Report on the implementation and evaluation of the UIS interface scheme pilots

Project Acronym	**Science2Society**
Project Title	Improving university, industry and society interfaces to boost the throughput capacity of Europe's innovation stakeholders
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1 EXECUTIVE SUMMARY (OVERALL)

Science2Society is developing, describing and assessing the mechanisms through which universities, research organisations, society and industry collaborate to create value. Key element considered in Science2Society is the university-industry-society interface schemes (UIS interface schemes) that take substantial advantage of Open Innovation and Science 2.0. These UIS interface schemes have been applied to seven concrete use cases (so-called pilots) of university-industry-society cooperation tailoring and adapting their building blocks to different contexts, sectors and applications.

The objective of this report is to describe how the seven pilots have been implemented and which lessons learned and recommendations have been derived. The implemented pilots can be summarised as follows whereas a more detailed executive summary can be found in the respective section of each pilot:

1. *Co-Creation: Product development with future users in a virtual idea laboratory*
   In the context of co-creation a Virtual Idea Laboratory as Live-Lab was realised to research processes, methods and tools of distributed product generation engineering consisting of a practical course for master students. Within this course, the students developed new product ideas, concepts and prototypes in the context of a real product development challenge provided by industrial partners. Within the course duration of 12 weeks, the students and the participating industry co-created mobility solutions for future sharing economies applying various innovation methods, techniques, process elements and tools.

   As a combined innovation and teaching project, this Live-Lab realises huge synergy potentials. It enables students to apply their knowledge to real-world problems and thus helps to improve their competence of action. On the other hand, it uses the perspective and networks of students as future users of mobility solutions to find promising ideas and concepts. This perspective in combination with the huge creative potential and already very solid technical knowledge of mechanical engineering master students is one of the main success factors of this pilot.

2. *Co-location: Establishing industry innovation labs within universities*
   University-Industry co-location integrates all benefits from collaborative research between university and industry regarding training and providing specialised staff, performing excellent but cost-effective research as well as dissemination towards the public. Despite these recognized benefits, as a long term partnership, co-location faces new challenges compared to other kind of collaborations. The following elements should be carefully defined and managed during a university-industry co-location:
   - The co-located team, a newly formed team composed by both university and industrial staff, will require time to define an own working schedule and accommodate to each other and become one single team.
   - The long-term objectives need to be agreed and include both parties' vision. Partners should be aligned to greater extent than on previous collaboration.
   - A framework agreement, which should be defined to fit the long-term nature of the co-location, should minimize the need to re-discuss contractual issues as the collaboration grows.
   - A dedicated contact point should be defined to facilitate the partnership and take maximum advantage of the collaboration.

3. *Collaborative R&D&I projects between universities, industries, RTOs, SMEs and public sector entities*
   Collaboration is a process of shared creation across various organizations to achieve shared goals. Thereby collaboration takes the form of interactions between organizations and people. While the first is related to the organization's strategy and structure, which initially acts as a boundary condition for collaborative interaction, the latter is directly related to interpersonal relationships, skills and the satisfaction of the persons involved and is of utmost importance for driving effective collaborative interactions. Within this pilot, the most important aspects impacting collaborative interaction, headed by "responsible behaviour of the persons involved", "global view on project by the project coordinator", "Face2Face meeting(s) as a communication method" has been identified. The least important aspects were related to the strategic interest of the partners to collaborate

(e.g. access to innovative research, new technologies, new customers). It could be concluded that the reason why to collaborate on strategic level is not that important for the quality of the collaborative action itself. Several aspects were reported to hinder collaborative interaction, e.g. not complying with deadlines, lack of a common understanding of the project mission and no clear project objectives for the project, poorly prepared meetings and technical problems and IT restrictions of partners when using online collaboration tools.

4. *Inter-sectorial mobility as an enabling tool for open innovation/science*
   Inter-sectoral mobility (ISM) describes the physical temporary mobility of researchers from one sector (academia, research industry, social sector or industry) to another sector and return mobility back to the original sector. As such, ISM can be a key enabler for open innovation and therefore easily conflicts with traditional (IP focused) innovation approaches and administrative procedures. The success of ISM will be driven by the people and their attitude (personal connections), but this attitude is heavily steered by the organisational culture and can be facilitated by the existence of agreements between organisations (organisational connections). Governmental funding schemes often act as a catalyst to grow open-innovation ecosystems by lowering the (financial) barriers to engage in ISM and by, in some cases, setting guidelines for the interaction intensity and knowledge sharing. The strong dependency on existence of both personal and organisation links explains the importance of adapting to local habits and explains the wide variation and scatteredness of ISM schemes.

5. *Collaboration through big data and science 2.0*
   This pilot tackles the critical challenge how to motivate researchers to open their big research data repositories as well as the industry to take advantage of them. The primary research question was how to develop sustainable business models for big research data that benefit both data owners and the external data users. The researchers' data sharing behaviour is largely driven by perceived career benefits and risks, effort needed to share data and the availability of data repositories. These are the factors that need to be considered in open science initiatives. Furthermore, the opportunities for open big data collaboration include organisational transparency, accelerated and reproducible research and new businesses. These opportunities are hindered by key stakeholder's unwillingness to participate in collaboration due to perceived risks, privacy and ethical issues and technical issues related to the complexity of big data. Within this pilot two frameworks have been developed that support the development of sustainable business cases for big research data sharing. The first framework is for opening the big research database. It emphasizes that the starting point for opening big data should always be a clear foreseen opportunity. This gives the motivation needed for the researcher to opening the database. The second framework is for the management of an open big research database. It provides best practices on how to efficiently manage a big open research database.

6. *Direct university coaching and training to SMEs*
   Increasing and improving the innovation capacity of SMEs is crucial for the European economy and society. In this context, universities can play an important role in innovation activities and clear advantages have been recognised when industry and universities collaborate. However, there is only little experience on knowledge transfer of business processes (e.g. strategy process, general management knowledge, innovation process) from Universities to SMEs. For this type of knowledge transfer the importance of one-to-one interaction and coaching is proposed as an effective mechanism. As such, this pilot explored predominantly the coaching and one-to-one training delivered to SMEs using university-developed knowledge on different business processes. Following selected recommendations have been derived:
   - RTOs need to employ facilitators who combine both academic credentials (in order to understand the research knowledge and methodologies) and industrial experience (in order to gain the trust of the SMEs).
   - Tools are an important element of the transfer process as they codify and summarise the academic knowledge in a suitable form. The tool development is an iterative process that requires both the academic and the practitioner to work together over a period of time; it also needs to involve SMEs in the pilot phase to ensure relevance.

- The transfer process needs to allow sufficient reflection time for the SME team for refinement and alignment before decisions are made.

7. Online knowledge marketplaces connecting universities, RTOs, industries, SMEs and start-ups
The research community at universities constantly produces new knowledge in the form of innovative technologies, expertise and processes that usually generate new patents and potentially great innovations for the society. In order to canalize the commercialization efforts for this new generated knowledge technology transfer schemes are needed reaching out to the market efficiently and on a timely basis. Currently, this task is entrusted to the Technology Transfer Offices at the University. However, they do not have the tools to get the maximum performance out of the volume of solutions, products and technologies generated by their research groups. Thus, the "technology-push" versus "market-pull" debate is still open. In this context, this pilot implemented two main open innovation components, which are highly interconnected:
    a. The first one responds to the creation of a Trusted Network allow Technology Transfer Office to "know what they know". By bringing their research community into the platform, they are offering their researchers a simple way to update their scientific profile as well as present their research output and initiate contacts with the industry.
    b. The second component is the called "Extended Trusted Network access". Innoget developed an API to connect the TU Darmstadt Open Innovation Marketplace established under the above bullet point automatically to its global open innovation network www.innoget.com.

    Launching such an Open Innovation Marketplace for technology transfer demands a high degree of combined expertise in the fields of Digital Platforms and Technology Transfer in order to be successfully and sustainably implemented and developed. One should make sure that expertise in-house and/ or sufficient external support to Manage, Create, Operate and Generate is available:
    - Manage an online Open Innovation platform for technology and knowledge transfer.
    - Create high-quality level content.
    - Operate under a peer-to-peer platform in order to become a partner of choice for innovation and R&D projects.
    - Generate more and better contacts and collaboration projects while protecting Intellectual Property rights and confidentiality of participants.

Keywords: Implementation of the pilots, Lessons learned, Recommendations derived

2 OVERALL OBJECTIVES

2.1 General

Science2Society is developing, describing and assessing the mechanisms through which universities, research organisations, society and industry collaborate to create value. Key element considered in Science2Society is the university-industry-society interface schemes (UIS interface schemes) that take substantial advantage of Open Innovation and Co-Creation. These UIS interface schemes have been applied to seven concrete use cases (pilots, see Fig. 0) of university-industry-society cooperation tailoring and adapting their building blocks to different contexts, sectors and applications. The overall objectives of the piloting exercise are to i) validate the UIS interface schemes and their application (regarding identified success factors and approaches as well as regarding how relevant bottlenecks and hurdles for open innovation and co-creation can be overcome) and ii) to validate the policy recommendations in support of the UIS interface schemes.

The concept, outline and approach for implementation of each pilot was described in deliverable D 3.1. The objective of this report is now to report how the pilots were implemented and to discuss the major finds. A particular emphasis is given to lessons learned and recommendations for uptaking / duplicating the respective pilots by others.

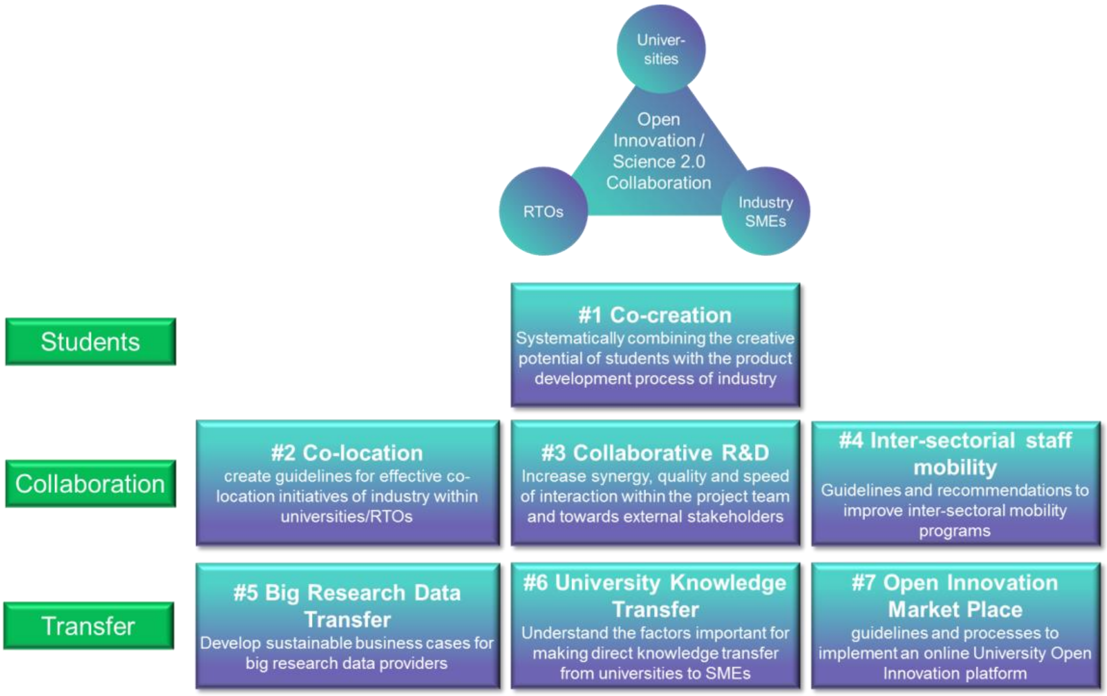

Figure 0: The seven UIS interface-scheme pilots

The reports for each pilot were prepared as Stand-Alone-Documents written by authors coming from different disciplines. As such, different styles and different formats varying from chapter to chapter could not be avoided.

2.2 Conceptual introduction to Open Innovation and Co-Creation

Open Innovation and Co-Creation is a concept developed since the early 2000s by Henry Chesbrough[1]. This concept has been taken up at high political level (Carlos Moedas, European Commissioner for Research, Science and Innovation confirms that "We need open innovation to capitalise on the results of European research and innovation. This means creating the right ecosystems, increasing investment, and bringing more companies and regions into the knowledge economy[2].

Henry Chesbrough[1] defines Open Innovation as the purposeful outflow and inflow of knowledge into the innovation process and as a strategic decision of the innovating company to increase and accelerate innovativeness and/or efficiency by using external resources. OI 2.0 moves towards ecosystem innovation through a step change in research, development and innovation infrastructure and innovation behaviour, which determine the way knowledge is produced and exchanged in the ecosystem and the way the innovation process is shared, nourished and implemented. Knowledge transfer refers to the circulation of knowledge between innovating organisations (academic, research and industry) for innovation purposes meeting specific market goals or more general societal goals.

Open innovation and knowledge transfer in general require a change in mind-set and approach moving from a linear and one-dimensional way of interacting (innovation shopping and collaboration) to an articulated, reticular process involving very different types of players in the innovation chain and in the context in which it takes place. The players involved may go beyond the mere innovation activity and involve governmental organisations, citizens, social interest groups, etc.

The co-creation approach to OI is more than the sharing of resources, knowledge and risk, but targets the integration of the entire innovation ecosystem to jointly develop knowledge in partnerships.

The effort of businesses on the one hand, is to build approaches and structures to improve the absorptive capacity of external knowledge. On the other hand universities and RTOs need to go beyond the mere supply of knowledge and innovation talents, but develop approaches and structures to understand and incorporate user needs. Both innovating categories will thus enhance their co-creation capabilities.

The S2S pilots, as they have been designed, are fully consistent with this approach, aiming at developing and testing best practices for the innovative cooperation of academia, research and technology organisations and industry / SMEs.

2.3 Implementation and evaluation of the pilots (General)

All seven pilots were implanted according the concept outline in deliverable D 3.1. The implementation of each pilot was done in close collaboration with WP 2. WP 2 does not only act as supervisor but also guided the pilots for extracting the required information for the modelling of UIS interface schemes.

All pilots were monitored during the implementation phase by the consortium itself as well as by the Expert Advisory Board (EAB) consisting of Toyota Motor Europe, CA Technologies, Siemens AG, International Association of Science Parks (IASP, represented by La Salle Barcelona), Big Data Value Association (BDVA, represented by Universidad Politécnica de Madrid) and the European University Association (EUA). In the semi-annual meetings the progress and the findings were presented and discussed. Yearly the results were also presented to the IAB and their feedback implemented. In this discussion, the KPIs identified in D 3.1 were used. AT the end of the implementation phase, all findings and recommendations were reviewed by the IAB in a dedicated workshop.

[1] Chesbrough, H.; Open Innovation: The new imperative for creating and profiting from technology. Boston: Harvard Business School Press, 2003, ISBN: 9781578518371

[2] http://europa.eu/rapid/press-release_SPEECH-15-5243_en.htm

Besides, an Evaluation Board (EB) was established at the end of the implementation phase. The EB was composed of senior staff from 13 partners or associates (AALTO, CARNET, CA, ViF, TU Da, CAM, I2M, KUL, Trumpf, CRF, LBF). The main purpose of the evaluation was to assess the contribution of each pilot to the open innovation process and to the specific scientific and innovation goals of the participants. The seven pilots were evaluated mainly using qualitative aspects like

- Completeness of information,
- Soundness of conclusions and recommendations and
- Usefulness of recommendations.

The final review of the EAB and the feedback provided by the EB was taken into account when compiling this report.

3 PILOT 1: CO-CREATION - PRODUCT DEVELOPMENT WITH FUTURE USERS IN A VIRTUAL IDEA-LABORATORY

Executive Summary

ProVIL – Product Development with future users in a Virtual Idea Laboratory is a Live-Lab to research processes, methods and tools of distributed product generation engineering[3]. It is offered as a practical course for master students at the Karlsruher Institute of Technology (KIT). In ProVIL, 48 mechanical engineering master students worked together in 8 teams with the support of 16 innovation coaches. The students developed new product ideas, concepts and prototypes in the context of a real product development challenge provided by the project partner Centro Ricerche Fiat (CRF). During the project duration of 12 weeks, the KIT students and CRF co-created mobility solutions for future sharing economies. Since the students did neither have a common office with each other nor a common workspace with CRF, all teams worked as distributed teams using modern software tools like an innovation platform[3].

To focus the attention of all teams to the most promising activities from an innovation point of view, ProVIL is structured into 4 stages. All these start with a common kick-off and end with a milestone at which the students present their results to the other groups and to the project partners.

After some team building and organisation activities in the first phase (called analysis phase), the students analyse markets, customers, technologies, competitors and trends in the field of the product development challenge. To support economic robustness of later ideas, concepts and prototypes, the students generate scenarios about possible future situations using the scenario technique.

In the second phase (called foresight phase), the teams generate product profiles defining the customer and user benefit which they are going to address with their product ideas, concepts and prototypes. To find promising product profiles, the students use different creativity techniques. The product profiles are evaluated on the innovation platform by using the crowd intelligence of the students.

During the third project phase (called conception phase), the students sought alternative solutions for the best product profile of their team that was chosen by the industry partner: Furthermore, they developed new product ideas. In this step it was important to consider and to evaluate the respective marked potential.

After the selection of the teams' best product idea, the students have specified their product idea (last project phase) whereby. mockups and prototypes have been generated for the technical concepts. These prototypes were presented to the project partner and other industry guests during a final workshop. In the end of this project course, 5 pending invention disclosures were developed.

As a combined innovation and teaching project, ProVIL realises huge synergy potentials. It enables students to apply their knowledge to real-world problems and thus helps to improve their competence of action. On the other hand, it uses the perspective and networks of students as future users of mobility solutions to find promising ideas and concepts. This perspective in combination with the huge creative potential and already very solid technical knowledge of mechanical engineering master students is one of the main success factors of ProVIL.

In the context of Science2Society, ProVIL was developed and applied to the mobility sector. Nevertheless, ProVIL consists of modules (project stages, innovation methods, techniques, process elements and tools) which are potentially transferable to other contexts. This means that ProVIL is designed to work as a blueprint for co-creation between companies and engineering students which can be applied with some adaption to other branches, companies, universities and countries.

[3] B. Walter, K. Duehr, N. Bursac und A. Albers, „PROJECT MONITORING METHODOLOGY FOR DISTRIBUTED PRODUCT GENERATION ENGINEERING," in Proceedings of TMCE 2018, Las Palmas de Gran Canaria, Spain, 2018

3.1 Introduction to the pilot

The unique selling proposition of ProVIL is to get students as representative future customers involved into the innovation process. As this involvement consists of much more than just asking them for their opinion regarding different products, use cases, problems or pain points, but give them the role of co-innovators, it transcends existing customer integration activities by far.

Apart from this, the objectives of ProVIL can be described in three columns (Figure 1). In the sense of the teaching objective, it aims to impart competence of action to the students. In the sense of the innovation objective, the aim is to generate solutions with a high innovation potential. In the sense of the research objective, ProVIL wants to promote the gain of knowledge regarding processes, methods and tools in the field of distributed product development. Between the mentioned dimensions, various synergy as well as conflicting goals (e.g. time spent for teaching activities vs. time spent for project work) arise which must be considered when implementing ProVIL[4].

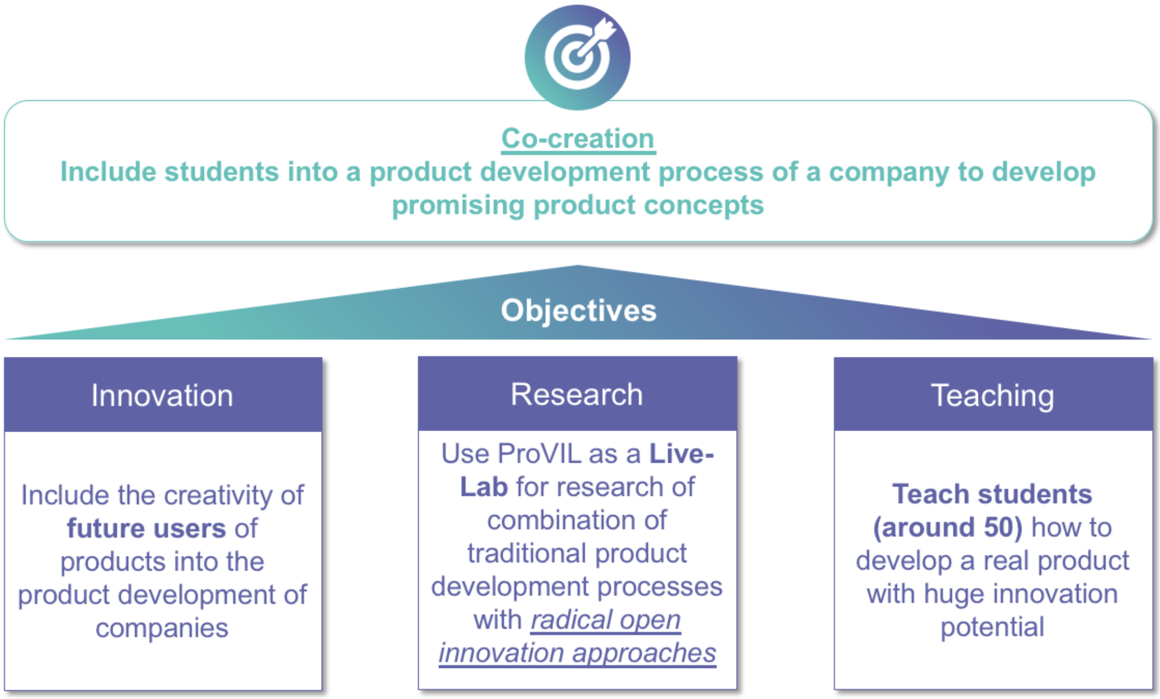

Figure 1: Objectives of Pilot 1

At the begin of ProVIL, the students got details from the project partner about the product development challenge: “Mobility solutions for future sharing economies”. In the four stages shown in **Figure 2**, the students gained knowledge about the market, customers and generate new product ideas. The first stage “Analysis” was about collecting information about the market, customers, boundary conditions and about getting an idea how the future may look in various scenarios. All this results were collected on an online platform for easier communication within the team and the project manager. On the platform, the project partner also had the opportunity to provide students with feedback on their work status in terms of early validation[5]. In the second stage after getting a basic knowledge about the boundary conditions the students used “Foresight” creativity methodologies to generate product profiles which summarize customer needs and market potentials. The online platform was used to evaluate and combine product profiles across the teams. The stage ends with the selection of one profile. This product profile was used in the next stage “Conception” to find alternative solutions for that and to develop product ideas. In the last stage “Specification” the students specified the best product idea and create a technical concept. With mockups and

[4] B. Walter, M. Wilmsen, A. Albers und N. Bursac, „Zukunftsmanagement in Zeiten der Digitalisierung: Die Szenario-Technik als Innovationsmethode in der standortverteilten Produktentwicklung,“ Bd. 2017, 2017.
[5] A. Albers, N. Bursac, B. Walter, C. Hahn und J. Schröder, „ProVIL – Produktentwicklung im virtuellen Ideenlabor,“ in Entwerfen Entwickeln Erleben 2016, Dresden, 2016.

prototypes, the concepts were presented in a final workshop to interested stakeholders from different branches. At the end of ProVIL, the students as future users of products created and developed new products under the aspect of innovation.

