Application' are created, which should be carefully archived as they will be needed later in the process. Additionally, the government funding entity requires the sign-off of a 'Consortium Contract' between the partners legal Representatives

The *Prepare Funding Application* process is very important for the R&D Program Initiation, since the external funding is essential - usually if this collaborative R&D programs are not able to get public funding they are cancelled. Therefore, it is absolutely critical to:

- Involve, closely and continuously, the Project Idea Leaders in the 'Funding Application' preparation;
- Ensure alignment between the 'Funding Application' and 'Project Idea Papers', guaranteeing the commitment of Project Idea Leaders with the project;
- Hold regular meetings between the two parties (University and Industry) and the entity responsible for preparing the 'Funding Application'. It is important to ensure greater involvement and interaction among all the parties involved in the 'Funding Application' preparation;
- Define clearly the roles and responsibilities of the different parties that are involved in the 'Funding Application' preparation;
- Establish a decision-making process transparent and flexible;
- Define a deadline for all documentation's delivery from the Project Idea Leaders;
- Define clear procedures for 'Funding Application' review;
- Validate all the information in the 'Funding Application' by the Consortium Members Representatives before its submission.

Negotiate Contract

During the evaluation process of the 'Funding Application' submitted, there is a period to make additional clarifications to the 'Funding Application' Evaluators established by the government funding entity. During this clarification period it is common to have iterations with the Project Idea Leaders in order to clarify or request additional information. This activity can be highly time-consuming for the PgPMO team that supports the Program Coordination, depending on how many clarifications' requests and iterations are required by the 'Funding Application' evaluators. These will support their final decision about the acceptance or not of the 'Funding Application' submitted. During this period, it is usual to perform clarification sessions for the funding Evaluators by the Program Coordination with the support of the Project Idea Leaders.

After the technical approval of the 'Funding Application' (program scope), the Legal Representatives Members of the Consortium start the 'Funding Contract' negotiation, properly supported by the Program Coordination. The 'Funding Contract' is signed between the government funding entity and each Legal Representatives Members of the Consortium. It is good practice during the process *Negotiate Contract* to:

- Hold preparation meetings with all participants in the clarification sessions, to inform about the agenda and procedures to be followed during those sessions (e.g., the Program Manager indicates who should answer to the Evaluator);
- Ensure that the Legal Representatives Members of the Consortium fully support the R&D program. For example, in clarification sessions, it is very important that the Legal Representatives Members briefly presents the program as a whole at the opening of the sitting;

- Hold a brief presentation of the Project Idea, in clarification sessions, which allows elucidating earlier the Evaluators. This presentation should start by showing previous research results achieved in prior programs, to highlight the Consortium ability in the R&D area;
- Point out, during the clarification sessions, the complementarities of the new project idea with previous projects, establishing the differences between both;
- Establish a pre-contractual agreement between the Legal Representatives Members of the Consortium as soon as it is known that the program will be funded, in order to start immediately the human resource allocation, materials/ equipment acquisition and financials assets, in order to not delaying the 'Program Initiation' waiting for the 'Funding Contract' signature.

B. *Program Initiation*

After the 'Contract Funding' sign-off, the project ideas will be turned formally into projects. These projects may result from one or more project ideas, although usually a project idea will be a project. The Program Manager assigns each project to a Project Leader of each partner. Project Leaders will put together a whole Project Team which will be responsible for the project development. Each project will have a PgPMO team, composed by one member from each partner, in order to support the Project Team in the project management activities and monitor the Project results to report to the Program Coordination. During this phase, a program 'Governance Model' should be established, clarifying the program and project management processes and the roles and responsibilities between all program's stakeholders. Several documents are developed to support further execution of the program and its projects, such as the 'Project Charters' for each project, the 'Program Charter', and initial 'Program and Project Plans'. This phase ends with the 'Kick-off Meetings' for program and for each project. The key lessons learned identified for the *Program Initiation* are:

- Promote workshops to ensure the alignment of key stakeholders and ensure the understanding of the interdependencies between the projects;
- Promote sessions to present and clarify the 'Governance Model' and the organizational procedures to different program's stakeholders;
- Provide collaborative platforms common to both parties, to facilitate information sharing;
- Establish the benefits and Key Performance Indicators for each project;
- Hold meetings with Project Leaders to ensure the 'Project Charter' sign-off;
- Ensure the existence of a final version of the 'Funding Application' to be used as a baseline, as new clarifications were added during the Evaluators clarifications period;
- Ensure the necessary resources to comply with project objectives;
- Clearly define the human resources, equipment and materials that will be assigned to each project 'Project Staff Plan' and 'Project Procurement Plan'.

V. CONCLUSIONS

This paper aims to make contributions to practice by sharing the key lessons learned on how to proceed from new project ideas/ innovation opportunities to the initiation of a large collaborative University-Industry R&D funded program, resulting in a detailed description of the structured proposed process (see Fig.3).

Based on their knowledge and experience, stakeholders play the central role on managing such initiatives, and the HMIExcel, IC-HMI and SC programs show main aspects related to stakeholders that should be emphasized. It is namely critical the creation of a Program Coordination and a PgPMO, as soon as possible, even to set up the program strategic planning and prepare the 'Funding Application' to submit to competitive public funding, since most of these large collaborative University-Industry R&D programs only initiate if they are partially supported by government. In Program Initiation phase, it is namely critical to provide collaborative platforms common to both parties, to facilitate information sharing and the conduction of workshops to ensure the alignment of key stakeholders; ensure the understanding of the interdependencies between the projects of the program; and the sign-off by Project Leaders of their respective 'Project Charters'.

Lessons learned focus on continuous improvements. However, it might be more difficult to transfer the lessons learned in a bilateral University-Industry research collaborations as this majority of research are project based. However, the PgPMO team may play an important role here [47]. In the case of UMinho and Bosch, the PgPMO supported the lessons learned collection and dissemination process, transferring the lessons learned from one program to another program in a continuous improvement process, mitigating some of the knowledge management problems that commonly occur in project based organizations.

The research was performed using only one case study, which we acknowledge as a research drawback, as it limits the generalizability of the findings. Therefore, exploring more collaborative university-industry R&D cases would result in expanding the outcome of this research

Further research will be conducted to understand how these lessons learned might impact the two phases of future R&D programs, the Program Strategic Planning and the Program Initiation and if they impact the next phases of the Program and Project Management lifecycle.

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