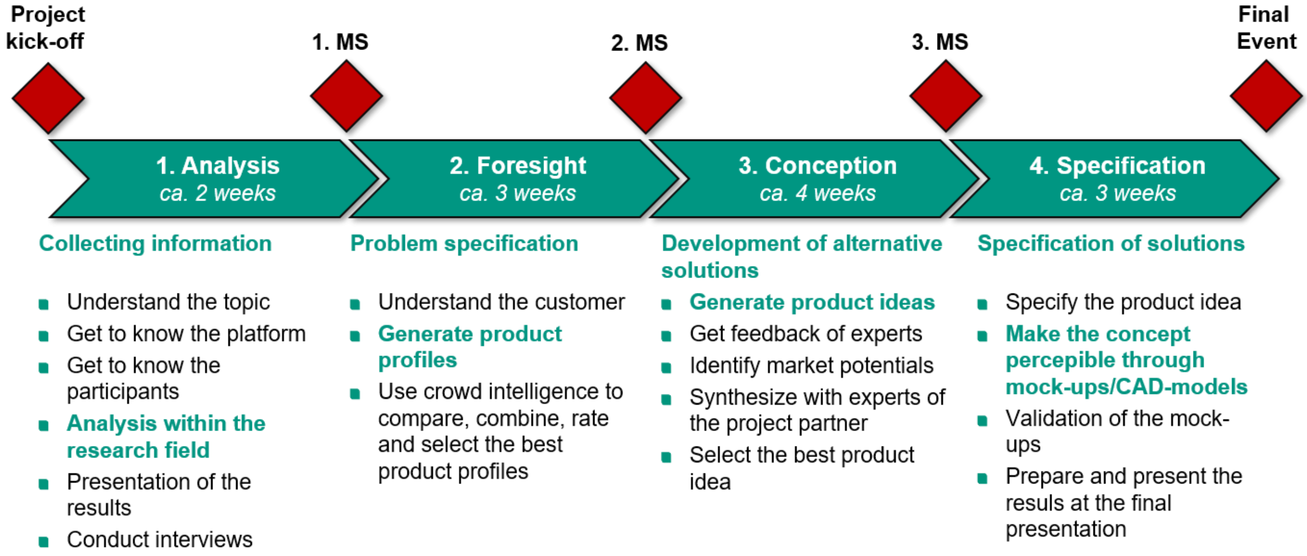

Figure 2: Course of the project[3]

By going through the four stages, students get a better idea of a product development. They also improve their decision-making competence and methodological expertise. Furthermore, the students learn to present in front of a larger audience through presentations at end on every stage.

ProVIL, as a Live-Lab, is a validation environment that enables a design researcher to investigate design processes, methods and tools under realistic conditions and with a high controllability of the boundary conditions at the same time. Regarding the external validity of research, that describes the ability for transfer of the observed results of research to other persons and settings, the real-world project character of ProVIL holds the potential to increase the external validity of research results regarding the validation of design processes, methods and tools.

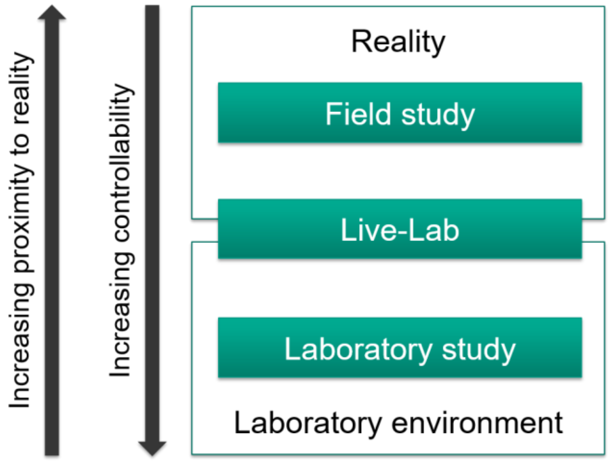

Figure 3: Live-Lab as validation environment[6]

[6] A. Albers, B. Walter, M. Wilmsen und N. Bursac, „LIVE-LABS AS REAL-WORLD VALIDATION," in INTERNATIONAL DESIGN CONFERENCE - DESIGN 2018, 2018.

3.2 Description of the Open Innovation Scheme

The central co-creation hub of ProVIL is the innovation platform. It allows ideas to be collected and shared and product concepts to be evaluated and discussed. In addition, the teams can use it as a central folder for all documents attached to different product ideas and concepts. This ensures that information can be used comprehensively and that the results of the innovations are shared internally.

To structure the innovation process of all teams according to the above described 4 project phases, the innovation platform was divided into several hierarchy levels. Each stage of ProVIL corresponds to a so-called campaign on the innovation platform[7]. The aim of these campaigns is to support the participants in their activities by explaining the processes, methods and tools to be used in a specific phase. In addition, the campaigns contain the required file templates, training materials or toolkits. Ideas can be created within these campaigns in form of so-called idea cards in order to share them with other team members or project managers. If necessary, sample idea cards are provided to exemplify their proper use.

Key element of ProVIL is the continuous validation of product profiles (phase 2), product ideas and concepts (phase 3) and mock-ups and prototypes (phase 4). The innovation platform allows for systematic feedback regarding specific profiles, ideas, concepts and prototypes by the project partner and by other student groups. By using this procedure, the development results of all teams are additionally validated by all other students which increases the informative value of validation results and helps to overcome cognitive biases which might occur if teams would evaluate only their own results[7]. On an operative level, this procedure is implemented using an online voting and feedback mechanism which is part of the innovation platform.

As almost all open innovation activities, projects and schemes, ProVIL is partly open and partly closed to different external groups. The basic idea is to involve many perspectives of different stakeholders in a very early stage of an innovation project. In ProVIL, the students have a hinge function between the “inner” circle of the company and the “outer” environment. As creators of profiles, ideas, concepts and prototypes, they are clearly part of the “producer side”. As future customers and users of mobility solutions, they are clearly part of the “customer side”. Additionally, to their own customer perspective, the student’s groups use their networks to generate ideas and validate solutions. This comes along with some questions regarding the legal framework as the company partner on the one hand wants to fall back on a huge pool of creativity on the one hand but wants to avoid that the solutions in ProVIL might be jeopardized by loosing them to possible competitors. That is why a stable and clea legal framework of ProVIL is an important success factor, especially when it comes to questions of non-disclosure and invention rights.

The biggest contact point between the project ProVIL and the public is the final presentation. At this event, other companies and researchers, but also friends and families of the students are invited. At the final presentation the student groups present their prototypes and mock-ups to all guest. The project partner can use this event as an additional platform to get in contact with different stakeholders and to test their reaction regarding the solutions developed by the students.

[7] B. Walter, A. Albers, M. Heck und N. Bursac, „ProVIL – Produktentwicklung im virtuellen Ideenlabor: Anpassung einer kollaborativen Innovationsplattform zur Realisierung eines communityorientierten Innovationsprozesses,“ 2016.

3.3 Implementation of the pilot

One of the first necessary steps before starting the project is to define the management team for the university. That includes the definition of the project manager and the supporting organization team. In addition, the time schedule must be detailed at an early stage of the project. The next step includes the selection of the industry partner. Together the legal framework conditions as well as the development task must be defined and the contracts have to be determined. The innovation coaches must be introduced to the project task and have to be prepared to support the students during the creation of the business model. The selection of the most motivated students follows a clear process that requires a closer look at the students' applications. The assignment of the students into 8 teams considers the different backgrounds of the students, e.g. education, language, to guarantee a successful project course.

To get a more detailed insight, **Figure 4** shows a detailed stakeholder map. The first stakeholder group is the Core team that consists of the project management of the Institute of Product Development (IPEK) of the Karlsruhe Institute of Technology. The progress of the project must be accessible to the project manager at any time. In addition, he must be enabled to react immediately to occurring problems[3]. The goal of the students is to develop convincing product concepts, to work efficiently and effectively and to acquire interesting knowledge. For this purpose, they have to be able to work in teams without social or technical constraints. Another core team stakeholder is the project partner that provides the task for the development project. The results are evaluated at selected dates during the process by interdisciplinary experts from the project partner, the so-called planning team. Representatives of the project partner are in contact with the responsible employees of the IPEK during the entire project. The project's supporting team from the IPEK is the professor of the institute, the chief engineer and the project employees. The project employees support the project manager as part of the executive organ while the KIT students occupy a dual role[3].

Due to a cooperation agreement with the IPEK, the Hochschule Karlsruhe (HsKA) is a further stakeholder of ProVIL. The students of the HsKA take a controlling and revising role in ProVIL as Innovation Coaches (Inno Coaches). For example, they control and revise the KIT students' results, moderate creativity meetings and coach them in various areas. In order to empower them in their role, some training lessons are conducted before and during the project[3]. SAP as the main software partner provides the innovation platform. Through the innovation platform, the involved stakeholders can communicate with each other, submit ideas as well as comment on them and exchange work results. It is also possible to provide working materials. The platform also supports the students in various cross-site activities, such as creativity sessions in virtual space. In order to promote research on the part of the IPEK, further researchers are part of the ProVIL project. For example, methodology and process researchers organize several workshops within the project. To develop the Live-Lab orientation in the future, the project and all its minor activities is reflected upon by a scientific responsible person. The last stakeholder is the project manager for the following year who must set up the next year's ProVIL project by analyzing, improving and correcting this year's process[3]. Integrating the next year's project manager already in the running project is one important measure to ensure the continuous improvement and future implementation of ProVIL.

After the development process, this Open Innovation Scheme is expected to continuously improve the development process and learn from mistakes. During ProVIL students can give feedback every week in a survey. Current satisfaction can be determined based on support, information provided and team spirit. In addition, it can show the progress of an individual's satisfaction over the entire period of ProVIL. This feedback can be used for follow-up and preparation of future projects to identify improvement potential.

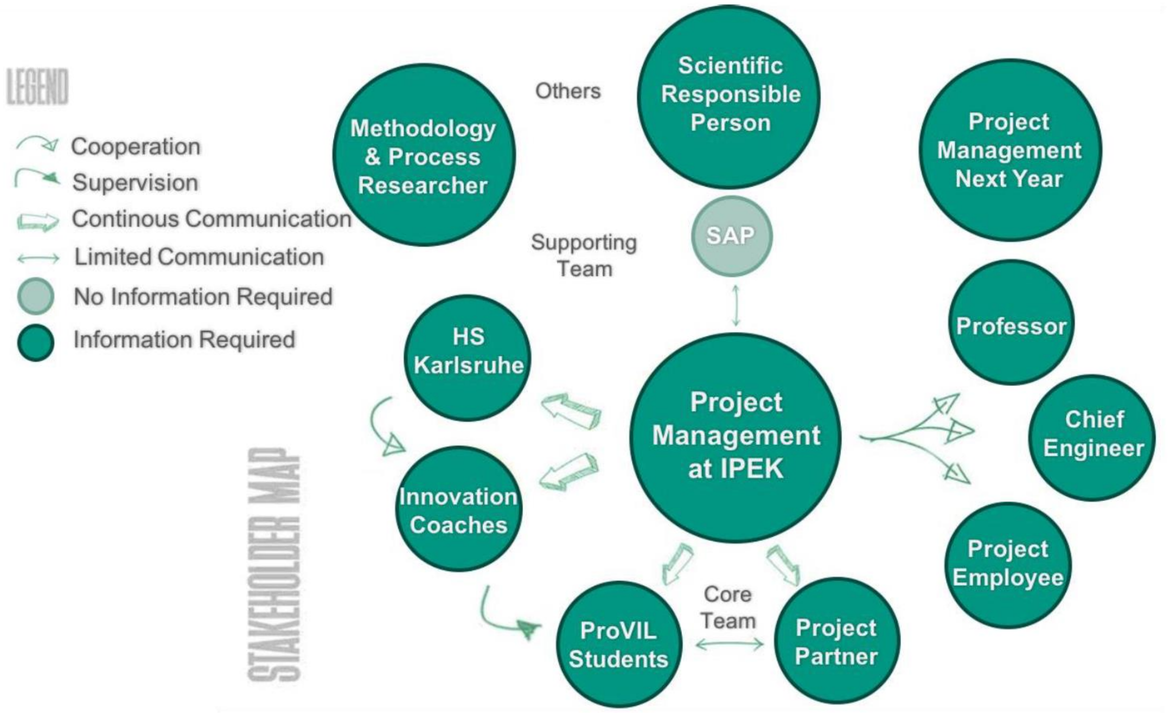

Figure 4: ProVIL stakeholder map[3]

To not only stabilise and improve the open innovation (co-creation) scheme of ProVIL at the KIT, but to replicate it, TU Darmstadt plans to use parts of the ProVIL modules for their teaching programme soon. Since TU Darmstadt participated in the conduction of the ProVIL project, they gathered valuable information and insights into the ideas behind the ProVIL. Some parts of the structure of the ProVIL project, such as the methodical process and the virtual group work, shall be integrated into a student project at TU Darmstadt, called Advanced Research Project (ARP). In order to maximize the benefit of TU Darmstadt by replicating the findings of KIT's ProVIL project, the network built between KIT and TU Darmstadt during Science2Society will be used in the future. However, the ARP replication project may start while Science2Society is still running but the results are expected to be available only after Science2Society has finished.

3.4 Conclusions & Recommendations

3.4.1 Conclusions

As co-creation project, ProVIL exemplifies how engineering master students can play a double-role as creators and producers of ideas, concepts and prototypes and as customers of these solutions at the same time. This double-role holds synergies as highly creative students are able to create concepts and solutions on a technologically demanding level which really meets their own needs and the need of customer groups which they investigate. In this sense, they are more open for new requirements stemming from modern lifestyle of the younger generation. As they are part of this generation, they can empathize on a more fundamental level and with a more open mindset than traditional companies are used to.

On the other hand, the mentioned double-role holds the risk of a cognitive bias: As they develop ideas and concepts with high effort, students might “fall in love” to much with “their” idea (in a sense the opposite of the non-incented-here syndrome). To overcome this issue, all results of all teams are continuously validated against the perspective of other teams, external students, other possible customers and the project partners’ experts.

On a methodological level, ProVIL is used as a Live-Lab environment. In this sense, the main processes, methods and tools of ProVIL are steadily improved and investigated through accompanying empirical studies by scientist from different fields. These insights help to improve the modules of ProVIL but are of value in the field of researching innovation processes, agile product development and distributed product development far beyond the actual project boundaries.

In this sense, ProVIL brings added value in three areas:

- In the field of innovation, it helps companies to create products with higher innovation potential
- In the field of teaching, it enables students to apply theoretical knowledge to practical problems and to acquire real competence to act
- In the field of research, it enables researchers to investigate innovation projects under relatively well controllable boundary conditions and to develop processes, methods and tools to further improve these kinds of product development projects.

Key Findings

The key findings of ProVIL can be separated into success factors and bottlenecks or hurdles.

The main success factors of the open innovation scheme which underlies ProVIL focus on the role of the students. The main success factor is the motivation and commitment of the students involved. Most students are highly motivated already before the course starts, as they have only limited possibilities to work on real product development projects during their bachelor’s and master’s programmes. This means that the challenge regarding the motivation of the students consists not in the challenge to motivate them, but to avoid demotivation. For this, the following measures were defined in ProVIL:

- Students can apply for ProVIL as pairs (so-called tandems). This tandems are then combined to so actual student teams consisting of six students. In this way, students can work together with a friend which helps also in difficult and stressful project phases
- Teambuilding measure help to establish trust within the teams.
- The objectives of all phases are communicated very clearly at all times.
- The project manager can always be contacted via email (or even be called).
- Additionally, there are regular office hours of the project management (offline and online)
- The innovation coaches (1 to 2 per team) are additional facilitators of the innovation processes within the teams.

- Students participate a short project survey each Friday. In this survey, they are asked about their opinion about the activities in the last week. They can express critics and suggest improvement measures (additionally to contact the project manager directly). This improvement measure are evaluated immediately and applied in the upcoming week, if possible.
- The students use modern, state-of-the-art software tools which meet their expectations.
- The students have direct contact with the company partner, which demonstrate that they are taken serious as relevant idea creators.
- Professional milestones at the end of all phases ensure a professional working environment.
- The final presentation with about 100 guests and professional conditions demonstrates that the project results are valuable.

To ensure the usefulness of the project outcome for the partner company, this company must be open for open innovation and co-creation. The company must be willing to invest attention and time into the project also between the milestones. For this, a mentor programme was established. Furthermore, you need at least one main driver in the company which fights for integration of the concepts and prototypes by the students to be integrated into the innovation funnel of the company. At least in big companies, the not-invented-here syndrome might lead to declining external ideas if there is not a patron fighting for the openness towards these ideas.

But openness must also work into the opposite direction. Without spending internal information to the students, they hardly can meet the company's requirements regarding new solutions to be developed. That's why the sharing of information towards the students must be organised already in phase of setting-up the project, even before the students are on board.

During ProVIL, two main bottlenecks appeared. The first one is the legal framework. As ProVIL was conducted with German students at a German university with an Italian project partner (CRF) in the context of a programme funded by the European Commission, it was hard to coordinate especially inventor's rights. That's why in this ProVIL course, inventors could not successfully apply for a patent.

The second bottleneck was the fact that the team had to work partly from different locations as distributed teams. Problems that occurred are also known from literature like communication problems and some inefficiencies. That's why the teams were supported very intensely by the project management. Additionally, some activities could be executed by the teams at the same place. That helped the teams partly to overcome problems stemming from their different locations.

3.4.2 Recommendations

Key takeaways

Key takeaways can be separated into these categories:

1. Takeaways to support stable and improved execution of ProVIL at KIT
2. Takeaways to support replication of ProVIL at other universities
3. Takeaways to support open innovation activities of companies without the integration of students
4. Takeaways to support innovation processes (e.g. agile product development, distributed product development) beyond the borders of co-creation and open innovation

As these 4 fields were already identified before the implementation of ProVIL, the whole ProVIL backbone was defined in clear modules from the beginning on. These modules can be separated into the innovation process (e.g. including phases, kick-offs and milestones), innovation methods (e.g. creativity techniques, customers surveys, product profiles, rapid prototyping, validation methods) and tools (e.g. innovation platform, social media, 3-D-printers).

All process elements, methods and tools are defined very clearly and prepared in modern, easy-to-understand media format. One example are YouTube videos explaining innovation methods which were defined, improved or specified in ProVIL, e.g.

- Research podcast in product development projects (https://www.youtube.com/watch?v=XXCOEA_Bdec)
- Product profiles in product development projects (https://www.youtube.com/watch?v=X7z4t1bNnrw)
- Prototyping in product development projects (https://www.youtube.com/watch?v=43N3l3laWGE)

Impact of the pilot

ProVIL addresses the area of co-creation which can be seen as a part of open innovation. ProVIL specifies methods and tools of co-creation and defines a modular co-creation innovation process which can be adapted to the needs of different stakeholders.

It uses the student as creator and customer at the same time. This, combined with a project duration of 12 weeks transcends the known co-creation approaches by far. In already existing co-creation approaches the involvement of customers into the innovation project in most cases is either limited to providing input to product developers of a company (which is not real co-creation) or limited to very small parts of innovation processes like idea workshops or idea platforms at which customers can provide input for new solutions. In opposite to this, the main drivers of the co-creation within ProVIL are the students themselves. All main activities are conducted by the students. By comparison to the students, the role of the project partner is rather passive. The provide input mainly when asked by the students which reverses the roles of the company and the customers when compared to “traditional” co-creation approaches.

Key Performance Indicators (KPIs)

To measure the success of ProVIL, a set of KPIs was defined. These are:

- Number of realized ideas, concepts, prototypes and mock-ups
- Level of motivation of the students (measured in the weekly survey)
- Level of motivation of company partner (measured after milestones)
- Mutual trust between the participants (measured in the weekly survey)
- Level of collaboration among the project actors
- Transferability into teaching projects of other universities

As ProVIL is marked by a huge number of different stakeholders, this set of KPIs must be increased over time. In some phases, the phenomenon which occurred were quite complex, making it hard to identify the right set of KPIs which will also be able to ensure project success in later, more mature ProVIL projects.

3.5 Future line of research

Future research can face the expand of the modularization of the project modules. Another way to improve further research is to look at the digital transformation of the methods that are used during the project. How should the methods be transformed to generate an added value? And how this transformation be unified within a transformation guideline. One step further will ask for a research on how the projects participants must be prepared to use the transformed methods.

4 PILOT 2: CO-LOCATION: ESTABLISHING INDUSTRY INNOVATION LABS WITHIN UNIVERSITIES

Executive Summary

In the last two decades, collaboration between universities, RTOs and industry has been intensified with the aim of increasing the innovation capacity to better face the rapid technological changes and the intense global competition. This situation has led to a continuous stimulus for developing new university-industry relationships. Currently, companies and academia are paying increasing attention to the physical environments in which creative and innovative activities take place, either in the form of novel offices for dedicated teams, idea generation rooms, co-working spaces, etc. Since the environment itself contributes to innovation performance, a step forward is taking place consisting in creating geographic areas where leading-edge institutions and companies cluster and connect with start-ups, business incubators, and accelerators. Innovative firms and talented workers are increasingly choosing to congregate in innovation districts locating key facilities close to other firms, research labs, and universities so that they can share ideas and practice “open innovation”.

As defined by the University-Industry Partnership Demonstration (UIDP), university-industry **co-location is “the purposeful combination of industry and university personnel in a dedicated space in which costs are shared for active collaborative or independent research with the strategic intent of encouraging idea exchange by reducing communication and cultural barriers that accompany the physical challenge of being located in different facilities”[8].** Despite the recognized benefits, as a long term partnership, co-location faces new challenges compared to other kind of collaborations, and the following elements should be carefully defined and managed during a university-industry co-location:

- The **co-located team,** a newly formed team composed by both university and industrial staff, will require time to define an own working schedule and accommodate to each other and become one single team.
- **The long-term objectives** need to be agreed and include both parties’ vision. Partners should be aligned to greater extent than on previous collaboration.
- A **framework agreement,** which should be defined to fit the long-term nature of the co-location, should minimize the need to re-discuss contractual issues as the collaboration grows.
- A dedicated contact point should be defined to facilitate the partnership and take maximum advantage of the collaboration.

The co-location between CA Technologies (CA) and the Technical University of Catalonia (UPC) dates back from 2011, thus Pilot #2 in the Science2Society Project takes into account this trajectory. It followed two main stages: a first stage, which consisted in the definition of contractual terms to drive the co-location, and a second stage or implementation stage, where the activities to be carried out by the co-located team were proposed, agreed, executed and improved.

During **the definition of contractual terms,** stakeholders agreed on different aspects which are important for each organization. Upper management from both organizations was involved and discussed all relevant topics in the co-location framework (IP, financial provisions, areas of knowledge, etc). Preliminary intentions were summarized in a Memorandum of Understanding, and company and university management found the most relevant teams to be the contact points of the relationship.

During the **implementation of the co-location,** the company and university staff first agreed on a shared strategic research **vision**, after exploring different options to implement the co-location (i.e. individual projects, organization of joint events, and participation in courses or activities at the university, joint submission of project proposals).

[8] «Co-Locating Industry Personnel on University Campuses: A Guide for Navigating the Complexities of Co-Location». University Industry Partnership Demonstration, 2017

Following, the co-located team **executed the research plan** jointly and discussed more ways to collaborate during next iterations. All the activities carried out within the co-location scheme were **evaluated and assessed**, with the objective to improve next iterations.

While performing the co-located activities during the pilot, we identified a series of benefits that make co-location a very profitable university-industry collaboration scheme, as well as some challenges that universities and companies will face when they decide to establish such a long-term partnership.

From a fundamental point of view, sharing a common space for long-term research **facilitates informal communication** channels and spontaneous interactions **that lead to creative problem-solving and/or proposal of highly creative new ideas**. For companies, co-location also provides a valuable **source of tailored workforce**. Co-location allows companies to identify and train their potential future workers in a dedicated collaborative space, thus reducing the time and risks of finding adequate candidates. As for universities, students can be trained in business skills, thus **improving their employability**. Co-location also accelerates and reinforces the **validation of academic research lines** and encourages the ideation of potential innovations with a sound **market impact**. It increases the probability of turning research outputs into market-ready solutions. The formal definition of a shared space for continuous collaborative research constitutes a living ecosystem that boosts the bidirectional communication and **generates an extra motivation for both partners** to make the best out of the collaboration. Finally, we identified the importance of having a dedicated contact point which understands both industrial and academic realities to act as an effective contact point between the company and the university when setting up a co-location.

Finally, and after the analysis of the co-location between CA Technologies and UPC, we realized that the process followed to co-locate had some challenges that should be faced in order to adapt the co-location process to the current volatile, uncertain, complex and ambiguous business environment. In this regard, companies need to find ways to adapt rapidly and cost efficiently to changes in the conditions and behaviour of the customers. Co-located teams at universities are facing the same challenges. In our report, we propose a new model for “lean co-location”, following lean and agile principles and a set of KPIs to monitor some key processes and activities.

4.1 Introduction to the pilot

4.1.1 Co-location and open innovation spaces

Science2Society Pilot#2 focuses on co-locating university-industry personnel in a shared space to develop joint research projects. We endorse the University Industry Partnership Demonstration definition of co-location [5]:

> "*Co-location of university and industry is the purposeful combination of industry and university personnel in a dedicated space in which costs are shared for active collaborative or independent research with the strategic intent of encouraging idea exchange by reducing communication and cultural barriers that accompany the physical challenge of being located in different facilities*".

The rationale driving this mechanism is the search for bigger and broader business, technology and societal impacts that go beyond the benefits of typical types of collaborations. Three key attributes, **people, space and open idea flow**, define a co-location arrangement, each of them representing the high commitment of both Industry and University in such partnership.

- **People**, as holders of knowledge and knowhow, are the key element that boost innovation and are of special importance in co-location schemes. The interaction of Industry and University personnel brings some difficulties related to uncertainty management, since they face multidisciplinary projects that presents not previously solved issues.
- **Dedicated space.** In a general sense, co-location is the act of placing multiple entities within a single location. Both the company and the university commit to share costs and management, establishing a controlled access to shared equipment [5]. This dedicated space should offer most of the resources needed to support the research and should enable a daily interaction to support the joint research and other cross-sectional activities such as workshops, conversations, events.
- **Open idea flow.** The ultimate objective of university and industry co-location is to increase the permeability and insight into each other's activities through proximity [5] and boost the ideation of new products and research lines. Open idea flow is not always that open, and valuable ideas are difficult to be generated. Sometimes, knowhow is one of the most valuable intangible, and sharing those ideas in an open space with open and cross-sectional teams can be considered a great risk.

Co-location offers all the general benefits from collaborative research between university and industry. At an institutional level, the educational mission of the university is complemented with the exposure of students and faculty to practical problems, providing a ''test bed'' for feedback as well as for employment opportunities. In this regard, industry also takes advantage of hiring specialized staff, training and professional development of their workforce. On the other hand, co-location enables a more cost-effective research for companies, which can develop products and processes or generate new IP at a lower structural cost. Co-location may be an additional source of revenue for universities, based for example on income from IP licensing. At social level, reputation of both universities and companies is enhanced by making their engagement with the community more visible and becoming more socially responsible.

Moreover, based on real experiences on co-location presented by the University Industry Partnership Demonstration [5], co-locating **industry and university personnel** is thought to catalyse technological development more effectively than other types of collaboration, and provide numerous indirect benefits, although the extent to which co-location impacts the technology pipeline is hard to measure. Additionally, co-location creates unexpected synergies based on complementary perspectives boosted by a daily interaction, and provides researchers with valuable real-world knowledge and insight into industrial and academic research practice.

The use of a **shared and dedicated space** provides access to specialized equipment and talent with reduced costs compared to the in-house research, which is of high importance for small companies and businesses with a high scientific profile. It also allows for a greater focus in research and less "noise" from operational business activities. Sharing a common space provides the basis for a more spontaneous and frequent interactions, strengthens the desire to combine focused research and finally building of trust, the key ingredient for **ideas open flow**, committing with a long-term perspective and agreeing in an exploitable intellectual property contract.

4.1.2 Case studies and literature review

A set of co-location experiences found in the literature have been collected for their description and analysis. Despite each co-location experience presents some particularities not found in others, we found very constructive to proceed with this analysis in order to provide generalized guidelines based on our own experience between CA Technologies and UPC. Co-location of small companies or university spin-offs are likely to present different reasons for co-location than big companies, and different working procedures, bottlenecks and best practices are found, and all of them need to be taken into account. For example, industries with a deep scientific profile such as bio-medical and pharma, have a stronger need of specialised equipment and laboratories, so they require university departments with different profiles [6]–[8].

We anticipate here that all case studies presented in this section highlight the importance of a solid background relationship on top of which a long-term partnership has to be built. Some personal statements found in the literature reflect the challenges, benefits and guidelines found during the co-location experiences.

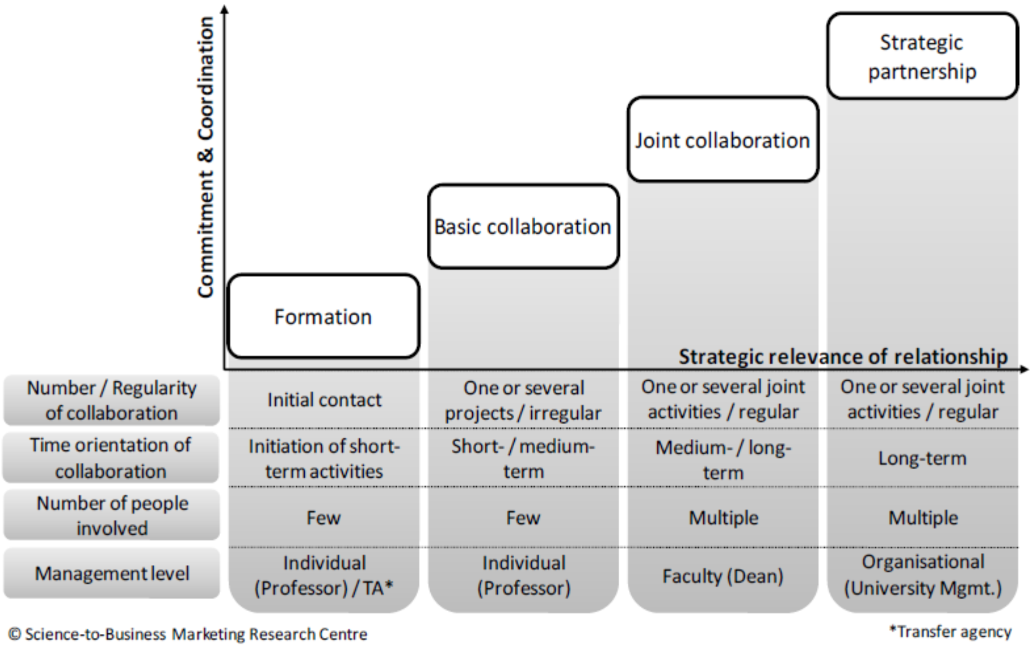

Figure 5 Stairway Model to Strategic Partnership [9]

Relationships between academia and industry often start with a personal interaction involving researchers from both organizations with mutually beneficial topics of interest, which consolidates into long-term collaborative research partnerships after years of collaboration. This process follows a **Stairway Model to Strategic Partnership** [9]. By climbing the stairs, institutional ties become tighter and more strategic involving more senior representatives at higher management levels. The Coventry University provides an ideal example of adopting this partnership approach [10].

NOKIA at AALBORG UNIVERSITY (AAU). In 2011, Nokia Denmark presented a potential plan for shutting down R&D activities in Denmark with the potential loss of 1.100 jobs [11]. Aalborg University, which was growing rapidly and had already strong collaboration with Nokia, decided to move into the Nokia buildings with the motivation of maintaining jobs and R&D activities in the ICT sector by creating an environment where researchers, students and companies lived next door to each other, which enable frequent planned and unplanned meetings between the entities. Main objectives of the initiative were to boost collaboration between the university and industry, by creating a shared space to provide both entities with fundamental facilities and services that improves the access to knowledge and facilitates co-creation, develop and sustain entrepreneurship and start-up activities, among other. After the co-location agreement, a steering committee was established that secured a close collaboration between the university's innovation department and the Technical Services Unit, in charge of subleasing the buildings.

IBM at ETH ZURICH and IMPERIAL COLLEGE. After decades of collaborative research on novel nanoscale structures and devices to advance energy and information technologies, ETH Zurich and IBM created in 2011 in Switzerland the Binnig and Rohrer Nanotechnology Centre [13]. One goal of the partnership was to attract and foster top nanotechnology talent in Europe by investing in leading-edge exploratory research. Scientists and engineers from IBM and ETH Zurich are working on joint and independent projects ranging from exploratory research to applied projects, as well as generating knowledge about the scientific foundations of nanoscale devices at the atomic level.

In 2014 IBM announced a new partnership with **Imperial College,** providing Computing students and researchers with access to IBM's cognitive computing technology [14]. With access to IBM developers, researchers and technical mentors the students work in project teams to develop prototype applications and business plans. IBM's Rashik Parmer said: "Cognitive computing will have a big role in the future of technology, but it requires a different sort of skill-set from traditional computing programming. At the moment there's a shortage of these kind of skills – which is why we're delighted to provide hands-on learning experience to Computing students at Imperial. For us it's about helping prepare the future talent that will take cognitive computing to the next stage".

SIEMENS at MIT and University of Tennesse. Siemens has shifted to long-term strategic partnerships with universities to foster an intensive transfer of knowledge [13]. As part of a Siemens-MIT collaboration in the area of brain research, Siemens provides MIT with the prototype of the latest magnetic resonance imaging technology to use in research, which then helps MIT researchers advance the base of knowledge about brain function. "We don't see this as product development, we see it as partnering in basic research or in some cases applied research," says Reinhold E. Achatz, former head of Siemens AG Corporate Research and Technologies. Achatz notes that university collaboration is vital to companies working on technologies that are part of a paradigm shift. Company research departments may have a harder time driving innovation in new technologies if they must displace existing ones that are successfully established in the market. "In universities, we find that people are more open," says Achatz.

BP Technology Ventures at University of California, Berkeley. UC Berkeley and BP had a prior, one-on-one traditional sponsored research agreement that had produced a number of interesting inventions [15]. This prior agreement was designed to create the expected; the current agreement allows, encourages, and enables the unexpected to arise. The co-location is at The Energy Biosciences Institute (EBI) at the University of California, Berkeley (UC Berkeley). The EBI Director and Deputy Directors are academics. BP is renting office space on campus and locates an Associate Director and several of its own analysts there.

Boeing at Caltech. After an analysis of their long-term relationships with academia, Boeing signed a long-term research agreement with Caltech on "systems integration" technology [15]. In order to engage in the partnership, Boeing required that the university sign a five-year agreement that provided upfront agreement of intellectual property and other key factors. The five-year agreement allows for long-term investments in key faculty and students. Senior executives at Boeing have access to key faculty and administration at Caltech. Company and academic scientists regularly interact throughout their respective collaborations. Symposiums may be held at the company or at Caltech, corporate scientists come to campus to visit and/or work in the lab of their Caltech collaborator, and Caltech faculty may give talks at the company.

Boeing had a single point of contact for all key university relationships. Caltech faculty members provide regular reporting and updates to their scientific partners and Boeing and Caltech hold an annual "Research Review" on campus to discuss the projects and key findings.

Procter & Gamble at University of Cincinnati Simulation Centre. P&G and UC have had tactical relationships through the years, where individual project teams within P&G would engage with a faculty member to do research on a specific project [15]. P&G personnel also sat on industrial advisory boards across the campus. To date the UC Simulation Centre is fully funded by P&G. P&G provides a “Site Leader” as the single point of contact for P&G project teams to engage with the UC Simulation Centre. An office is leased 10 minutes from UC’s College of Engineering and Applied Science. The Site Leader works with P&G project teams to assess the project needs and determine if it is a good fit for the Simulation Centre. He also works with UC faculty and staff to recruit the right talent into the Simulation Centre. UC provides an “Operations Manager” to handle daily operations, onboarding and oversight of the students.

4.1.3 Objectives of the co-location pilot

The aim of Pilot #2 is to identify the main advantages and bottlenecks of university-industry co-location by analysing a real experience: the research collaboration between a multinational company with distributed R&D labs/teams (CA Technologies) and the Technical University of Catalonia (UPC).

The outputs of this Pilot include:

1. An advanced set of recommendations and guidelines for the effective collaboration between single R&D labs and local universities in a shared space, to strengthen the dissemination an application of R&D results.
2. A detailed set of final KPIs to be monitored.

4.2 Description of the Open Innovation Scheme

After several short collaborations, a university and a company may decide to go a step further and agree to foster a long-term partnership. As an open innovation scheme, the university-industry co-location is mainly defined by two elements:

- **Personnel**: Co-location involves the interaction of teams from both sides at corporate and technical level (research projects teams), and the definition of the co-located team, which will be the centre and main stakeholder of the scheme.
- **Shared space:** Is the centre of the co-location, where the co-located team interacts making use of shared resources and boosting co-creation.

As compared to their previous relationship, the university and company teams will face new challenges when they decide to partner following a co-location scheme:

- The **co-located team**, formed by both university and industrial staff, will require time to define an own working schedule and accommodate to each other and become a single team.
- **The long-term objectives** have to be agreed and include both parties vision. Partners should be aligned to greater extent than on previous collaboration.
- A **framework agreement,** which should be defined to fit the long-term nature of the co-location, should minimize the need to re-discuss contractual issues as the collaboration grows.
- A dedicated **contact point** should be defined to facilitate the partnership and take maximum advantage of the collaboration.

All these elements are summarized in Figure 6, highlighting the main elements (personnel, corporate and research teams, shared space and long-term agreement):

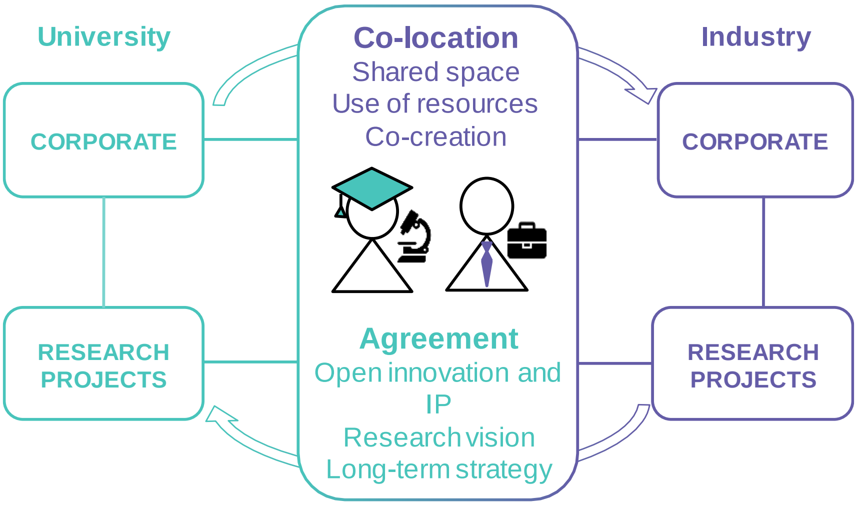

Figure 6: University-industry co-location scheme

We have identified two main stages taking place when a university and a company decide to establish a co-location. A first stage, which consists on the definition of contractual terms that will drive the co-location, and a second stage, where the activities to be carried out by the co-located team are proposed, agreed, executed and improved. Next, we give some details on the most important aspect of each stage.

4.2.1 Towards establishing a co-location

The first stage in the co-location process refers to establishing the framework for the strategic partnership. It is a key point in the relationship, as it will determine the sustainability of the co-location. We hereby describe the different steps followed to establish the co-location framework.

STEP 0: PRE-STARTING POINT

As we have detected in the literature and in our experience, university-industry co-location is always the consequence of a trust built between both partners. A person (or a group of people) at the company and a professor or professors at the university know each other well and they have built a relationship of trust through previous research collaboration. Usually they have a previous informal research relationship. It is, therefore, excepted to create a transparent communication of organizational goals in the collaboration. We see this transparent communication crucial for the long-term survival of a co-location collaboration.

We would like to refer the reader to the Stairway Model to Strategic Partnership (Figure 1) as an example of the steps previous to strategical partnerships such as co-location. Organizations first experiment with several different collaborations, varying complexity and commitment until they feel comfortable with the other partner. At a certain point, the company and the university consider formalizing a strategic research collaboration. After analysing the different possibilities, they decide to co-locate and work together in a shared space. Several reasons may provoke the co-location choice:

- **Educational:** to jointly train future workforce.
- **Product innovation:** to boost market-validation of research-based innovations.
- **Financial:** to share costs of research and equipment.

Enabling Elements:

- Organizational trust built with previous joint collaboration.

- Mutually beneficial topics of research with impact in the university and business.

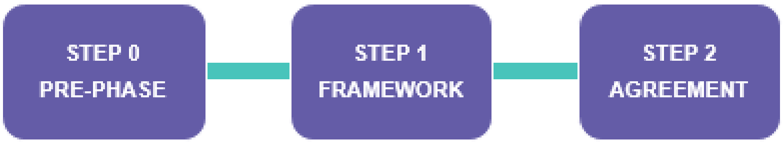

Figure 7: Steps involved in the first stage of a co-location

STEP 1: ESTABLISHING THE CO-LOCATION FRAMEWORK

This step is about agreeing on different aspects which are important for each organization. For this, upper management from both organizations is involved and discusses all relevant topics in the co-location framework: IP and other legal issues, financial provisions, duration, logistics (shared space and infrastructure), areas of knowledge, and others. Preliminary intentions, research lines and resources are summarized in a Memorandum of Understanding, which is an initial commitment from both organizations. In this step, the company and the university management find most relevant teams (or individuals) in each organization to be the contact points of the relationship. Finally, the agreement is written and reviewed by both legal departments.

It is crucial that both sides create a win-win situation out of this co-location framework. A partnership is a relationship where two or more individuals or groups work jointly towards common shared goals. Therefore, in co-location, as in any other partnership, identifying the win-win situation for both organizations is one of the key elements to gain long-term commitment and motivation to continue with the partnership.

The co-location relationship will always be based on individuals. The main reason for a company to choose a certain university to co-locate in is the previous relationship with (typically) a professor, who has proven to be trustful. In certain occasions, a previous relationship is not really in place, but a professor is the international pioneer and expert in a certain area, and the company will want to co-locate where that professor is. Therefore, we must acknowledge the importance of this single contact point. However, it is essential to think about ways to keep the relationship beyond individuals, to plan for a success in case this individual is no longer at the institution or no longer interested in keeping the collaboration.

The space where co-location will take place is also very important. It must be felt as a "safe" environment for the co-located team to create and grow new ideas with a high exploitation potential. It must allow for quick and informal conversations, more formal group meetings, as well as innovation, learning and creativity. Co-location is traditionally seen as the partnership between an industrial organization and an academic organization. Therefore, this space is usually provided by the university, as the company perceives a higher potential to benefit from the expertise at the university if the company co-locates at the university.

Enabling Elements:

- Trust from previous collaboration.
- Transparent communication.
- Clearly identify and accept a win-win situation (own and counterpart).
- Find and agree on a shared long-term strategy

STEP 2: AGREEMENT

After all important aspects are agreed, both organizations need to formalize the relationship by signing the agreement. Anticipate signature of the agreement by understanding the process to approve its contents. If necessary, involve key actors in validating earlier versions of the framework document and explain why this collaboration is essential for the organizations. This will potentially reduce significant delays in signing the agreement.

4.2.2 Definition of activities within a co-location scheme

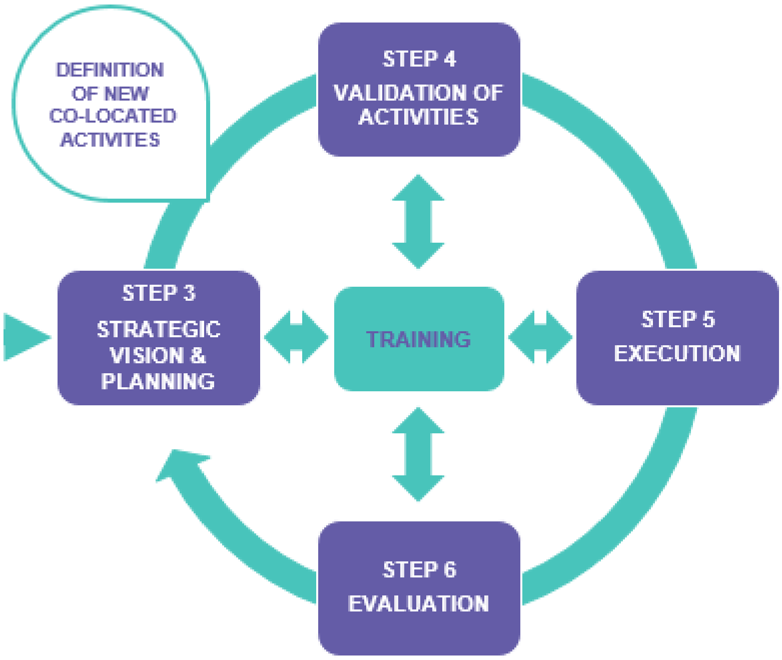

Figure 8: Stage 2, implementation of the co-location

In the second stage, the activities to be carried out by the co-located team are proposed, agreed, executed and improved. Training activities are transversal and have an important impact in co-location. Section 0 “

Projects and activities" will describe some of the research activities that CA Technologies and UPC executed as part of their co-location.

Transversal activities: Training

Training is a central element on co-location to ensure teams understand each other at all levels, to enable good performance and to foster the optimal exploitation of their respective knowledge. In co-location, it is key to train the team in different areas: technical (i.e. IP and classification of information, open innovation, technical areas) and on processes (co-location spirit, culture, management and processes). The most important area, however, is building the team: activities to build team trust and motivation are an essential part of these training activities. We depicted training in a central position of the process, connected to all the different steps, to reinforce the idea that training is essential and should be provided continuously during the full co-location period.

Enabling elements:

- Motivational speeches
- f2f meeting & workshops
- Specific training
- Team building activities
- Training materials

STEP 3: VISION AND PLANNING

In co-location, there are two different organizations working together. In order for this to succeed, a win-win situation needs to be identified. In this step, company and university staff agree on a shared strategic research vision, they explore different options to implement the co-location (i.e. individual projects, organization of joint events, participation in courses or activities at the university, joint submission of project proposals), and they define Key Performance Indicators (KPIs) to assess the specific activities.

Enabling elements:

- Transparency from both organizations on goals.
- Key Performance Indicators.
- Continuous engagement of the potential customer of research results

STEP 4: VALIDATION OF CO-LOCATION ACTIVITIES

Once the co-located team agrees on the shared vision, the activities for the period and the metrics to assess performance, a formal meeting is carried out that aims at validating the planning of activities (R&D and others) by university and company management.

Enabling elements:

- Presentations of activities and ideas (Elevator pitch).
- Engagement of the potential customer of research results

Decision: joint research vision and planning is accepted by both organizations

STEP 5: EXECUTION

In the execution step, the co-located team executes the research plan work jointly. Resources and methodology will depend on the type of research activity.

While research is performed, the co-located research team discusses more ways to collaborate during next iterations.

Enabling elements:

- Trust and communication through team building activities.
- Clear deadlines and responsibilities.
- Incentives.

STEP 6: EVALUATION

Finally, the co-located activities are evaluated and assessed based on joint KPIs created by both organizations. The aim is to improve next iterations. Company and university staff presents the results of their joint research to management, to gather their feedback, which will be used to define the next period's vision, goals and activities.

Enabling elements:

- Incentives.
- KPIs
- Collaborative retrospective

4.3 Implementation of the pilot

The co-location experience between CA Technologies and UPC has been our subject of analysis for the past 2,5 years: it has been our inspiration as well as the framework to pilot and improve the process. This real experience has allowed us to identify the drivers, success factors, bottlenecks, and process of establishing and running a co-location, as well as it has helped pilot different activities, with different iterations, to assess the value added for each organization and how it could be improved.

During pilot 2, the following activities have been conducted:

- Analysis on what were the drivers to set up the co-location
- Analysis on how the process from informal research collaboration to establishing a formal co-location relationship was
- Analysis on past co-located activities and the value offered to each organization
- Piloting of new activities based on challenges and gaps identified in past activities
- Analysis of different iterations of the activities to test new hypothesis to increase the value of co-located activities

In the next subsections, we will explain the real co-location experience between CA Technologies and UPC. The first two are related to how trust was created between both organizations and how they decided to formalize their relationship. The third one describes past activities, as well as activities piloted during this project. Finally, the last subsection includes our conclusions and recommendations.

4.3.1 CA & UPC background relationship

The relationship between CA Technologies and UPC officially started in 2011, built by a Senior Vice President of CA Labs (the research and innovation branch of CA Technologies) and the leader of the DAMA-Data Management Group in the Computer Architecture Department). The deputy research director of the DAMA research group and UPC professor, also joined discussions after some months. The professional relationship between these three individuals dates back to more than 10 years ago, when the vice president (working for another large enterprise by that time) and the DAMA group leader established a short-term research collaboration. Also, the deputy research director of the DAMA research group was one of the first Ph.D. students funded through this program, going through different Ph.D. internships in IBM Toronto labs that added up to almost a year in Canada.

4.3.2 Agreement and framework of the co-location

In view of the benefits from the previous collaborations, both parties agreed that a more formal relationship would increase the value for both organizations. In this regard, it was decided to create a dedicated space for joint research activities, separated from operational business, as well as the commitment of clearly defined resources.

In 2011, this existing relationship of trust between both entities led CA Technologies to start a co-location scheme with UPC, establishing a permanent office in K2M building, at UPC's North Campus. This was executed as part of a strategic plan to strengthen local relationships with the strongest technical university in Catalonia, with expertise in those areas that were particularly relevant for CA Technologies, such as Big Data Management, Security, IT management, etc. The main objectives of CA Technologies to co-locate a team at UPC were detecting, training and hiring talent, leveraging expertise from UPC and increasing brand visibility in Europe. Specifically, CA Labs Europe (now CA Strategic Research) was to work with CIT UPC to develop research relationships with various research groups and individual researchers at UPC, as well as with other universities, research organizations and private companies to exploit synergies and create joint projects.

Barcelona has become one of the most vibrant technology scenarios in Europe, with an important ecosystem of start-ups and hosting first class congresses, such as the Mobile World Congress and the Smart City Expo World Congress.

Establishing the co-location framework. The idea to formalize the collaboration led to conversations about legal issues, IP management and logistics between CA Technologies, UPC and CIT UPC (the Technology Centre of UPC). As a result, CA Technologies decided to place the second European research team at UPC as their main working office. For the success of the co-location initiative and given the different nature of industry and academia, both parts identified the importance of i) a mutual understanding in terms of needs and capabilities and ii) providing high levels of flexibility on working approaches and project definition. In this moment, the deputy research director of the DAMA research group, who was also a professor at UPC, was hired by CA Technologies as Vice President of Strategic Research and Research Director and managed the creation of the co-located office of CA Technologies at UPC. One of the important aspects to hire this professor for this position was his scientific background, his publication and patent track record, his experience managing large organizations in other sectors at the executive board level, and his soft skills. On the other hand, UPC was the perfect partner for the co-location based on the mutual trust built in previous collaborations, their R&D interests aligned with those of the company and its willingness to commit at a long term.

Agreement. In September 2011, and after more than a year of conversations, an important milestone was achieved, consisting on the signature of a Memorandum of Understanding between CA Technologies, UPC and CIT UPC. This Memorandum, renewed on a yearly basis, was agreed to define the framework for the creation of CA Technologies' European research team, hosted at the North Campus of UPC. In an initial phase, two activities were agreed to take place within the co-located team: research in future IT trends with the potential to have an impact on CA's lines of business and the creation of a virtual space to evaluate ideas in the form of undergraduate final year projects (PractiCALabs). This Memorandum also included the definition of a Scientific Advisory Committee in charge of the selection of research topics, the assessment of progress and the continuous improvement of the collaboration. Finally, IP management rules were defined in a Master Collaboration Agreement signed between the parties.

A scheme explaining the co-location activities between CA Technologies and UPC is depicted in **Figure 9.** It describes co-location activities involving CA technologies and different groups at UPC, including research projects and educational activities and courses at undergraduate level.

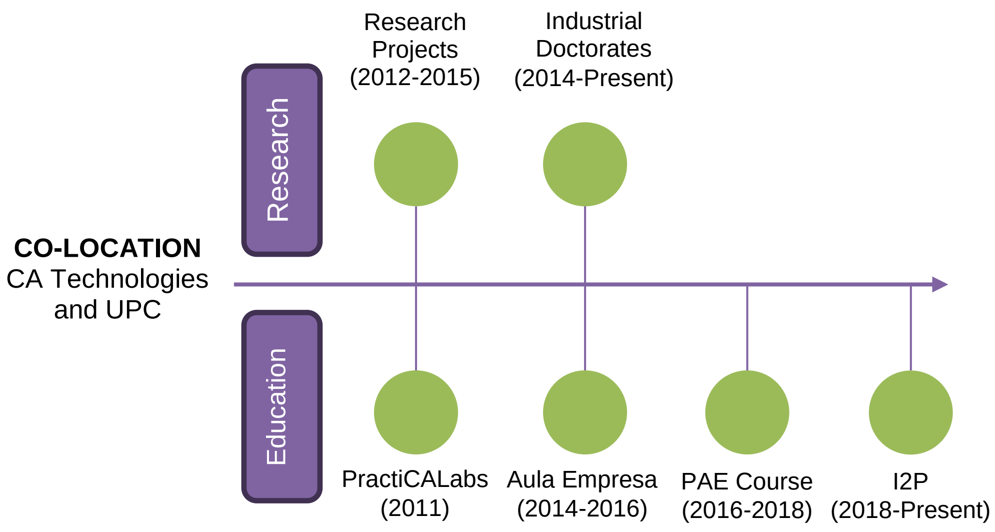

Figure 9: Co-location activities involving CA technologies and different groups at UPC

The rest of this subsection describes the two types of activities that are devised as the seed of the future co-location activities, which are explained in detail afterwards.

4.3.3 Projects and activities

PractiCALabs - first co-location activity

Vision, planning and validation of activities. Once the contractual terms were agreed and co-located teams were defined in both parts, CA Technologies and UPC defined the first research project to be developed within the co-location framework (September 15, 2011). This research work, under the name of PractiCALabs, focused on novel techniques for managing the data used in the graphical representation and analysis of complex computing environments.

This starting plan was defined and validated as the seed for the generation of future activities within the co-location, so a proactive attitude from all participants was promoted along the project, in order to define and optimize the co-location activities as they happened. Interviews to project leads were scheduled to support the evaluation of the co-location and the optimization process, which takes place once a year.

Execution and evaluation. PractiCALabs consisted on undergraduate final year projects conducted by undergraduate students from the Computer Science School (UPC) and undergraduate students from Business (from a Business School with whom UPC had a collaboration), who jointly carried out a research project and a related feasibility studies under the supervision of CA Technologies and DAMA Group (UPC).

At the same time, CA Technologies and CIT UPC evaluated the possibility to increase UPC participation in the co-location framework, focusing on creating value through research activities, identifying talent and increasing the visibility in the local innovation ecosystem. PractiCALabs was identified as a key educational activity, oriented to talent acquisition and to train students in business related skills. Both organizations agreed that participating in educational activities was a common strategy to create value. Therefore, both institutions defined and conducted a new joint course at the Computer Science School at UPC, named “Applied Engineering Project” (PAE). This course, that will be explained in detail later in this report, had two main objectives: i) training students to build their own solutions to real industrial/societal challenges, and ii) narrowing the gap between industry and students. PAE started in February 2017 and 3 iterations have been analyzed in our pilot in project Science2Society. After these iterations, a retrospective analysis was performed, and a new idea for a course was born, directly linked to the benefits identified from PractiCALabs and PAE course together. The name of this new course is Innovation 2 Practice (I2P), which is also explained more in detail later in this report.

Subsequent research co-located projects

Vision, Planning and Validation of the activity. After the closure of PractiCALabs, the research director of CA Technologies explored further synergies between the company strategy and research groups of UPC. Being close to the university enabled faster and informal conversations with key researchers at UPC.

Agreed by the Research Director and the DAMA group, a new research line was defined for both groups around reducing energy-consumption of large infrastructures and automation of software localization. The research line was validated by both institutions, with sufficient funding from CA Technologies to grow the co-located team during the subsequent years.

Execution and Evaluation. At the beginning of each academic year, objectives were set for the co-located team with respect to this research project. Officially, a Project Attachment was prepared every year and included in the Master Collaboration Agreement, so that both organizations had a clear understanding of the objectives and expectations of the year.

During the rest of the academic year, the co-located team combined both research activities with the creation of a proof of concept to show the final end-users of the research and business value of the project. Because of the dual expertise of the co-located team, the business consumers of the project understood the necessity of spending most of the initial phases of the project on non-exploitable results, but basic research and field interviews.

At the end of every academic year, a decision to continue the project was made by the industrial research director and CA Technologies' management. Not only tangible results were assessed to make the decision, but interviews to project leads and business consumers were scheduled to support the evaluation of the project. Albeit funding for 4 years was available from the beginning, it was agreed to renew the contract each year as a mechanism to ensure that the research project was progressing adequately and that both organizations were still interested in the idea. The project was finally stopped during the third year, as a consequence of: (1) lead academic researcher leaving the university and (2) change in corporate strategy. Since then, further research projects have been carried out with UPC in the form of Industrial Doctorates, as explained later in this report.

Training. The team was formed as a mixture of senior and junior positions, as a mechanism to coach promising talent to attract it to a long-term position within the co-located team. Junior positions had time to get used to the new technical stack required for the project, and senior positions were trained in IP protection to ensure that an adequate dissemination level was established in the project.

Aula Empresa

For two weeks, the Computer Science School (FIB) at UPC hosts short workshops/seminars of 9 hours each, where professionals from ICT companies present different aspects of their companies. It is an optional activity for students, who decide which sessions they want to attend.

As part of the usual communication strategy of UPC to the university ecosystem, CA Technologies was notified of the possibility for participating in this type of activities. CA Technologies decided to participate in this activity as a continuation of PractiCALabs, looking forward the opportunity to detect talent and train the future workforce in business skills. Since 2014, CA Technologies has participated every year until 2016, involving employees from different departments.

Aula Empresa

A motivational seminar to engage students in developing skills needed by the industry and attract talent to an organization.

Stakeholders involved:

- **University management** is in charge of the logistics of seminars, including the preparation of the public website, setting up the process of contact with other organizations, closing the final agenda of the event and supervision of the enrolment process.
- The **industrial research director** coordinates the preparation of their slot, including the initial contact with potential speakers, making clear which is the benefit for the organization and coaching speakers to adapt the session to nowadays students.

Workers outside the co-located team might be involved in this activity as speakers. **They** also prepare and deliver the content of the seminar.

Communication channels:

Asynchronous communication via e-mail between university management and the research director.

9-hour face-to-face seminar between industry representatives and students.

Commitment required:	**Value:**
Organization starts months in advance, but it should not require more than a few weeks of effort.	Students understand their future employers' interests. Talent detection.

Structure of the activity

Vision, Planning and Validation of the activity. At the beginning of the academic year, UPC publishes a call for participation and the potential dates for the seminar at the Aula Empresa website. The goal is to attract and get contacted by ICT companies that are willing to give a free seminar to students. From the university side, mainly management is involved at this stage. The vice-rector of international affairs from FIB might be involved to identify and contact companies with whom FIB is actively collaborating. University also starts promoting the workshop sending digital newsletters to students, so they are aware of this opportunity.

Companies internally decide topics to present and find the right individuals to deliver the seminar to the students. At this stage, the industry co-located research director coordinates with the different potential speakers, and close the agenda. Afterwards, the company sends the agenda and its availability (based on the previous potential time slots set by the university) to UPC for approval.

Execution and Evaluation. Once all companies have provided their agenda and availability, UPC can officially start the Aula Empresa enrolment process. All accepted seminars are published on their website, so students may choose in which sessions they wish to enrol.

When the enrolment process has finished, the workshop is carried out at UPC's facilities. Companies' representatives use the allocated time to hold their seminar. The format is chosen by each company, although it is expected to be a simple presentation. In some cases, companies do short hands-on workshops to better interact with students. After the workshop ends, UPC asks students to provide feedback about the workshop and seminars. This information is later provided to companies so they can improve their seminars in consecutive runs of Aula Empresa.

Industrial Doctorates

During the execution of the co-location pilot, we have experimented with three different types of co-located doctoral schemes: the Catalan industrial doctorate program, the European Training Networks and 100% company sponsored Ph.D. fellowships. At large, the three schemes follow the same type of activities, but differ on the exposure with industry/academia as described below.

The Catalan industrial doctorate program brings together an industrial organization and a university to collaborate for the successful execution of a Ph.D. that aims to solve an industrial problem. The company agrees to co-locate a Ph.D. candidate (who is a full-time employee) within a university team (led by her academic advisor) with a significant dedication to the execution of her Ph.D. thesis. Typically, this student spends 20% of her time at the university and 80% at the company. A company representative is assigned as a co-advisor, helping the student transfer knowledge from the university. The university appoints a professor to be the advisor of the student, guiding her through the journey.

European Training Networks (ETNs) are more flexible in terms of mentorship and hosting institution, but the most usual approach is to have one mentor at the industry and another one at the university. For us, the main difference with industrial doctorates is how the student is exposed to industry and academia. In industrial doctorates, the student usually spends around 20% of her time with university staff. ETNs spend approximately the same time, but in the form of secondments (i.e. around 6 months to perform a particular research activity). Exposure of ETNs to the academic environment is, hence, more limited in time, but with a clear scope. Nonetheless, our approach with ETNs is that they are enrolled in a local doctoral programme with UPC, thus providing them with a research environment to support them throughout the whole PhD.

Finally, company sponsored **Ph.D. fellowships** spend most of their time at the university premises (they are hired by the university), and around 20% of their time is dedicated to show and validate results to the final industrial consumers. Exposure to industry is limited, but greater than most Ph.D. students with no connection to industry. In exchange, the student and research group may have more flexibility in terms of timings and scope of the project.

Industrial Doctorates

Funding a Ph.D. candidate and a research group to collaboratively perform blue-sky research.

Stakeholders involved:

- **Industrial research director and academic researcher** define **the lines of research of interest for the**ir organization and guide **the preparation of the research project proposal.** They collaborate to find a student willing to pursue her Ph.D. on the selected topic. Both actors may actively participate in the necessary interviews, which may be supervised by the **human resources department**.
- An **academic supervisor** guides the student and supervises the scientific quality of the results, whereas the **industrial supervisor** ensures that results are aligned with corporate expectations. Both actors might share some of these responsibilities.
- The **student** must familiarize himself with the different academic and industrial procedures. The different research activities will be mainly executed by the student. In practice, it is responsibility of the student to establish the mechanism to collaborate with both environments.
- **Typically, the legal and financial departments of both organizations are involved in the preparation of the formal agreement between all stakeholders, and, in some cases, the human resources department may be also needed to guarantee compliance with funding conditions. From the university perspective, approval from their government may be also required.**
- Depending on the type of program, a **funding agency** establishes conditions for the grant, scope, deadlines, and supervises evaluation of project proposals.
- Administrative staff guides the student through the doctoral process and might be required to prepare a financial report for the funding agency.

Communication channels:

- Regular face-to-face meetings between the student and both industrial and academic supervisors to coach the student, set objectives and solve potential roadblocks. 1-to-1 meetings might also be needed, depending on the research and exploitation necessities.

Commitment required:

Between 10% and 20% of the supervisors' time. The industrial organization commits to fund the doctoral student during a reasonable time (3 years).

Value:

- Student is trained to be a professional, versatile researcher.
- University department receives feedback and needs from society through the industrial researcher.
- The industrial partner can execute risk-free, blue-sky research.

One can find below the different doctorate experiences that we contemplated to conduct this research.

Structure of the activity

Vision, Planning and Validation of the activity. A representative of an industrial organization and a researcher from a university must agree on a topic to jointly develop in the context of an Industrial Doctorate Program. The industrial partner usually provides the industrial challenge, which typically includes an analysis of its impact on society and potential internal exploitation. Whereas the academic partner ensures that there is a research gap that can be fulfilled by a Ph.D. Candidate. A document explaining the research proposal is jointly written and submitted to the funding agency.

Depending on the funding scheme, other constraints must be considered. In the case of the Catalan industrial doctorate program, both industry and university partner must be co-located in Catalonia. The Catalan government oversees selection of projects that will be funded under this format. In the case of the European Training Networks, a bigger consortium with industrial and academic partners across Europe is needed. Evaluation is performed by external reviewers, and only the best proposals in Europe are funded. Finally, Ph.D. fellowships are typically 100% funded by the industrial partner, and evaluation is only performed internally in both organizations.

After the funding agency approves the proposal, finding a Ph.D. candidate is the responsibility of the participating organizations. The candidate is formally incorporated into one of the organizations depending on the funding scheme. For instance, the Catalan industrial program asks organizations to hire the student. The industrial supervisor and the academic advisor oversee the hiring process. Moreover, all partners must sign a formal agreement which includes, at least, a common understanding on their innovation processes, how conflicts will be resolved, and intellectual property rights.

Execution and evaluation. After the Ph.D. Candidate is found and hired, the student must register to the Ph.D. program of the advisor's university. The first major task that the student must complete during the first year is the research plan, a document compromising a formal description of the research challenge, the proposal of a solution, a detailed state of the art, and a planning for the execution of her research activities. The academic advisor must guide the Ph.D. Candidate on this process.

After the research plan is validated by the university, the student must continue with the execution of her Ph.D. activities. The administrative staff from the university may ask for progress reports during the end of the second and third years, to detect deviations from the research plan and mitigate potential issues.

The main touch points of this activity are the regular and periodical face-2-face meetings between the Ph.D. candidate, the industrial supervisor and the academic advisor. The objective of these meetings is to enable a space in which to keep track of the research activities, brainstorming, discuss about applicability of the results, detect and remediate bottlenecks and blocking issues.

The student should schedule time to prepare the final dissertation. The student and both advisors should be aware of potential hard deadlines and expected duration of the academic procedure, and plan accordingly. For instance, Catalan industrial doctorates ask to defend the Ph.D. thesis during the next six months after the end of the third year. This process may start prior to the third-year review if the academic advisor recommends it, or the research activities are conducted earlier than expected.

Training. During the three years of the student's doctoral thesis, she should dedicate time to enhance her soft-skills outside the domain of her thesis. Some students may ask for formal training in delivering presentations that they usually put in practice during scientific conferences.

Industrial doctorates are a great framework to train students in knowledge transfer to industry, including how to shape the message to be understood by non-academic business people. Besides, they can get specific training with respect to IP detection and protection. Training materials are usually available within all industrial organizations that actively pursue IP protection. These materials can be shared with the student and the rest of the co-located team, so they are all aware of the tempos and trade-offs between protection and dissemination.

Applied Engineering Course / Inter-disciplinary Innovation Project

Applied Engineering Course (PAE) is an optional course of the Computer Science Bachelor at the Universitat Politècnica de Catalunya (UPC) with two main objectives: training students to build their own solutions to real industrial/societal challenges, and narrowing the gap between industry and students. Students improve their soft-skills, technological stack and business vision through the development of an innovative project in close collaboration with a co-located company. To foster entrepreneurship, companies act as consumers of the solution, providing regular feedback and helping them to shape their proposal with a business-oriented vision.

Applied Engineering Course

A group of engineering students and industry co-creating a solution to societal challenges established by the industry.

Stakeholders involved:

- A co-located **industrial researcher decides a research challenge to be presented in the course. If necessary, they may involve product management to ensure that the project validates a hypothesis of interest for the company.** This researcher actively collaborates with the students to shape a business speech around the project.
- **PAE professors organize the first plenary session, inviting representatives of the different organizations participating in this activity. After the session, they assign the selected projects to groups of students.** During the execution of the activity, they guide students in defining a sound technical proposal. Finally, they organize the closure of the subject.
- **Students attend the plenary session and decide which projects are aligned with their interests.** They are the main responsible for proposing a solution and generating a business speech, which includes a preliminary market analysis. They should seek advice from PAE professors or industrial researchers. At the end of the course period, they prepare a short presentation that covers the business and technical aspects of the project. A small Proof of Concept (PoC) might also be showcased during the presentation.
- The **legal department** may be involved in reviewing the formal agreement between the organization, the university and the students.

Communication channels:

- Regular face-to-face meetings between the student and industrial researchers or PAE's professors to collaboratively shape the project proposal and PoC.

Commitment required:

At most 10% of the supervisors' time. Typically, researchers and professors do not need to prepare a lot of material for the face-to-face meetings.

Value:

- Students are trained to be professional, versatile engineers. They learn to switch language when speaking with professors (technical meetings) and industrial researchers (business meetings).
- Talent detection.
- PoC might be used to assess future research lines.

Structure of the activity

Vision, Planning and Validation of the activity. In the team formation stage, participant companies independently decide the problem to be proposed to PAE students. During the first plenary session, companies introduce themselves and explain their project motivated by societal challenges. Students then choose the project in which they would like to participate depending on their own motivations and interests. Students and companies are then paired and can proceed with the project definition and execution.

Execution. The project ideation and implementation stage comprises several regular face-2-face meetings between students and the company. During the first meetings, students and companies may reshape their projects to better fit students' and business' goals, as well as set a preliminary, reasonable roadmap for implementation.

Once the project is defined, team members are free to organize work among themselves. It is important that students get used to agile principles and methodologies. Therefore, periodical demos are welcomed so students get constant feedback from the company and coaching on how to add business value to their proposals. Parallel to the meetings between students and the company representatives, PAE teachers help the students to define their solution, roadmap and find the most optimal technical architecture for its implementation.

Evaluation. During the last week of PAE, an evaluation of all the projects is conducted during the second plenary session. Students show their solution and business proposal to the rest of the classroom and companies' representatives. Students are mainly assessed on efficiency of the knowledge transfer process, not on quality and maturity of the solution. Hence, PAE students are expected to show a clear alignment of the solution and the industrial problem, as well as provide a clear business vision. The results of PAE projects may be exploited and disseminated by both companies and students, as results are typically released as open source.

Even though all stakeholders are present in this meeting, interaction between them is minimal. Companies are only expected to participate during Q&A time, asking questions to the other groups. Hence, companies only act as spectators.

Training. The regular face-to-face meetings have a double objective. First, to ensure that the project is being executed and according to the industrial needs. And, second, but not less important, to coach students to deliver presentations and pitch ideas to business people. From the university side, students are regularly coached on finding the necessary technical stack and how to prepare a project plan in an agile environment.

4.4 Conclusions & Recommendations

4.4.1 Conclusions

After examining current literature on co-location, carrying out the pilot activities and analysing the real co-location experience between CA Technologies and UPC, we will describe, in the following subsections: i) the conclusions reached, including the key findings, ii) our recommendations to implement a co-location, and iii) a set of Key Performance Indicators (KPIs) to measure the performance of co-location.

Thanks to the participation in this pilot, both organizations have reinforced their opinion that the major benefit in co-locating is not producing individual, short-term research outcomes. Co-location is a strategy for long-term collaboration, with a clear win-win situation. It is about generating trust between the stakeholders, building common understanding, and how this poses a benefit to both organizations in the long-term. In the rest of this section we will see how the three activities previously described (Aula Empresa, Industrial Doctorates and the Applied Engineering Course / Inter-disciplinary Innovation Project) are interconnected and contributed to the long-term relationship between CA Technologies and UPC.

Chronologically, CA Technologies first participated in Aula Empresa to gain brand visibility at the university, as well as to detect talent. Even though the research team was the only contact point between the university and the company, the research team saw this as an opportunity for the rest of the departments of the company to detect talent. For that reason, people from different departments at CA Technologies were invited to participate in a joint seminar.

In addition to the mentioned benefits of participating in such activity, the professional relationship of CA Technologies Research team with PAE coordinator at UPC was strengthened. Later in this section, it will be shown that he approached the company several times to propose new research ideas and formats. This shows that continued commitment with university staff creates an environment of trust, where both parties continuously bear in mind how they can help each other.

While the first iteration of Aula Empresa was being executed, the first industrial doctorate student joined the company (he was both a CA employee and a UPC Ph.D. student). It is important to remark that a professor, who closely worked with CA's Research Director in the past, recommended the candidate. CA's Research Director previously worked as a professor at the university and, hence, he already had a strong network in the organization. Again, the relationship of trust between both organizations led to a new joint research activity.

In the next year, two other industrial doctorate students joined the company research team. One of them through the Catalan government programme, and the other one through a European Training Network. All three Ph.D. candidates followed CA's research innovation procedure, which includes continuous alignment of research outcomes with corporate strategy. This was typically managed by the Research Director during the initial stages of their doctoral studies, but responsibility was slowly transferred to the students as their career progressed.

After some iterations of Aula Empresa, the seminar coordinator, who participated in this pilot on UPC side, decided to approach the CA's researchers with a research idea around software-defined networking. It was then decided that CA Technologies would sponsor a Ph.D. candidate, hosted and hired by UPC, and this activity would be included in the Science2Society pilot. Finding a candidate for this Ph.D. was extremely difficult, and both organizations had to look for candidates outside their usual hiring channels. At the end, a candidate was found through an international search.

It became clear that CA Technologies' strategy to find Ph.D. candidates was not effective enough. UPC made CA aware that other organizations initiate their talent detection and engagement processes much earlier. In general, other organizations have created a pipeline that involves detecting talent during bachelor's degree, and engaging the best students by sponsoring their Bachelor's and Master's thesis. At the end of the pipeline, they can easily find candidates for their open positions.

To start tackling this issue for future positions, UPC recommended CA Technologies to participate in the Applied Engineering Course (PAE) as a mechanism to detect talent. As mentioned in the previous sections, CA's impression of this program is that it is a good candidate for detecting talent, measuring the students' soft skills and resilience. These skills are extremely necessary for industrial researchers. The participation in the "enhanced" version of PAE, I2P, successfully contributed to CA Accelerator, since one of the projects was pitched and approved.

I2P proved to be a great tool to train Master students in soft skills required by the industry, and, therefore, prepare them to enter the labour market. During the course the organizations realized, however, that this type of courses could be enhanced to tackle one of the main problems in the IT sector: the lack of women and, therefore, lack of diversity.

Key Findings

While performing the co-located activities during the pilot, we collected a series of benefits we identified, which make co-location a unique university-industry collaboration scheme, as well as other findings, and the challenges we faced, aiming at continuously improving the scheme.

The **benefits** of co-location, compared to other types of university-company collaboration, are:

- Sharing a common space facilitates spontaneous interactions that will lead to creative problem-solving and/or new joint ideas. Co-location creates informal communication channels, and therefore, more opportunities for new ideas or solutions to problems.
- At a time when technological companies face shortage of highly skilled employees, co-location provides them with a valuable source of tailored workforce. Co-location allows companies to identify and train their future workers in a dedicated collaborative space, thus reducing the time and risks of finding adequate candidates.
- For universities, it prepares students for industry career paths, thus improving their employability.
- Co-location accelerates and reinforces the validation of academic research lines and encourages the ideation of potential innovations with a sound market impact. It increases the probability of commercializing basic research into market-ready solutions (it covers the full path from idea to market).
- It creates higher levels of accountability between researchers working together.
- Putting diverse people together creates new synergies.

- It allows to leverage research practices from companies and universities.

Other findings of the analysis include:

- CIT UPC (UPC's Technology Transfer Office) –who was the contact point between CA Technologies and the UPC– played a key role in setting up the co-location by understanding both industrial and academic realities, and dealing with the contractual terms.
- The living ecosystem boosts the bidirectional communication and generates an extra motivation for both partners to make the best out of the collaboration.

We also found some **gaps and issues** that might not covered by the co-location approach:

- Risk of compromising patentable discussions that may be arisen during informal interactions. IP needs to be clearly defined in the relationship.
- The relationship of trust is often created between individuals and depends too much on those individuals: when one of them leaves her role, position, department or organization, the relationship of trust is very damaged, so it is important to work on training a successor for those individuals.
- Changes in management may imply changes in priorities and strategies, and the co-location collaboration may become less important and be neglected by one of the organizations or both, thus tending to vanish.
- The agreements that establish the global collaboration between both organizations are very formal, static, inflexible. For example, the scope of the Master Collaboration Agreement between CA Technologies and UPC was very limited and it only defined the rules for specific research activities, pushing activities outside its scope to be delayed for several months waiting for a new agreement. And framework conditions made it difficult to include students in the co-location activities.
- Including more organizations in the collaboration is not an agile process.
- Flexibility and continuous alignment with customer needs are key to reach the market faster and more efficiently.
- Finding balance between academic blue-sky research and industrial applied research is not straightforward.
- Co-located team members may have different working conditions depending on the organization they belong to (university staff and company staff have different salaries, benefits, schedules, flexibility, performance reviews, development tools, etc). This may create conflict in the co-located team. Activities, tools or strategies are needed to overcome this.
- For universities, creating a strategic partnership with a specific company might hinder academic collaborations with direct competitors of the industrial partner.
- Changes in management: It was detected as a major risk with high likelihood of happening. After each management change, researchers need to explain co-location to their respective organization new decision makers. Hence, activities may be delayed, and some deadlines may be missed during this transition phase.

4.4.2 Recommendations

CO-LOCATION FRAMEWORK

- **Understand the complexities of each organization** and build expectations and commitments according to them.
- **Start small**, then scale. **Focus first on building a strong network**. During the first activities, it is better to prioritize creating new contacts. Quality and quantity of research outcomes will naturally come once the co-located team has the network to ask the right questions to the right people.
- Sign a Non-Disclosure Agreement before starting in-depth discussions.
- **Start conversations on Intellectual Property (IP)** and other legal issues, financial provisions, duration, logistics (shared space and infrastructure), areas of knowledge, etc. **before drafting an agreement**.

- Use a broad framework contract and then addenda for special circumstances (each specific activity) for easy collaboration. **Anticipate conflict of interest**.
- Co-location should be **part of each organization's strategy/roadmap** and should be deeply rooted within the organization. Changes in management should not interfere in or damage the co-location framework.
- Appoint the co-location team: university and industry teams for research activities, management team for contractual terms and a contact point to accelerate and facilitate of interactions and get the best out of the relationship.
- **Be prepared to change in management**, include this as a risk in the risk plan.

INTELLECTUAL PROPERTY

- Be flexible on IP terms. **Do not overestimate the economic potential of joint patents**. Analyse in depth the exploitation and access rights of both parties. Train your staff on IP.
- Take into account and **find a balance** of each organization's interest: research dissemination and IP protection. Time between idea protection and dissemination should fit both parties.

STAFF AND RESOURCES

- **High level stakeholders** should prepare and communicate a highly motivating plan.
- Ensure **organizational support** to co-located team. The co-located team needs support from other units in the organization.
- The operational structure of the co-located team should embrace differences between both organizations. **Training and team building activities** may help.
- Develop and communicate overall evaluation methods.
- Define and regulate the dedicated resources and equipment to be used by the co-location team.

VISION, PLANNING & VALIDATION OF ACTIVITIES

- Define the **strategy and goals**, ensure they are understood by all stakeholders.
- Keep a **continuous improvement** mindset, communicate changes at all levels.
- Plan follow-up meetings to **evaluate progress and market potential**, involving potential customers of the research in the planning.
- Continuously **align research outcomes with stakeholders' expectations**: be ready to steer and terminate ongoing projects.
- Define dedicated **Key Performance Indicators** (KPIs) to assess each activity.
- Allocate the appropriate resources needed by projects and activities.

EXECUTION AND EVALUATION OF CO-LOCATION ACTIVITIES

- Do frequent presentations and meetings with stakeholders to **ensure alignment** with corporate strategies.
- Tools and methods to evaluate framework and co-location activities:
  - Define KPIs to assess performance.
  - Those KPIs should fit with the goals of the collaboration.
  - Some KPIs apply to the co-location framework, and a subset of KPIs apply to each specific activity.

TRAINING

- The co-located team should be **aligned in terms of strategy, vision, processes**, etc. This is particularly relevant in a team with staff from different backgrounds. The following points will help:
  - Set clear roles and expectations in the co-located team. Explain the conditions of the framework clearly.
  - Plan **team building activities**, build team trust and motivation.
  - Increase familiarity with industrial/academic cultures. Team members need to understand each other's organizational cultures.
  - Explain the operational structure to ensure processes are clear and easy to follow.

- Communicate organizational expectations from co-location to ensure team members understand the importance of their activities.
- Increase knowledge on IP protection to avoid conflicts.
- Create an **environment of openness**.

4.5 Further lines of research

Finally, and after the analysis of the co-location between CA Technologies and UPC, we realized that the process followed to co-locate had some challenges that should be faced in order to adapt the co-location process to the current volatile, uncertain, complex and ambiguous business environment. In this regard, companies need to find ways to adapt rapidly and cost efficiently to changes in the conditions and behaviour of the customers. Co-located teams at universities are facing the same challenges. In our report, we propose a new model for “lean co-location”, following lean and agile principles.

The Market

- The market demands agility in the product/service development process.

Research and Innovation

- It is not straightforward to align research outcomes with corporate strategy in a research team co-located at a university and not in the company’s headquarters.
- Research and innovation teams need to take into consideration dynamic business environments and adapt to them to impact company business.
- Continuous alignment with market needs and relevance of solutions offered for the customer is a must.
- There is a need to remove boundaries with research partners and customers to accelerate cycle time.

The Framework

- The co-location framework needs to continuously evolve to keep the alignment of long-term objectives of the university and the company.
- The co-location framework needs to ensure an agile research able to pivot and to fail fast in a constantly evolving environment.
- Static frameworks create uncertainty around continuity of the co-location after changes in corporate strategy or management.

This section reports our thoughts on how to systematize university-industry collaborations, so that these embrace changes in the industrial needs and environment as well as they benefit the necessities of universities and their academic staff. Two topics are proposed, the “lean colocation process” and a set of KPIs that will help during the definition and execution of a university-industry co-located team.

LEAN CO-LOCATION – THE PROCESS

To address the challenges mentioned in the previous section, we propose a “Lean co-location”, which is a framework inspired by the co-location model described in the section “Description of the Open Innovation Scheme”, where the focus is placed on a continuous flow of activities and a collaboration agreement that evolves to embrace current and future type of activities. The flow ensures faster and more consistent delivery, as well as the identification of problems to continuously improve the framework.

Figure 10 depicts the new framework as a double iterative model. As we will later describe, the inner cycle represents the usual iterative approach that continuously provides new research outcomes; whereas the outer cycle represents a collaboration agreement that evolves as required by the environment.

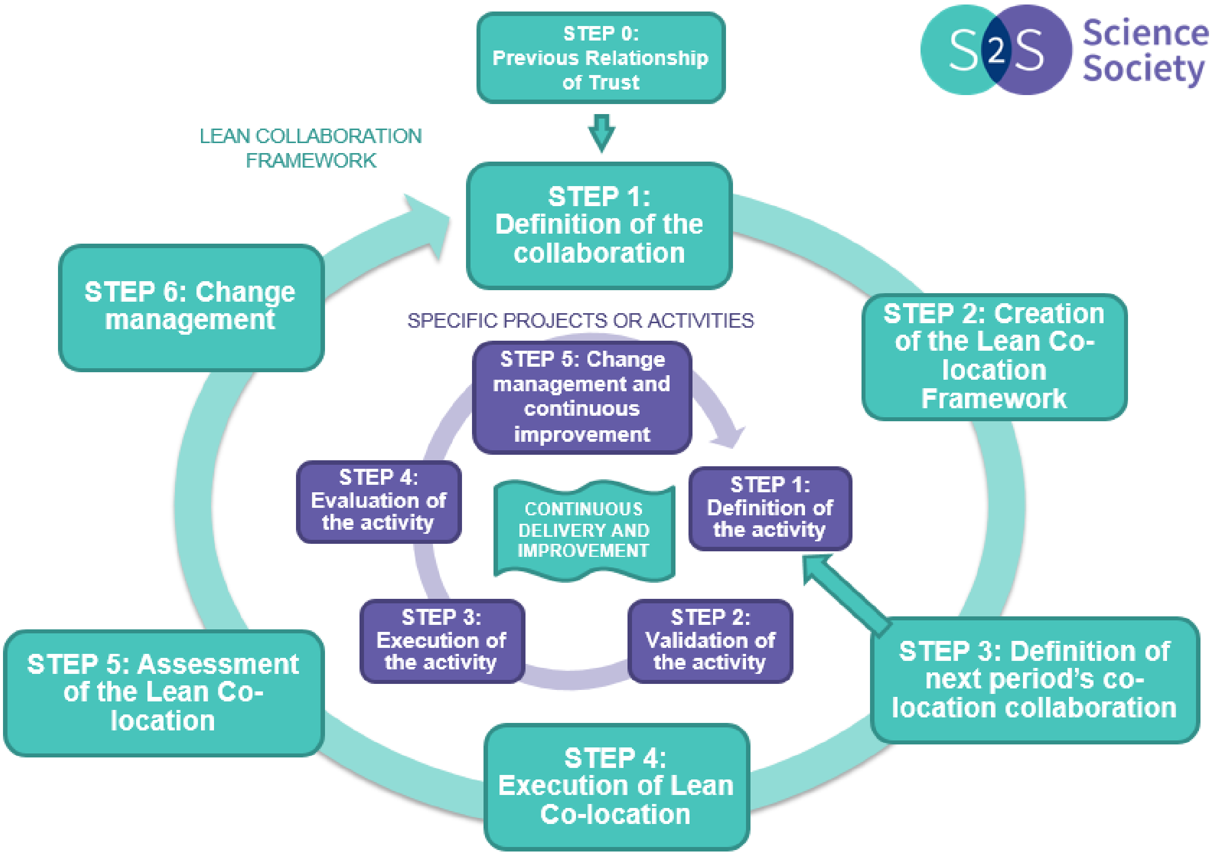

Figure 10: Lean Co-location Process Visualization proposed by CA Technologies and CIT-UPC

The flow of specific projects or activities in the framework is represented by the violet cycle. There are five steps, where activities are defined, validated, executed, evaluated and improved. The first four steps follow the same ideas as in traditional co-location. The fifth one, change management and continuous improvement, creates a specific framework to make the appropriate changes to continuously improve each activity with respect to the previous one, to increase the activities' efficiency.

The flow of the framework is represented by the green cycle. It also follows specific steps, which include the definition of the collaboration (long-term strategy), the creation of the framework, the definition of next period's collaboration (short-term strategy), the execution of the collaboration, the assessment of the framework and change management, to ensure continuous improvement.

At the centre or heart of the whole process, as a key element, we find continuous delivery and improvement. These are the main drivers of the research collaboration. Continuous delivery is essential to align projects with business strategy and market conditions and customer behaviour. Continuous improvement allows for fast changes to the framework to eliminate roadblocks and make the process more efficient. In traditional co-location, training is at the centre of the process. Training is a clear driver of co-location. In this new proposed model, training is also part of continuous improvement; therefore, it does not disappear, but is part of a larger group of activities and a wider concept.

The biggest change with respect to the traditional co-location process is at the framework level, in which we propose to proactively and continuously improve framework conditions. The process flow in Figure 6 depicts the framework level as a cycle too, making implicit that assessment of the framework must be periodically be done so that the framework can be improved.

KEY PERFORMANCE INDICATORS (KPIS)

Organizations (companies as well as universities) will only invest in activities from which they will obtain value**.** Research teams, as any other team in the organization, need to create valuable outputs for the organization. However, since university-industry co-located research teams are formed by individuals from different organizations, the main challenge is to provide value to all organizations involved in the co-location (in our specific pilot, a company and a university). To ensure the generation of value for all partners, it is of major importance that all kind of joint activities are monitored to support a quantitative evaluation and continuous improvement.

Previous work was identified related to defining KPIs for industry and university collaboration. We took as a reference the EUIMA collaborative research project report on university-business collaborative research [19], from EUA, which introduces a set of novel KPIs to measure the more intangible aspects of research collaborations and combines them with traditional quantitative metrics. Qualitative aspects and intangible value in collaborative research should be taken into consideration as an important value driver; however, organizations need to assess their collaborations in terms of quantitative measurements to improve them.

We have been working to identify and classify a series of key performance indicators (KPIs) for a university-industry co-located research team, aiming at producing a set of KPIs that are quantitative to allow for a better and faster assessment of the value generated by the co-located team (see Annex **Error! Reference source not found.** KPIs based on EUIMA report for a proposal of quantitative KPIs derived from qualitative metrics).

Considerations on setting KPIs for university-industry co-located teams

Next, we summarize several thoughts that have arisen along our pilot on university-industry co-location and support the proposal of a respective set of KPIs for the company and the university.

On the one hand, the long temporal gap between idea generation and commercialization is the main challenge for defining performance metrics in a co-location scenario. For instance, executive teams may be tempted to measure performance of the co-located team by terms of research outcomes that are being commercialized. Nevertheless, in the best scenario possible, new ideas will take 3 to 5 years to achieve market readiness. And, what is more worrisome, changes on the innovation process will approximately take the same amount of time to have an impact on performance metrics. In this regard, we suggest following an alternative approach that tackles this issue by defining **a set of long-term KPIs and another set of progress KPIs.** The former can be used to measure alignment with the long-term strategy of the organization, while the latter are correlated with the long-term KPIs. For instance, the number of exploited patents is correlated with the number of patent applications and number of meetings with business units. The number of meetings with business units increases the likelihood of research outcomes to be exploited by the business: it is expected that they are interested on research outcomes commercialization if they regularly meet the co-located team.

On the other hand, we have concluded that **there is no one-size-fits-all list of KPIs**. Each organization needs to evaluate and define its own set of KPIs. The final set of KPIs proposed in this report is just a guideline, and we emphasize that it should be personalized to the long-term strategy of the organization. As an example, some organizations may choose to create a self-sustainable co-located team and, hence, KPIs related to projects and funding by external agencies may be considered as a relevant performance metric. Furthermore, the same organization will need to re-visit the set of KPIs to remove those that are not relevant any more, incorporate new ones, and to establish priorities among them.

Taking the aforementioned into account, the process we followed to come up with these KPIs was progressive, based on a design thinking approach: first, we identified the main goals of each organization when co-locating a research team, to ensure KPIs are measuring results that create value for both organizations. After identifying the goals, we established a set of strategies the organizations would use to achieve those goals. This way we identified how organizations try to reach those goals. This helped define long-term KPIs that would assess the success of the strategy. Finally, following our approach, we also defined a set of progress KPIs that correlate with long-term KPIs.

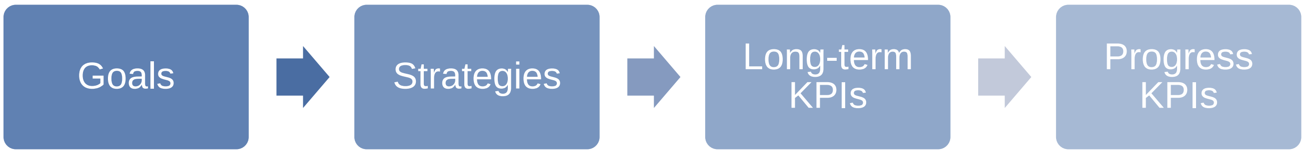

Figure 11: Design thinking approach to defining KPIs

Industrial KPIs

Firstly, we should highlight that the set of KPIs has been defined in the environment of the co-location pilot; particularly, they were defined in the context a co-location of a research team of a multinational IT company within a University. This approach has been validated with other multinational IT companies with research teams. However, companies from other sizes or other sectors could have different goals or strategies.

As the co-location is expected to be running for several years, it is expected that the set of KPIs will evolve as the co-located team gets more mature, according to the expectations from the organization's management. Newly generated co-located teams may focus on generating new research opportunities, even if only a few lead to commercialization, as this will generate trust between the university and the industry. Trust is crucial for a longstanding collaboration between the two entities.

The set of KPIs is intended to continuously improve the co-location, not to assess the performance of the co-located team compared to other not co-located research teams in the company, other research teams from other companies, or even the same co-located group over time. Individual team members are different, the environment is different, and the circumstances are different, so the co-located team performance can only be assessed aiming at improving the efficiency, but not to compare it to other groups or even the same group in different circumstances.

Innovation processes should also be mutable, to better adapt to business necessities. Using progress KPIs enables organizations to experiment and iterate on the innovation process. The program manager can measure much earlier changes on the behaviour of the program, without the need to see changes on the long-term KPIs. On the other side, corporate strategy could check both sets of KPIs to take decisions at an executive-level.

Main objectives considered by the company when stablishing a co-location

Following the design thinking approach described above, we defined the main goals of our company when co-locating, as well as the strategies followed to reach the goals. This is illustrated in the following figure:

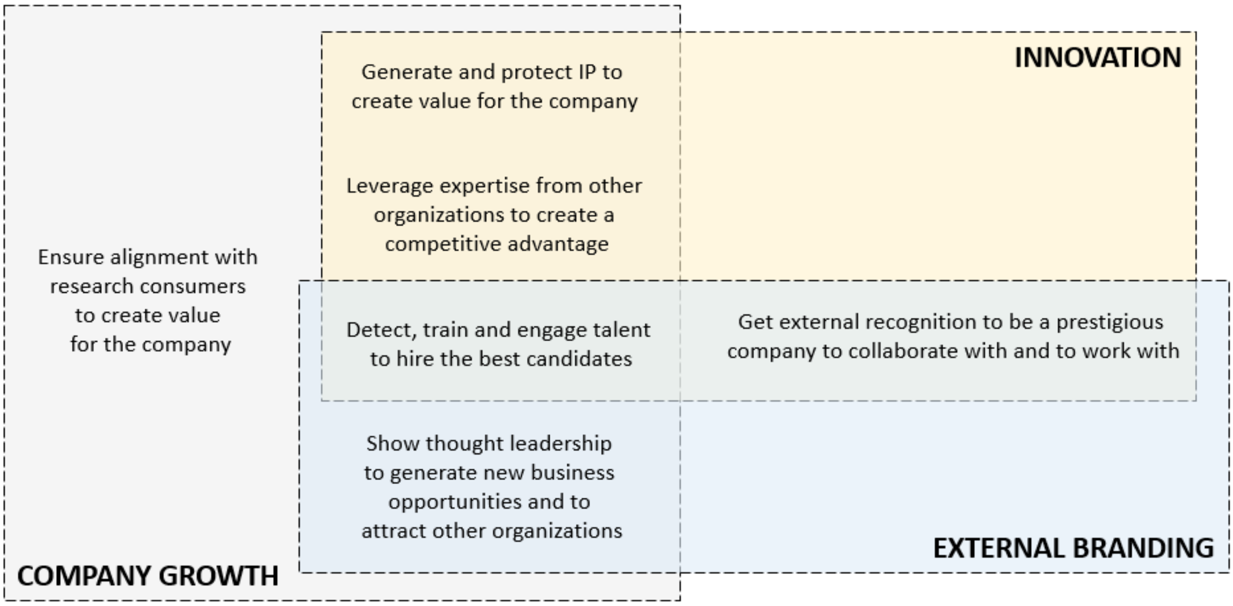

Figure 122: Main objectives and strategies considered by the company when stablishing a co-location

The next step was to identify the long-term metrics to measure the success of each strategy. Finally, progress metrics were defined to correlate intermediate results with long-term metrics. The following tables include the strategy and examples of long-term and progress metrics.

Generate and protect IP to create value for the company

Examples of long-term metrics

- Number of patents being used by Business Units.
- Number of projects with impact in the Business Units.

Examples of progress metrics

- Number of patentable results detected
- Number of filed patents
- Number of granted patents

Ensure alignment with research consumers to create value for the company

Examples of long-term metrics

- Number of projects successfully transferred
- Number of days from idea conception to market

Examples of progress metrics

- Number of demos or Proof of Concept validated by business units and/or customers
- Number of contacts with business units / customers to ensure long-term alignment
- Number of missed deadlines

Leverage expertise from other organizations to create a competitive advantage

Examples of long-term metrics

- Number of new lines of research
- Number of collaborative projects with excellent rating by external evaluators

Examples of progress metrics

- Number of internal technical dissemination activities
- Number of approves research projects defined by the co-located team
- Number of collaborative projects submitted to external agencies
- Number of collaboratives projects granted by external agencies

Show thought leadership to generate new business opportunities and to attract other organizations	
Examples of long-term metrics • Number of collaborative projects with excellent rating by external evaluators • H-index of co-located team • Number of invitation for a keynote / organizing conferences • # of publications in A* and A scientific conferences & journals (according to Australian CORE Ranking)	Examples of progress metrics • Number of collaborative projects submitted to external agencies • Number of collaboratives projects granted by external agencies • Number of publications in scientific conferences and journals co-authored with the University • Number of presentations in conferences and workshops

Detect, train and engage talent to hire the best candidates	
Examples of long-term metrics • Number of positions covered by candidates coming from co-located activities	Examples of progress metrics • Number of talented students detected by a member of the co-located team • Number of engineering students trained in business • Number of talented students engaged in higher-education activities (Master, PhD)

Get external recognition to be a prestigious company to collaborate with and to work with	
Examples of long-term metrics • Number of quotations from research partners or customers	Examples of progress metrics • Number of articles published in media • Number of events with customers organized / participated

University KPIs

In a general sense, every university action or activity should comply with one or more of the following objectives: educational, which aims at preparing the future workers that will support the competitiveness of companies in the future by ensuring an adapted curriculum to industrial needs, and a second objective, which arises from the key role of universities in generating knowledge and scientific breakthroughs.

University-industry **co-location partnerships have a measurable impact** on these university objectives as follows. From the point of view of the **educational endeavour**, co-location offers a well-defined and industry-oriented framework for master and Ph.D. studies to take place; thus, it is expected that the number of talented students engaged in higher-education activities, and, particularly, those involved in industrial Ph.D. theses in co-located companies, may increase in such a framework. Also, engineering students may have an easier access to training taking place in the company, increasing their expectations to be finally hired by the co-located company (or related).

From the point of view of **scientific impact**, university-industry co-location results in an increase of the number of ideas generated, which potentially result in new projects. As a result, a similar increase is expected in research papers, published/conference presentations, submitted/filed/granted patents, products introduced in the market and spin-offs and start-ups created.

Finally, university-industry co-location defines a **financially sustainable** structure to grow by reducing or sharing operational costs and enabling new sources of income/funding. The operation of a common lab between a company and a university may also have a “call effect” to other companies from a common value chain, which increases the value of the shared space by involving more stakeholders. A similar effect may also take place in the income from collaborative projects granted from co-funding programs by building up more solid and competitive proposals.

Besides those straightforward metrics, which can be easily measured within the framework of a co-location, we find others that are more suitable to **measure the health, the direction or the intensity of the activity** [25]. Especially in the beginning of the collaboration, it is of utmost importance to anticipate whether a successful strategic partnership should be nurtured, has opportunities to grow or it is plateauing. In this regard, co-location impact can also be measured the by number of ways that co-located company is engaged with university (research, student engagement, philanthropy, curriculum development), the number of researchers involved in the co-location, the number of faculty sent to companies, the number of company/university representative on counterparts' boards, or the number of number of start-ups jointly supported.

Next, we propose a set of KPIs related to involvement of students and researchers, intellectual property production, funding activity, generation of new products, etc. As co-location is a long-term process where results are not immediate, we propose a set of progress KPIs which support the achievement of the main long-term KPIs, following a similar structure to that proposed in the previous section. We emphasize here that each university-industry relationship should be measured by a selected set of KPIs depending on their particular objectives.

Involve students and university staff in business	
Examples of long-term metrics	Examples of progress metrics
● #of students that participated in collaborative projects with co-located companies. ● #of students hired by co-located companies.	● # Theses co- supervised by university- industry researchers. ● #of hackathons organised by the University. ● # of students with active participation in solving real-world company problems in their courses. ● # of talented students engaged in higher-education activities (Master, PhD).

Establishment of technology development program supported by an agile KTT	
Examples of long-term metrics	Examples of progress metrics
● # of patents licensed to industry. ● # of approved and financed research projects pitched by co-located team. ● # of collaborative projects granted from co-funding programs. ● # of products introduced in the market. ● #of spin-offs and start-up created.	● # of submitted/filed/granted patents. ● # of international patents. ● # of new contract research or R&D consulting ● # ideas generated by the co-located team resulting in new projects. ● #new business ideas incubated.

Adopt incentives schemes for academics, scientists and KTO staff to engage with the industry	
Examples of long-term metrics	Examples of progress metrics
● # of patents licensed to industry ● € received from patent licences, royalties, etc. ● H index of university staff ● # of university researchers collaborating to co-located companies ● # of approved and financed research projects pitched by co-located team. ● # of collaborative projects granted from co-funding programs. ● # of products introduced in the market.	● # ideas generated by the co-located team resulting in new projects. ● # of new contract research or R&D consulting ● # Nr. of research papers published in co-authorship with industry (JCR) ● # of International patents (more probability to be commercialised) ● # of submitted/filed/granted patents

Make University more entrepreneurial to commercialize the research results	
<u>Examples of long-term metrics</u> ● # of spin-offs and start-up created.	<u>Examples of progress metrics</u> ● # new business ideas incubated.

Establishment of venture capital schemes (co-investment, public and private sector) to support entrepreneurs	
<u>Examples of long-term metrics</u> ● # of spin-offs and start-up funded by private sector. ● # of start-ups and spin-offs that overcome the valley of death.	<u>Examples of progress metrics</u> ● # of investment rounds organised by the University.

Support university-industry collaboration at a strategic level to foster co-location	
<u>Examples of long-term metrics</u> ● # of companies with participation in university committees. ● # of strategic alliances with companies.	<u>Examples of progress metrics</u> ● € invested by companies in university (i.e Labs). ● # of Industrials PhD. theses in co-located companies. ● # new programs degrees with participation of industry in curricula design.

Improve (university + co-located companies) external visibility towards other potential interested companies	
<u>Examples of long-term metrics</u> ● # workshops, top conferences with active participation of co-located companies.	<u>Examples of progress metrics</u> ● Number of new contacts established by the university ● The number of publications in newspapers, and social media channel

4.6 References Pilot 2

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5 PILOT 3: COLLABORATIVE R&D&I PROJECTS BETWEEN UNIVERSITIES, INDUSTRIES, RTOS, SMES AND PUBLIC SECTOR ENTITIES

Executive Summary

Collaboration is a process of shared creation across various organizations to achieve shared goals. Thereby collaboration takes the form of interactions between organizations and people. While the first is related to the organization's strategy and structure, which initially acts as a boundary condition for collaborative interaction, the latter is directly related to interpersonal relationships, skills and the satisfaction of the persons involved and is of utmost importance for driving effective collaborative interactions.

Within this pilot, interpersonal relationships in collaborations and the essential skills of the acting persons were analysed based on interviews and questionnaires. From the interview results DOS and DONTS for effective collaborative interactions were extracted. Then, a procedure to capture the satisfaction level of a collaborative project team was developed. The results of this pilot will be used in future collaborative R&D&I projects to monitor the collaboration quality (related to the level of satisfaction of team members) and to identify corrective measures to support efficient and effective collaborative interaction. In more detail, a novel "collaborative team satisfaction KPI" to assess the satisfaction level within a project team was developed. The "collaborative team satisfaction KPI" can be used in future projects to make the collaboration quality of project teams comparable between different projects. This KPI enables tracking of collaborative quality and quantifies the effect of measures taken to improve the satisfaction level within collaborative project teams. DOS and DONTS in collaborative R&D&I support the problem solving with issues indicated in collaborative projects.

Key findings of the pilot's interviews include a list of most important aspects impacting collaborative interaction, headed by "responsible behaviour of the persons involved", "global view on project by the project coordinator", "Face2Face meeting(s) as a communication method". The least important aspects were related to the strategic interest of the partners to collaborate (e.g. access to innovative research, new technologies, new customers). It could be concluded that the reason why to collaborate on strategic level is not that important for the quality of the collaborative action itself. Several aspects were reported to hinder collaborative interaction, e.g. not complying with deadlines, lack of a common understanding of the project mission and no clear project objectives for the project, poorly prepared meetings and technical problems and IT restrictions of partners when using online collaboration tools.

The most important aspects impacting collaborative interaction are structured along a generalized 4 stage project implementation process. Within step 5, the "collaborative team satisfaction KPI" supports the monitoring of collaborative quality. The identification of corrective measures in case of bad performance in step 6 is facilitated by DOS and DONTS, supplementing each of the aspects.

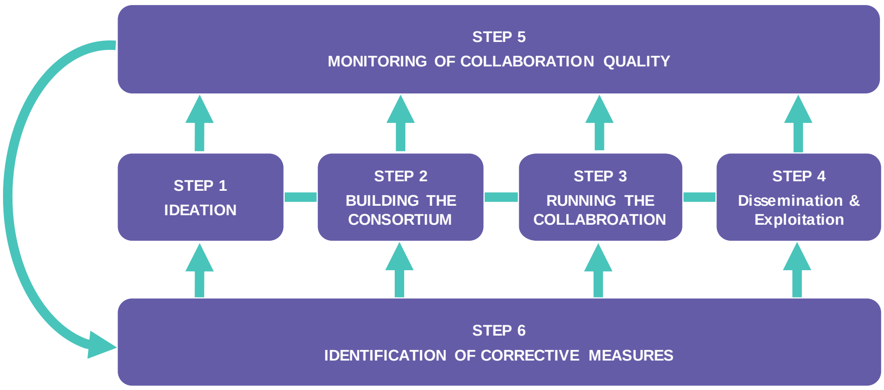


Figure 12: Pilot implementation process

5.1 Introduction to the pilot

Publicly co-funded collaborative R&D projects are a common instrument to bring together and use the knowledge of different organizations from academia and industry (see Figure 14). However, their design, implementation and exploitation can still be improved to optimize outcomes in terms of e.g. speed, marketing of results or fitness for exploitation.

The purpose of this pilot is to identify key success factors for the design, implementation and exploitation of collaborative R&D&I activities submitted to public research and innovation funding of EU H2020 or equivalent instruments at national or local level. The more specific goal of the pilot is to increase synergy, quality and speed of interaction within the project team and towards external stakeholders, supporting the **working together of individuals across various organizations to achieve a shared goal**. This is achieved by the following objectives, which are assigned to the three columns “Assessment”, “Prioritization” and “Check” (see Figure 13):

- **Extract** key success factors from existing R&D&I activities to amplify buy-in from participating people
- **Identify** main drivers to facilitate and motivate cross organizational collaborating teams
- **Validate** main drivers for successful collaboration to elaborate pragmatic/effective guidelines and key success factors

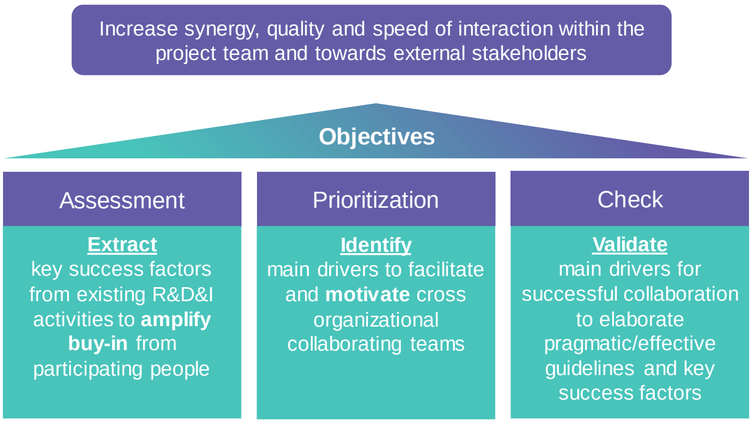


Figure 13: Objectives of Pilot 3

To reach the above objectives, publicly co-funded collaborative research projects (EU/national) were analysed to extract success factors of collaborative projects and to identify the main drivers facilitating and motivating cross organizational teams. This was done based on questionnaires and interviews with project coordinators and project team members. The results were then validated in workshops with expert groups, leading to guidelines and key success factors for collaborative R&D&I projects:

- How to initiate, facilitate and motivate cross organizational research teams using valuable opportunities of the digital world
- How to profit from effective communication patterns, trust building elements and reflective learning
- How to reconcile individual motivations in one common goal

The methods used within this OIS place a special focus on the identification of organizational preconditions and “hidden” skills necessary in conducting collaborative R&D&I projects in the context of Open Innovation. This approach aims at supporting the individual persons involved in collaborative projects with guidelines, formulated as blueprints and DO’s and DON’T’s.

5.2 Description of the Open Innovation Scheme

Open Innovation per se implies **collaborative relationships** between all involved stakeholders. The pilot inherently supports Open Innovation: collaborative work, as a **process of shared creation across various organizations to achieve shared goals** (Figure 14)**.** This process takes place in three dimensions:

- Shared creation through exchange of data, information and knowledge (collaborative work on present projects, all Pilots)
- Shared creation through staff mobility (Pilot 4)
- Shared creation through exchange of ideas (for future collaborations, Pilot 7).

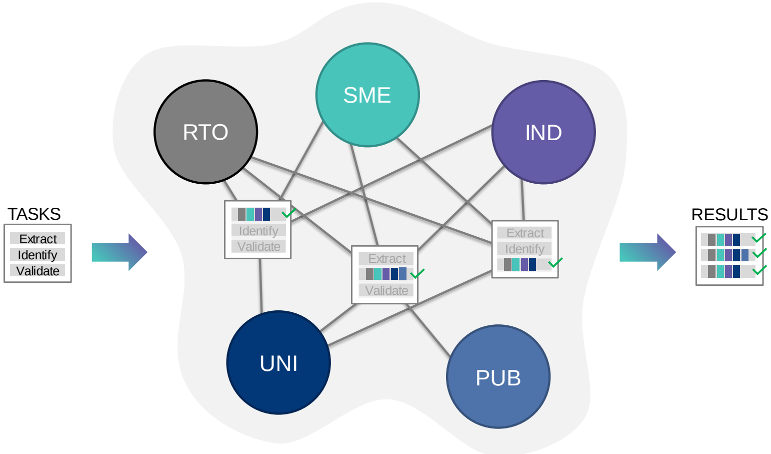


Figure 14: Concept of collaborative interaction

This relationship of Pilot 3 “Collaboration” with the other Open Innovation Schemes within this project is illustrated in Figure 15. Collected success stories during the project give insights to real Open Innovation projects[9] and make the developed key success factors for collaborative research tangible.

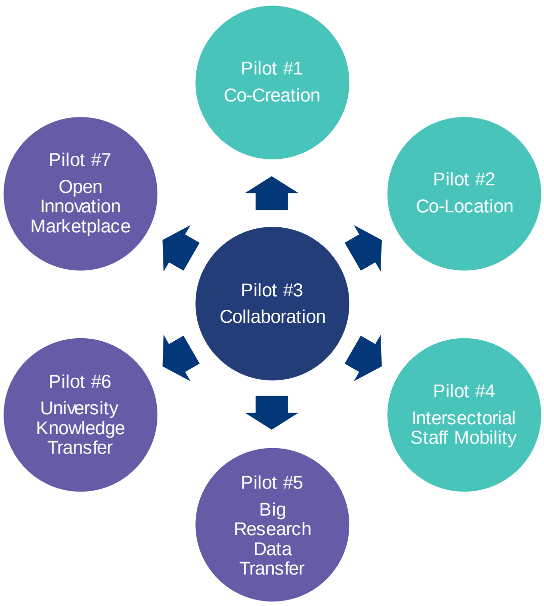


Figure 15: Pilot 3 supports all other Open Innovation Schemes of Science2Society

[9] Refer to S2S Knowledge Database: e.g. Case Study “Towards Successfully Initiating a Large-Scale European Research Project”; http://www.science2society.eu/main-knowledge-database/

According to (Hill, 2013) collaboration as a process to achieve shared goals is not the same as "openly share information across organisations". Against this background, the focus of collaboration lies on "interaction of organizations" and "interaction of people". While the first is related to the organization's strategy and structure which initially acts as a boundary condition for collaborative interaction, the latter is directly related to interpersonal skills and is of utmost importance for driving collaborative interactions. The following publications give insights and guidelines to collaborative relationships across organizations.

The European initiative "Responsible Partnering" published a report (EIRMA, EUA, EARTO, PROTON, 2009) aiming at improving the effectiveness of collaborative research and knowledge exchange involving the public and private sectors. In this report, two "principles that underpin Responsible Partnering" were mentioned: Maximum Beneficial Use of Public Research" and "Responsible Use of Public Research". To turn these principles into action, 10 guidelines were formulated to improve the effectiveness of collaborative research.

- Treat collaboration strategically
- View innovation as a trans-disciplinary activity
- Provide relevant training
- Achieve effective management of intellectual property
- Use standard practices and communicate regularly
- Foster strong institutions
- View innovation as a trans-disciplinary activity
- Provide relevant training
- Achieve effective management of intellectual property
- Use standard practices and communicate regularly

A structured approach to implement these guidelines was defined, addressing "senior managers who have strategic or operational responsibilities".

The online software "U-B Tool", maintained by the European University Association EUA (EUA - European University Association, 2015). It is a "self-assessment tool for collaborative research partnerships addressed to universities, businesses and other non-academic organisations" and contains "47 indicators involved in setting up, taking forward and sustaining successful partnerships". These indicators are structured in 4 areas: (i) strategic approaches, (ii) structural factors, (iii) facilitating aspects, (iv) goals, outcomes and benefits. The assessment tool allows to "compare the objectives and expectations at the outset of the collaboration with the current outcomes or between two specific dates" based on levels of importance for each of the indicators.

In literature a number of KPIs related to collaborative interaction are available supporting the evaluation of collaborative interactions. Table 1 gives an extract on sources where KPIs are defined related to interpersonal relationships. Further KPIs are available to assess the stability (Bu, Murray, Ding, Huang, & Zhao, 2017), the impact (Lee & Bozeman, 2005), and the success (Hoegl & Gemuenden, 2001) (Fernandes, Pinto, Araujo, Magalhaes, & Machado, 2017) of collaborative projects.

Table 1: Facets of collaboration involving interpersonal relationships from literature and KPIs defined

Facet of collaboration	KPIs defined for
Team Work Quality (Hoegl & Gemuenden, 2001)	Quality of Communication (frequency, formalization, structure, and openness), Coordination, Balance of member contributions, mutual support, effort, cohesion
Team performance (Hoegl & Gemuenden, 2001)	effectiveness (quality), efficiency (schedule and budget)
Personal success (Hoegl & Gemuenden, 2001)	work satisfaction, learning (knowledge and skills)

Preferential attachment (to collaborative network) by new entrants (Abbasia, Hossain, & Leydesdorff, 2012)	Betweenness Centrality[10]
Collaboration ability (Zhao & Wei, 2017)	Collaborative rate, Collaborative breadth, Collaborative depth
Success of collaborative university-industry R&D funded programs/projects (Fernandes, Pinto, Araujo, Magalhaes, & Machado, 2017)	Researchers' capability, Researchers' motivation, Industry collaborators' capability, Industry collaborators' motivation, Opportunities/ challenges, Applied research, Governance established, Collaboration intensity, Technology, New knowledge, Management and organization quality, Governance embedment, Human capital, Innovations, Solution concepts, New project ideas, Technology achievement, Turnover, Partnership sustainability

The "Responsible Partnering" guideline (EIRMA, EUA, EARTO, PROTON, 2009) is related to the strategic level of collaborations and has its focus on the interaction of organizations. The "U-B Tool" enables the assessment of collaborative interactions mainly on strategic and managerial level. Further, KPIs available from literature help to assess collaborative projects mostly strategic and managerial level. They describe the performance of collaborative projects in terms of numbers. There are KPIs available from literature that can assess interpersonal relationships (Table 1), mostly on an abstract level. According to (Aram, Morgan, & Esbeck, 1971) there is a significant relationship between team collaboration and the satisfaction of individual's needs.

Measuring the level of satisfaction within a project team to assist project managers in maintaining a good interpersonal relationship will help to initiate, facilitate and motivate cross organizational research teams. The definition of a "collaborative team satisfaction KPI" allows the monitoring of a project and enables the comparison of different projects.

Extracting success factors from collaborative projects to identify the main drivers facilitating and motivating cross organizational teams supported by a KPI that can capture and monitor the satisfaction level within a collaborative team can support other managerial or strategic KPI's bottom-up.

With this work, the lower operative level of collaboration – the interpersonal collaboration - was analysed and a tool to capture the spirit/atmosphere/mood of a collaborative project was developed. This will help the project coordinators in future to

- identify problems or more specific "unsatisfying conditions" within projects,
- focus on the most important ones and
- try to resolve these problems step by step.

[10] The term „betweenness centrality" is related to social network analysis. Considering a network with participants (nodes) and communication actions (paths) it captures the "number of times a particular node lies 'between' the various other nodes in the network" (Abbasia, Hossain, & Leydesdorff, 2012) following shortest paths. Nodes with "high betweenness centrality" play the role of a "broker" or "gatekeeper" and can be considered as most influencing actors within a network.

5.3 Implementation of the pilot

The implementation of Pilot 3 followed a multi-step process, as illustrated in Figure 16. The “Preparation” step is followed by the three main stages “Assessment”, Prioritization” and “Check” which are related to the objectives of the pilot (Figure 13). The result of these steps was then formulated as “Do’s and Don’t’s” for key success factors in collaborative interaction and “Blueprints” to support this UIS.

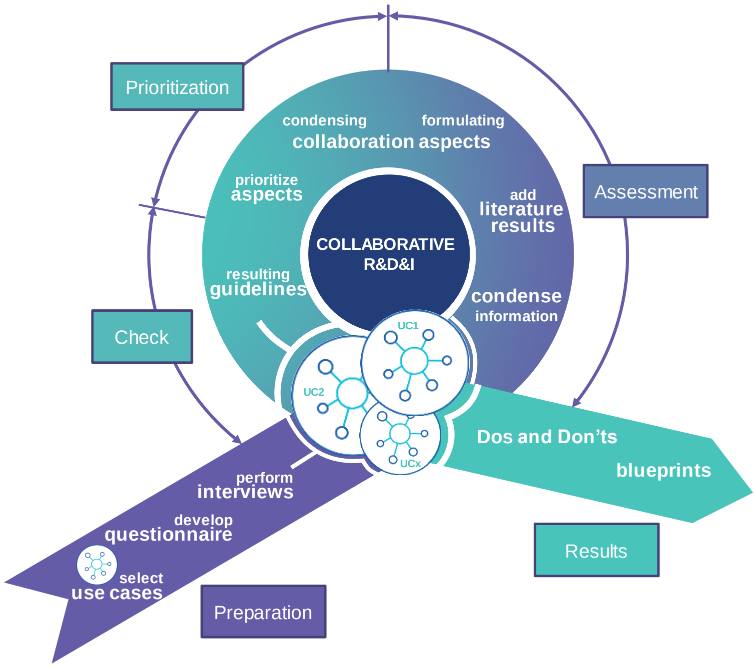


Figure 16: Implementation of Pilot 3 – Collaborative R&D&I

5.3.1 Preparation

During the preparation phase, use cases were selected to gather all necessary information for the further steps. The main purpose of the use cases was to interview persons involved in concrete collaborative projects. The use case projects were selected among the core team partners of the project. Figure 17 illustrates the different structures of the four use case projects.

Within these 4 use case projects, 9 semi structured interviews were performed. The aim was to identify success factors of collaborative projects right from the field. For that, an interview guideline was developed and structured as follows:

- How was this specific collaborative RDI project initiated - from the “first move” to project start?
- How is this use case project coordinated?
- How was this collaborative R&D&I project implemented?
- How were/are the results of the use case exploited?
- How was the communication within the project structured?

It follows a logical structure throughout a general project and was developed iteratively during workshops at VIF and with inputs from JIIP. The full interview guideline is given in the Appendix A to this chapter.

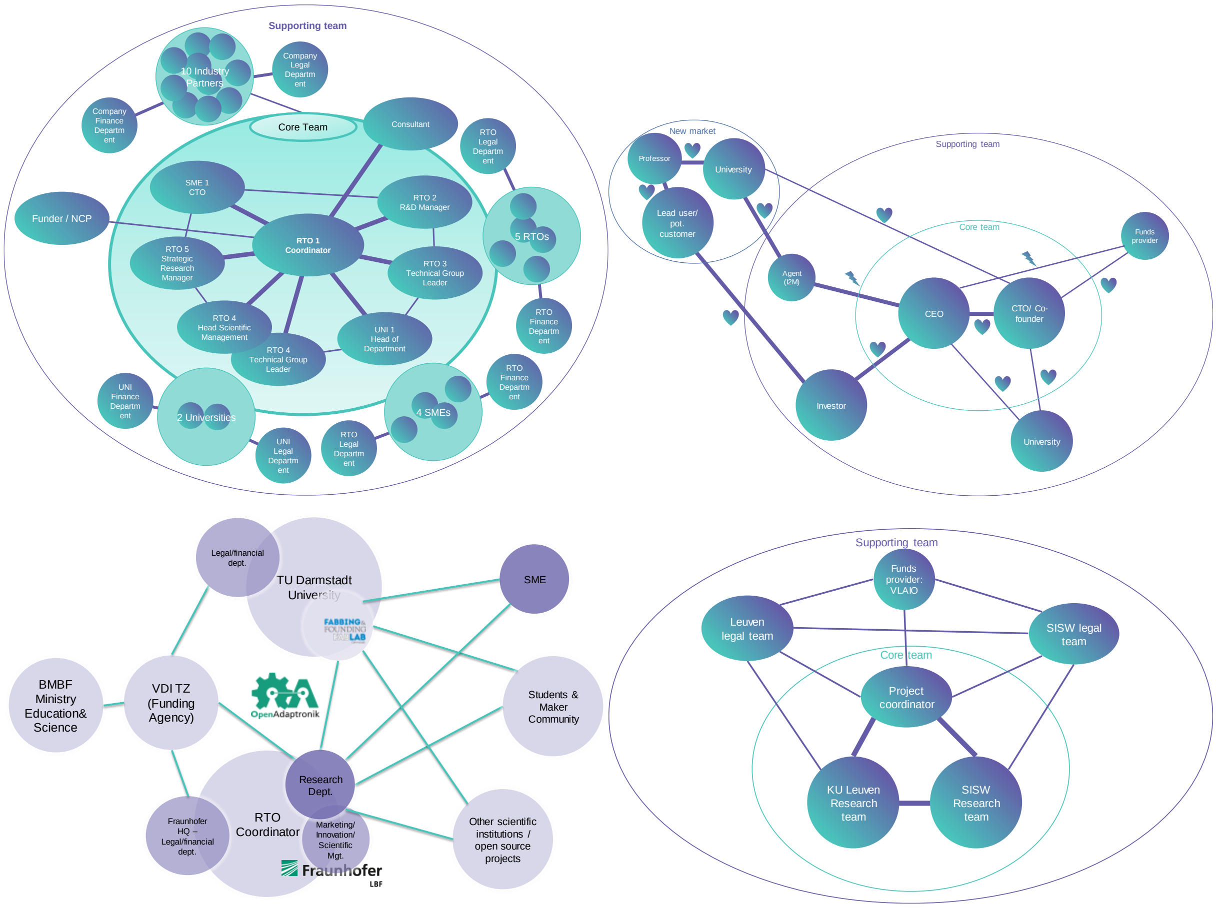


Figure 17: Map of actors of use case projects of Pilot 3

The answers of the interview should be related to the background of personal experience/knowledge on a specific ongoing project experience, namely the use case project. During the interviews, notes were taken to capture the main information in written form. Additionally, the interviews were recorded to have the full information available for later analysis. The interview results were anonymized so that the answers cannot be associated with the interviewee. During the project, 9 interviews were performed.

5.3.2 Assessment

From this set of 9 interview results, single statements were isolated and translated into specific aspects, useful for the assessment of collaborative interaction. These aspects from the interview results (field data) represent issues relevant for people involved in collaborative projects. This work was performed during several workshops following an iterative method named summarizing qualitative content analysis (Mayring, 2014).

For each interview, in the analysis step both the recordings and the interview notes were considered for condensing the interviews to relevant information in the form of statements. To reduce the number of misinterpretations due to subjective perception, the interviews were analysed by three different persons of VIF's project team. The intermediate result was a set of statements stemming from all interviews, based on the 27 interview analyses (3 persons x 9 interviews).

In a next step, the formulated aspects were combined in a single list and analyzed according to their relation and similarity. In this process congruent aspects were consolidated. Based on literature research (Ankrah & Al-Tabbaa, 2015; Baker, Murphy, & Fisher, 1988; Belassi & Tukel, 1996; Cooke-Davies, 2002; Cserháti & Szabó, 2014; Fortune & White, 2006; Markwell & Leigh-Hunt; Mira & Pinnington, 2014; Radujkovića & Sjekavicab, 2017;

Turner & Müller, 2005) the structure of the interview and the content of the aspects, an appropriate categorization for grouping aspects was developed.

In addition to the results of the interviews, a literature review on important aspects influencing collaborations in research projects was conducted. Literature sources used for this review focus for example on key elements that influence collaboration success (e.g. (Bammer, 2008), (Fernandes, Pinto, Araujo, Magalhaes, & Machado, 2017)) and on effects of collaboration for individual partners (e.g. (Melin, 2000)). Further authors investigated essential informal social aspects of collaborative projects (Chompalov, Genuth, & Shrum, 2002) and recent trends in collaborations (Adams, Black, Clemmons, & Stephan, 2005). Lukkoonen et. al investigated in (Luukkonen & Persson, 1992) cognitive, social, historical, geopolitical, and economic factors in patterns of international collaborations in scientific fields. Recommendations are given in e.g. in (Bammer, 2008), (Traitler & Saguy), (Guidelines for Collaborative Reserach and Knowledge Transfer between Science and Industy, 2004) and (Saguy, 2011) on how to improve collaborations.

The aspects extracted from the interviews were compared with the aspects found from literature and merged into a list of relevant aspects. These resulting 170+ aspects were classified into these useful groups and subgroups, forming a hierarchical structure as represented in

Appendix B. These aspects were evaluated by a group of experts from the whole Science2Society consortium regarding their tangibility and completeness.

5.3.3 Prioritization

For the prioritization of the 170+ aspects, a two-step approach was chosen.

- First, a qualitative survey was performed to reduce the number of aspects to the most important ones.
- Second, these most important aspects were given a weight reflecting their level of importance in collaborative R&D&I projects. This aims at turning these aspects into a set of parameters suitable for the assessment of the level of satisfaction inside collaborative research teams. The basic assumption here is that import aspects have a higher impact on the level of satisfaction than less important ones. Methods from the Analytical Hierarchical Process AHP[11] were applied for that purpose.

First step: Qualitative survey

Therefore, people were asked to assess the level of importance of each aspect based on their overall project experience. The levels follow a 7 item Likert-Type scale, modified from (Vagias, 2006), with the following levels:

- 1 – Not at all important
- 2 – Lowly important
- 3 – Slightly important
- 4 – Moderately important
- 5 – Rather important
- 6 – Very important
- 7 – Extremely important

[11] Thomas L. Saaty: Multicriteria decision making - the analytic hierarchy process. Planning, priority setting, resource allocation. 2. Auflage. RWS Publishing, Pittsburgh 1990, ISBN 0-9620317-2-0.

Figure 18 shows a screenshot from LimeSurvey of a part of one single question block. The full LimeSurvey Structure File can be downloaded from the link below[12].

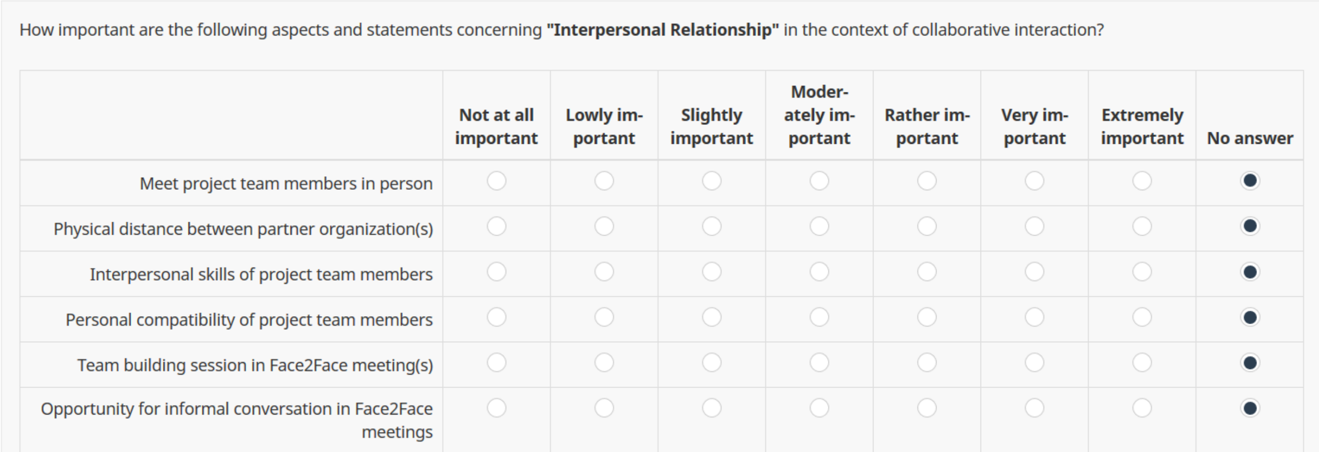


Figure 18: Screenshot from LimeSurvey of a part of one question block from the qualitative survey

The survey was performed online using LimeSurvey (Limesurvey GmbH, Version 3.7.0+180418). The qualitative survey was spread among the core team partners of Pilot 3 and external stakeholders via newsletter, personal invitations and social platforms (LinkedIn, Xing). From 138 total responses, 34 full responses were received, mainly coming from Industry and Research & Technology Organisations (38% IND, 35% RTO, 18% SME, 6% UNI, 3% others). The current positions of the respondents are listed in Table 2. The respondents had an average professional experience of 6 years in their current position and an average total professional experience of 16.5 years. Only full responses were considered for further analysis.

Table 2: Current Positions of qualitative survey respondents

Current Position	Count
Consultant	9
Senior-Level Project Manager	5
Research Manager	4
General Manager	3
Researcher	3
Head of Department	2
Chief Innovation Officer	1
Industrial Liaison Officer	1
Junior-Level Project Manager	1
Research Associate	1
Senior Industrial Research Manager	1
Senior Programme Manager and Policy Advisor	1
Teamleader Technology Marketing and Communication	1
NA	1

To analyse the survey results, the response frequencies were sorted according to the used Lickert scale items from “7 – Extremely important” to “1 – Not at all important”. Figure 19 shows the first 20 aspects which were interpreted as the 20 most important aspects impacting collaborative interaction in R&D&I activities.

[12] https://sde.v2c2.at/public/5cc623--de

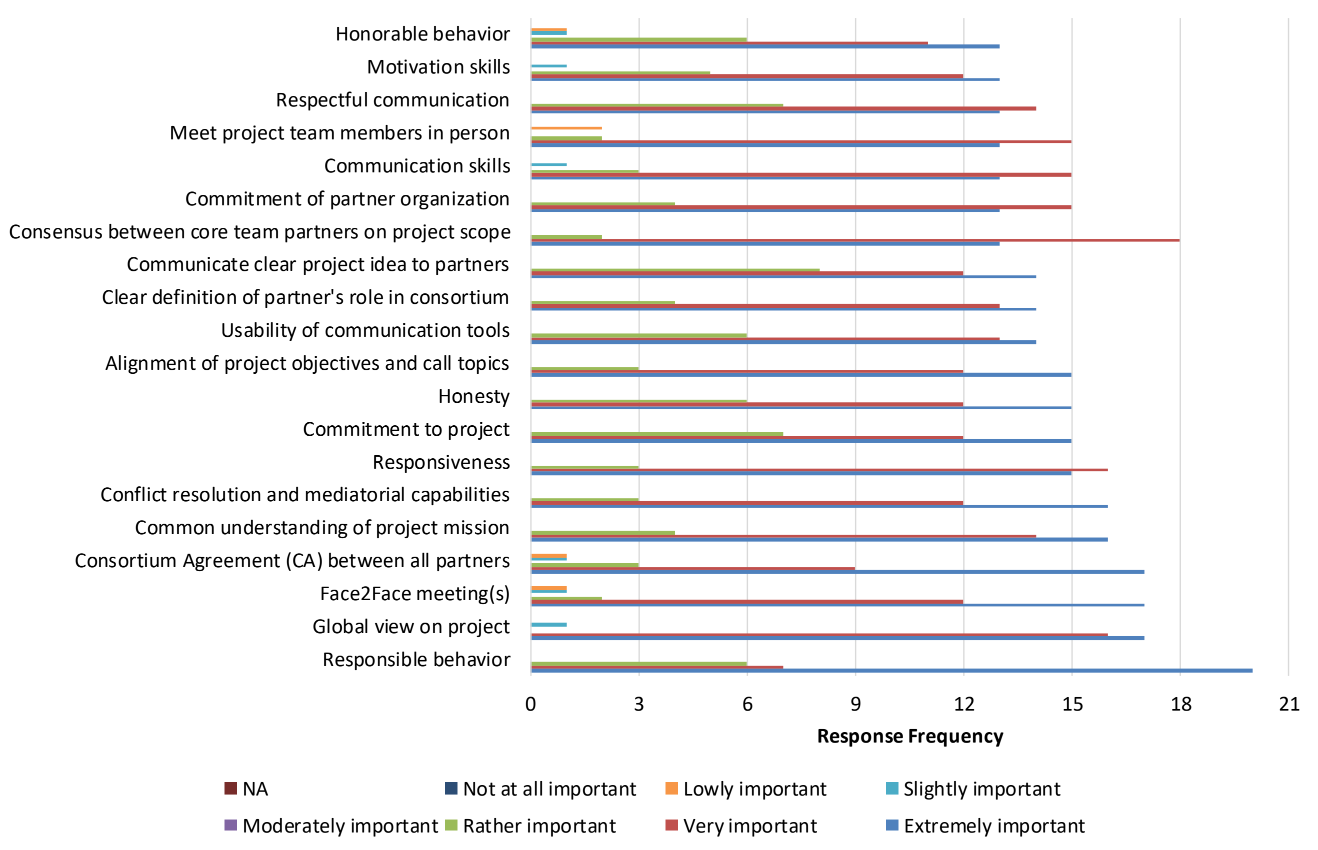


Figure 19: Response frequencies from the qualitative survey for the first 20 aspects

The resulting important aspects were related to generalized project steps as illustrated in Figure 20, pointing out important aspects within specific project phases to provide a practical overview of the results of the survey. This overview was condensed in a so-called "Blueprint" of the UIS containing Activities, Challenges & Tips and enabling elements. The content of the Blueprint was enhanced by specific outcomes of the interview and literature research. Appendix 5.6.3 contains the relevant excerpt from the Blueprint.

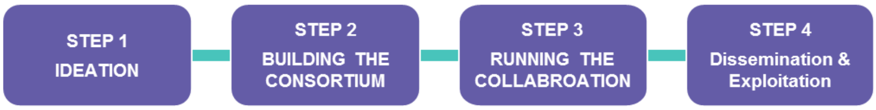


Figure 20: Generalized project steps

Second step: Analytical Hierarchy Process

In the next step, these resulting important aspects were given a weight reflecting their level of importance in collaborative R&D&I projects. As mentioned before this aims at turning these aspects into a set of parameters suitable for the assessment of the level of satisfaction inside collaborative research teams. The basic assumption here is that import aspects have a higher impact on the level of satisfaction than less important ones. Methods from the Analytical Hierarchical Process AHP were applied for that purpose. The used methods are described in the following.

From the full hierarchical structure of the initial set of aspects (refer to

Appendix B) the 20 most important aspects (see Figure 19) have already been extracted. Hence, the hierarchical structure reduces to 9 highly relevant subgroups, presented in Table 3. From these highly relevant subgroups, at least 3 aspects were chosen as a precondition for the further quantitative analysis. The hierarchical structure from Table 3 now contains 4 groups, 9 highly relevant subgroups, 20 most important aspects plus 11 additional aspects to reach at least 3 aspects within every subgroup. These 11 additional aspects were chosen according to their level of importance within each subgroup (marked with ***)**.

Table 3: Hierarchical structure of most important aspects which impact collaborative interaction in R&D&I

Level 0 – Group	Level 1 – Subgroup	Level 2 – Aspect
Communication	Communication Methods & Tools	Face2Face meeting(s)
		*Conference calls
		*Email
	Communication Procedures & Characteristics	Usability of communication tools
		*Usability of online collaboration tools
		*Versioning of project documents
Management	Capabilities and Skills of Project Coordinator	Global view on project
		Conflict resolution and mediatorial capabilities
		Responsiveness
		Commitment to project
		Communication skills
		Motivation skills
Social	Interpersonal Relationship	Meet project team members in person
		*Opportunity for informal conversation in Face2Face meetings
		*Team building session in Face2Face meeting(s)
	Trust & Motivation of Persons	Responsible behavior
		Honesty
		Respectful communication
		Honorable behavior
Strategic	Building the Consortium	Clear definition of partner's role in consortium
		Commitment of partner organization
		*Composition of core team
	Cross-Organizational Relationship	Consortium Agreement (CA) between all partners
		*Level of knowledge/competencies/qualification of partners
		*Set up a non-disclosure agreement (NDA)
	Project Objectives	Common understanding of project mission
		Alignment of project objectives and call topics
		*Common agreement on project's objectives beyond state-of-the-art
	Project Scope	Communicate clear project idea to partners
		Consensus between core team partners on project scope
		*Precisely define scope of initial idea

To calculate a weight regarding the importance of each of these 31 aspects, the approach of pairwise comparisons from the Analytical Hierarchy Process (Saaty, Fundamentals of Decision Making and Priority Theory With the Analytic Hierarchy Process, 2000) was chosen. This method is widely used for decision-making problems and is "based on ranking general activities (or rather *criteria*, remark of the author) in terms of relative ratio scales"

(Saaty, Fundamentals of Decision Making and Priority Theory With the Analytic Hierarchy Process, 2000). The necessary pairwise comparison of the criteria, expressed as groups, subgroups and aspects within this work, was realized as an online survey using LimeSurvey (Limesurvey GmbH, Version 3.7.0+180418). This quantitative survey was spread among the core team partners of Pilot 3 and external stakeholders via newsletter, personal invitations and social platforms (LinkedIn, Xing). From 223 total responses, 20 full responses were received, mainly coming from Academia and Industry (25% IND, 20% RTO, 15% SME, 30% UNI, 5% PUB, 5% others). Compared to the previous qualitative survey, the share of respondents from Industry stakeholders is lower. The current positions of the respondents are listed in Table 4. The respondents had an average professional experience of 6 years in their current position and an average total professional experience of 13.5 years. Only full responses were considered for further analysis.

Table 4: Current Positions of quantitative survey respondents

Current Position	Count
Consultant	4
General Manager	1
Head of Department	2
Research Associate	1
Researcher	8
Research Manager	1
Senior-Level Project Manager	2
NA	1

The pairwise comparisons within the survey were structured according to the clusters in the hierarchical structure of Table 3. The elements inside "Level 0 – Groups" form one single cluster. The elements inside "Level 1 – Subgroups" related to a single element of the previous level "Level 0 – Groups" (e.g. Communication) form another cluster. This procedure results in 13 clusters for the overall hierarchy. The elements inside every cluster (groups, subgroups or aspects) are compared pairwise, meaning that every element is compared with every other element. An example for the three elements "Conference calls", "Email", and Face2Face meeting(s)" inside the cluster of "Communication Methods & Tools" is illustrated in Figure 21. The response for every pairwise comparison lies in the range of 9 to 1 to 9.

The number of pairwise comparisons N is related to the number of elements n of a cluster, given in equation (1).

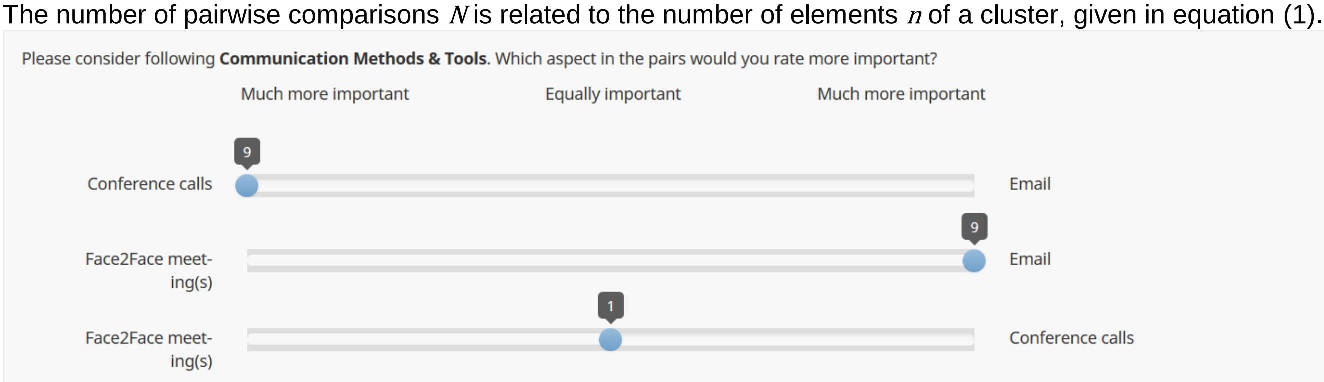


Figure 21: Screenshot from LimeSurvey of one question block from the quantitative survey

For the 13 clusters of this problem, this leads to a total number 56 pairwise comparisons for the survey. Compared to 465 pairwise comparisons for all 31 aspects without clustering, this is a great advantage. This issue is the main reason for hierarchical structuring of the problem and using the AHP. The single pairwise comparisons were derived from Table 3 and are visible in the LimeSurvey structure file[13].

$$N = \frac{n\ (n-1)}{2} \qquad (1)$$

The single responses from pairwise comparison are transformed into a matrix structure for every cluster where only N position of the matrix are filled, depending on what aspect (criteria) is more important. If e.g. “Conference Calls” is seen much more important than “Email”, $a_{12} = 9$ and $a_{21} = 1/a_{12}$ subsequently. This standard judgement scale from “1 – Equally important” to “9 – Much more important” is widely used but has the problem3 aspect that it does not lead to a linear distribution of the later calculated weights (Priority Vector) over the judgement scale. Further, the later calculated weights are also dependent on the number of criteria or rather the comparison matrix size. The “Generalized Balanced Scale” from (Goepel, 2018) overcomes these problems and was used during this work. It modifies the scale values $x = 1 \div 9$ according to equation (2) considering the number of criteria n to a new scale $c = 1 \div 9$. This procedure also reduces the later calculated Consistency Ratio (Table 3), making the AHP more stable. This procedure is repeated for all responses, ending up in 13 comparison matrices for the overall problem.

$$c = \frac{9 + (n-1)x}{9 + n - x} \qquad (2)$$

The next step in the AHP is to calculate Priority Vector *PV* (Table 5) which represents the weight of each criteria inside the comparison matrix. Therefore, the Geometric Mean *GM* of every row is calculated and divided by the sum of all Geometric Means (normalized). This is the first major result of the process, indicating the importance of one criteria over the other(s). More precisely, the Priority Vector is the right eigenvalue of the comparison matrix. Since this approach needs some programming effort in Microsoft Excel, the above described approximation was applied instead. Further details on calculating eigenvalues can be found in (Saaty, Fundamentals of Decision Making and Priority Theory With the Analytic Hierarchy Process, 2000).

To check the consistency of the responses from the pairwise comparison inside a single comparison matrix, a Consistency Ratio CR is calculated. Therefore, the sum of each column of criteria is multiplied by the corresponding value inside the Priority Vector. These values are summed up (λ_{max}) and the Consistency Index is calculated according to the equation given in Table 5, line 7. The Consistency Ratio is the Consistency Index divided by the Random Index which is a function of the number of criteria being considered. The Random Index is the average Consistency Index of randomly generated comparison matrices. For further details refer to (Saaty, Fundamentals of Decision Making and Priority Theory With the Analytic Hierarchy Process, 2000) and (Saaty, Decision Making for Leaders: The Analytic Hierarchy Process for Decisions in a Complex World, 2012). The Consistency Ratio should ideally be <10%. Since this value was calculated posterior to the survey and there was no possibility for correcting the responses, a value of 20% was assumed to be acceptable for this work. This also goes along with discussions in the community, using AHP in various fields (ResearchGate, 2015). So, from the initial 20 full responses, 2 were eliminated because of massive violation of this rule. The remaining 18 responses were considered for the calculation of global weights for all the Level 0 – Aspects.

Table 5: Calculation of the comparison matrix; general example for n=3 aspects

j / i	**Face2Face meeting(s)**	**Conference calls**	**Email**	Geometric Mean GM	**Priority Vector PV**
Face2Face meeting(s)	1	a_{12}	a_{13}	GM_1	$PV_1 = \frac{GM_1}{SGM}$
Conference calls	$a_{21} = 1/a_{12}$	1	a_{23}	GM_2	$PV_2 = \frac{GM_2}{SGM}$

[13] https://sde.v2c2.at/public/aff66c--de

Email	$a_{31} = 1/a_{13}$	$a_{32} = 1/a_{23}$	1	GM_3	$PV_2 = \frac{GM_3}{SGM}$
Sum	$S_1 = \sum_{i=1}^{3} a_{i1}$	$S_2 = \sum_{i=1}^{3} a_{i2}$	$S_3 = \sum_{i=1}^{3} a_{i3}$	$SGM = \sum_{i=1}^{3} GM_i$	1
$S_j \times PV_i$ (i=j)	$S_1 \times PV_1$	$S_2 \times PV_2$	$S_3 \times PV_3$		
λ_{max}	$\lambda_{max} = \sum_{j=1}^{n} S_j$				
Consistency Index	$CI = \frac{\lambda_{max} - n}{n-1}$				
Consistency Ratio	$CR = \frac{CI}{RI}$	*RI = 0 (n=2); 0,58 (n=3); 0,90 (n=4); 1,12 (n=5); refer to* (Saaty, Decision Making for Leaders: The Analytic Hierarchy Process for Decisions in a Complex World, 2012)			

The hierarchical structure from Table 3 is defined as “incomplete structure” (Saaty, Fundamentals of Decision Making and Priority Theory With the Analytic Hierarchy Process, 2000) because it contains “incompletely connected criteria levels”: not all Level 2- Aspects are connected to the same Level 1 – Subgroups and not all Level 1 – Subgroups are connected to the same Level 0 – Groups. The clusters at the different levels are of different size and the paths from the Level 0 to Level 2 have unequal length (e.g. there is only one criteria below Level 0: Management). Since, the average of the priority vector depends on its length or rather cluster size (this applies to all levels), this structural bias must be removed to make the global weights of each Level 0 - Aspect comparable. This is done by structural adjustment of every Level above the lowest one according to (Saaty, Fundamentals of Decision Making and Priority Theory With the Analytic Hierarchy Process, 2000).

$$SA = \frac{\#\ of\ criteria\ within\ the\ descent\ level\ of\ the\ given\ node}{\#\ of\ total\ criteria\ of\ the\ lowest\ level\ of\ the\ hierarchy} \qquad (3)$$

$$structural\ adjusted\ PV_i = SA_i \times PV_i \qquad (4)$$

The global weights of all the Level 0- Aspects for each response was calculated by multiplying the structural adjusted Priority Vector values along the hierarchical path for each aspect. The result is a global weight for each Level – 2 Aspect for every response. To aggregate all responses, the normalized Geometric Mean *GM* of the global weights for every Level – 2 Aspect over all individual responses was calculated. This method is known as “Aggregation of Individual Priorities” (AIP) in the literature and most suitable for the aggregation of individually acting stakeholders “with their own value systems” (Ossadnik, Schinke, & H., 2016). Figure 26 illustrates the global weights for an AHP with/without structural adjustment (SA). Two extreme cases were considered here: (i) “AHP/SA one high”: the first Level-2 Aspect for every cluster was set “9 – much more important” while the others were set “1 – equally important”; (ii) “AHP/SA equal”: all Level-2 Aspects were set “1 – equally important”. The Level-1 Groups and Level-2 Subgroups were all set “1 – equally important”. This produces a fictious AHP result where it can clearly be seen that without structural adjustment SA, the aspects within the Strategic level in general are given a higher (less important) rank compared to the other levels. This arises due to the 4 subgroups of the group “Strategic” and the 1 or rather 2 subgroups of the other levels (compare with Table 3), previously described as “structural bias”.

As a result for the Level-2 Aspects, the normalized Geometric Mean over the global weights of every response was calculated for every aspect and summarized in Figure 22. A high global weight is related to a high importance level.

The result for the Level-0 groups and Level-1 subgroups is analysed visually using Boxplots of the aspect’s global weights of all responses related to each hierarchical structure item, shown in Figure 23. Social aspects in general are given a slightly lower weight than Communication, Strategic or Management aspects. This goes along with the observation in Figure 23 that “Interpersonal Relationships” has the lowest weight. Further, “Project Objectives” is given the highest rank. In general, the weights on the level of groups and subgroups are quite diverse because they contain aspects that are very important and aspects that are less important.

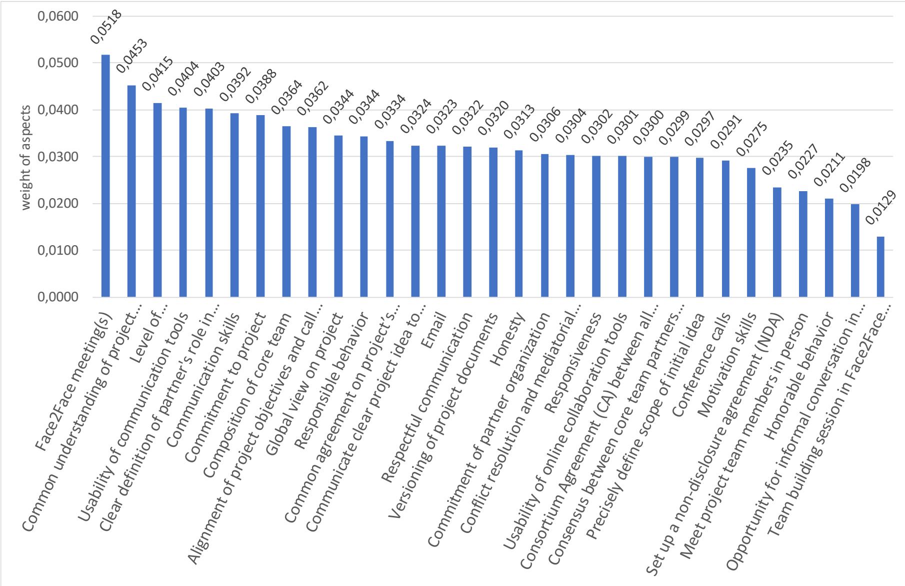


Figure 22: Global weight of important aspects

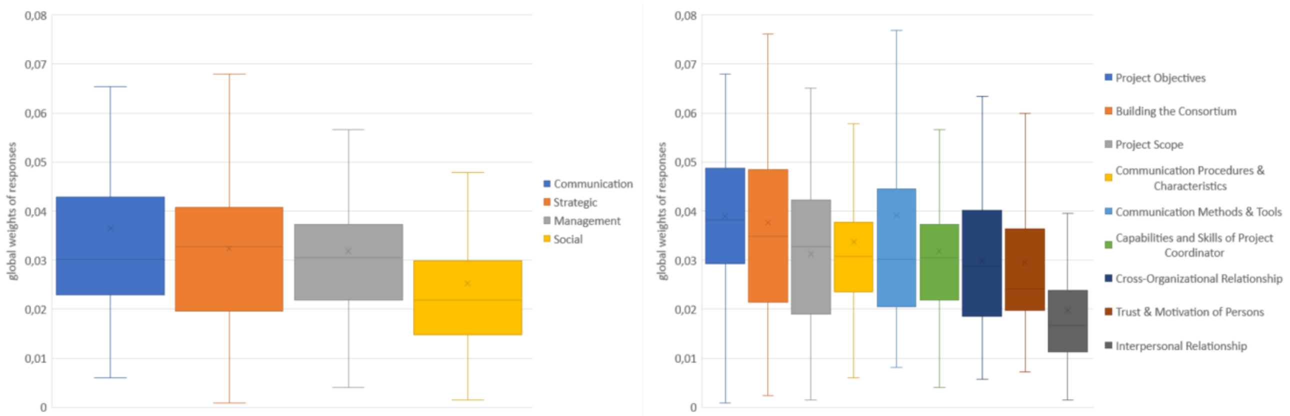


Figure 23: Boxplots of the aspect's global weights related to the hierarchical structure items

5.3.4 Check

Having the now the global weights of the important aspects of collaborative research available, a method was derived that enables project managers to check the spirit/atmosphere/mood of running or past collaborative R&D&I projects, based on levels of satisfaction. Therefore, the aspects from the hierarchical structure of Table 3 are used to develop a questionnaire, asking for the individual satisfaction of persons involved in the specific project. The results are the response frequencies regarding the level of satisfaction for all aspects. These are ranked from 1 to the total number of aspects n=31 and the ranks are normalized to 1. The global weights from the AHP as given in Table 6 are then used to weight these normalized ranks from the response frequencies of the level of satisfaction across all aspects. This procedure calculates a parameter that will rate the satisfaction level of aspects in relation to the importance of the considered aspect. This tool can then be used as a decision support on how to raise the quality of the actual or future collaboration.

The assessment survey is realized in LimeSurvey (Limesurvey GmbH, Version 3.7.0+180418). The satisfaction-levels follow a 6 item Likert-Type scale, modified from (Vagias, 2006), with the following levels:

- -14 – Extremely dissatisfied

- -5 – Dissatisfied
- -1 – Somewhat dissatisfied
- 1 – Somewhat satisfied
- 5 – Satisfied
- 14 – Extremely satisfied

A mean level is not being used here to avoid undecided answers. The distance between the scale items follows a quadratic function to express a larger numeric difference between “Extremely dissatisfied/satisfied” and “Dissatisfied/satisfied” than between “Dissatisfied/Satisfied” and “Somewhat dissatisfied/satisfied”. This assumption relates to the issue that there is an unproportional bigger hurdle to express an extreme dissatisfaction/satisfaction than to express just dissatisfaction/satisfaction. Extreme dissatisfaction/satisfaction is given more emphasis. Figure 18 shows a screenshot from LimeSurvey of one single question block. The full LimeSurvey Structure File can be downloaded from the link below[14].

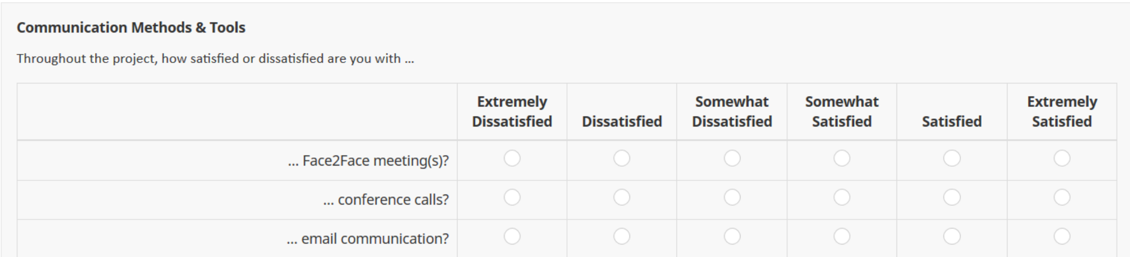


Figure 24: Screenshot from LimeSurvey of one question block from the assessment survey

From all survey responses, the frequency or rather count of all satisfaction levels over all responses is calculated and normed. From this result, a Mean Satisfaction Level is calculated based on the numerical values of the satisfaction levels described previously. The result for every aspect is multiplied with the respective global weight from Figure 22, leading to an Assessment Indicator. Ranking this indicator according to its value from small to big values indicates aspects the project team is unsatisfied with (lower ranks) and aspects the team feels satisfied with (higher ranks). The project manager or coordinator could now take a closer look at the e.g. 5 lowest ranks and try to solve the problems there. To support the problem solving,a set of DOS and DONTS in collaborative R&D&I projects were collected from the interviews conducted in the preparation phase (see section 5.3.1) and during workshops with involved stakeholders and Science2Society participants. These DOS and DONTS can be viewed and downloaded from this link[15].

The numerical representations of the satisfactory levels become positive values when the Likert-scale values described previously are offset by 15. Calculating a Scaled Mean Satisfaction Level from these numbers and multiplying the results with the respective global weight of every aspect leads to positive indicators of the satisfaction level for every aspect. Summing these values up results in a single value, expressing the overalls satisfaction level of all responses. This value serves as a KPI for the satisfaction level within a project team and can be related to the now scaled 6 item Likert-Type scale:

- 1 – Extremely dissatisfied
- 10 – Dissatisfied
- 14 – Somewhat dissatisfied
- 16 – Somewhat satisfied
- 20 – Satisfied
- 29 – Extremely satisfied

A template to calculate the ranking and the “collaborative team satisfaction KPI” can be downloaded here[16].

[14] https://sde.v2c2.at/public/7e2572--de
[15] https://sde.v2c2.at/public/c9fd3d--de
[16] https://sde.v2c2.at/public/8efa4f--de

5.4 Conclusions & Recommendations

5.4.1 Conclusions

With this work, the lower operative level of collaboration was analysed and a tool to capture the level of satisfaction of a collaborative project team was developed. This will help the project coordinators in future to

- identify problems or more specific “unsatisfying conditions” within projects,
- focus on the most important ones and
- try to resolve these problems step by step.

Key Findings

Most important aspects for facilitating collaborative interaction were identified:

- Responsible behaviour of the persons involved
- Global view on project by the project coordinator
- Face2Face meeting(s) as a communication method
- Consortium Agreement between all partners to organise the cross-organisational relationship

Least important aspects for facilitating collaborative interaction:

- “Strategy of the coordinating Partner” and “Strategy of the Individual Partners”
- The reason why to collaborate is not that important for the collaborative action itself

5.4.2 Recommendations

Key takeaways

The following issues were reported to hinder collaborative interaction:

- Not complying with deadlines
- Lack of a common understanding of the project mission and no clear project objectives for the project
- Poorly prepared meetings
- Poor usability of online collaboration tools (e.g. failures in document versioning)
- Technical problems and IT restrictions of partners when using online collaboration tools

Impact on the pilot

The result of this pilot will be used in future collaborative R&D&I projects to monitor the collaboration quality (related to the level of satisfaction of team members) and to identify corrective measures to support efficient and effective collaborative interaction. This process is visualized in Figure 25.

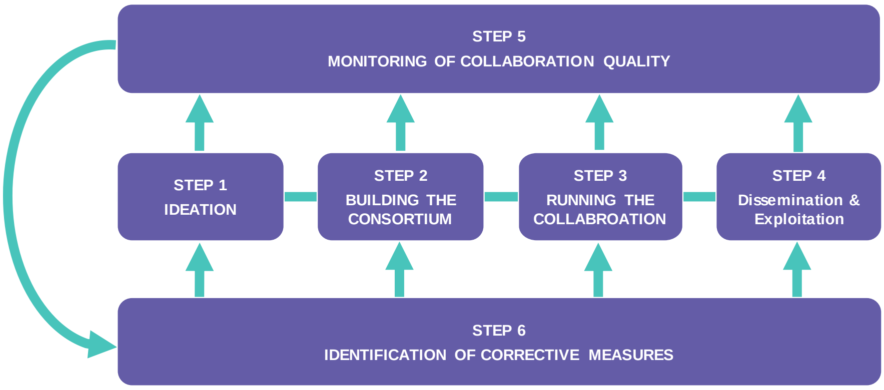


Figure 25: Pilot implementation process

Key Performance Indicators (KPIs)

A novel KPI to assess the satisfaction level within a project team was developed. This KPI can be used in future projects to make the collaboration quality of project teams comparable between different projects. This KPI enables tracking of collaborative quality and quantifies the effect of measures taken to improve the satisfaction level within collaborative project teams.

DOS and DONTS in collaborative R&D&I support the problem solving with issues indicated in collaborative projects.

5.5 Future line of research

The future line of research will focus on the evaluation of the “collaborative team satisfaction KPI” to assess the satisfaction level within a project team. The KPI will be calculated at present and upcoming projects at VIF and results will be tracked. The published document of DOS and DONTS to support critical aspects within collaborative project teams will support with concrete solutions here. It is envisioned that this document is continuously updated and published.

5.6 Appendix to Pilot 3

5.6.1 Appendix A

1.1 Project-related Part

TITLE OF USE-CASE: Click here to enter text.

YOUR ROLE IN THIS USE-CASE: Click here to enter text.

1.1.1 How was this specific collaborative RDI project initiated - from the "first move" to project start?

Give YOUR EXPERIENCE from the USE CASE for the following topics:

- START OF COMMUNICATION and PROJECT IDEA
- THE PROJECT CONSORTIUM – BUILDING THE CROSSORGANIZATIONAL TEAM
- COMMON PROJECT GOAL

1.1.1.1 START OF COMMUNICATION and PROJECT IDEA

1. What is the motivation to be part in this collaborative research project and how did your institution get involved?

   Click here to enter text.

   ☺ Click here to enter text.

   ☹ Click here to enter text.

2. How was the project idea developed (origin, communication and development of the idea)?

   Click here to enter text.

   ☺ Click here to enter text.

   ☹ Click here to enter text.

3. Who leads the communication and who is involved in this initial phase (e.g. departments, people)?

   Click here to enter text.

   ☺ Click here to enter text.

   ☹ Click here to enter text.

4. How do you communicate with the involved players in this phase (e.g. TelCo, F2F)?

   Click here to enter text.

   ☺ Click here to enter text.

   ☹ Click here to enter text.

5. How is the decision making process in this phase (Who decides what, when and how)?

   Click here to enter text.

   ☺ Click here to enter text.

   ☹ Click here to enter text.

1.1.1.2 THE PROJECT CONSORTIUM – BUILDING THE CROSSORGANIZATIONAL TEAM

1. How do you "build" the team? (How to get from just a group of persons to an efficiently collaborating team) – examples for "team building elements"?

Click here to enter text.
☺ Click here to enter text.
☹ Click here to enter text.

2. How to you establish a "common language" and "common communication practices"? (> different industries, industry vs. research organizations or universities, different departments (financial, legal, research, production,…), different nationalities, different personalities…..) -> helping procedures, rules, tools..?
   Click here to enter text.
   ☺ Click here to enter text.
   ☹ Click here to enter text.

1.1.1.3 COMMON PROJECT GOAL

1. What is the process to align individual objectives and to define the common project goal?
   Click here to enter text.
   ☺ Click here to enter text.
   ☹ Click here to enter text.
2. How is it assured that all! project members know, understand and support the common project goal? (approved strategies?)
   Click here to enter text.
   ☺ Click here to enter text.
   ☹ Click here to enter text.
3. Do you think that the project goal has been clearly communicated to you?……….Choose an element.
   ☺ Click here to enter text.
   ☹ Click here to enter text.
4. Do you think that the project goal is/was well understood in the whole project consortium? …Choose an element.
   ☺ Click here to enter text.
   ☹ Click here to enter text.
5. Do you think that the understanding of the project goal was rising during the project work? …Choose an element.
   ☺ Click here to enter text.
   ☹ Click here to enter text.

1.1.2 How is this use case project coordinated?

Give feedback on the organizational backgrounds, the processes applied, the persons involved etc. from an institutional perspective and from a personal perspective.
In general: What is your understanding of the coordinators role? Give your personal understanding and also the general understanding in your institution of this role.

- PERSONAL PERSPECTIVE
- INSTITUTIONAL PERSPECTIVE AND TOUCH POINTS

1.1.2.1 PERSONAL PERSPECTIVE

1. What impact has the quality of coordination on the project success? How can the coordinator (the person) influence the quality of the projects outcomes? Give real examples!

   Click here to enter text.

   ☺ Click here to enter text.

   ☹ Click here to enter text.

2. How do you coordinate projects? (give main aspects of processes applied, organizational background and persons involved)

   Click here to enter text.

   ☺ Click here to enter text.

   ☹ Click here to enter text.

3. Reasons to be / not to be the coordinator of a research project?

   Click here to enter text.

   ☺ Click here to enter text.

   ☹ Click here to enter text.

4. The coordinator is the central person in the project – the heart of communication. What are beneficial communication strategies for a coordinator? (e.g. strategy to communicate with WP-leaders, or EU project officer, ….)

   Click here to enter text.

   ☺ Click here to enter text.

   ☹ Click here to enter text.

5. What skills does the coordinating person need?

   Click here to enter text.

   ☺ Click here to enter text.

   ☹ Click here to enter text.

1.1.2.2 INSTITUTIONAL PERSPECTIVE AND TOUCH POINTS

1. What are the benefits / drawbacks for an institution being the coordinator?

   Click here to enter text.

   ☺ Click here to enter text.

   ☹ Click here to enter text.

2. "Touch points" – What internal and external departments are involved in the coordination process and how is the quality of interaction with these departments? Give real examples for conflicts and also for "good quality" interaction!

   Click here to enter text.

😊 Click here to enter text.
☹ Click here to enter text.

1.1.3 How was this collaborative R&D&I project implemented?

Give YOUR EXPERIENCE from above USE CASE for the following topics:

- A GOOD START
- COLLABORATION OR COOPERATION – GET THE THINGS DONE
- MOTIVATION, TRUST AND CONFLICTS

1.1.3.1 A good start

1. How do you organize a face-to-face kick off meetings? What are the essential outcomes of a kick off meeting?
   Click here to enter text.
   😊 Click here to enter text.
   ☹ Click here to enter text.
2. How do you communicate in this phase of the project?
   Click here to enter text.
   😊 Click here to enter text.
   ☹ Click here to enter text.
3. How do you keep the project team working – keep them motivated?
   Click here to enter text.
   😊 Click here to enter text.
   ☹ Click here to enter text.

1.1.3.2 Collabortaion or Cooperation – Get things done

1. What supports and motivates the cross organizational team to collaborate efficiently? (tools, communication style, environment, incentives…)
   Click here to enter text.
   😊 Click here to enter text.
   ☹ Click here to enter text.
2. What is the nature of the use case implementation? ....Choose an element.
3. What is your strategy to be on the "collaborative way"? (strategies for communication, interaction)
   Click here to enter text.
   😊 Click here to enter text.
   ☹ Click here to enter text.
4. How do you ensure that each project member has a clear understanding of his/her role in the project, the work to be done and the results to be delivered? (strategies, rules, feedback, etc…)
   Click here to enter text.

☺ Click here to enter text.

☹ Click here to enter text.

5. **What is the role of the society in this project?** ....Choose an element.
specify "other role": Click here to enter text.

1.1.3.3 Motivation, Trust and Conflicts

1. **What trust building procedures do you use for a cross organizational team?**
   Click here to enter text.
   ☺ Click here to enter text.
   ☹ Click here to enter text.
2. **What are common conflicts in cross organizational teams and how do you overcome these conflicts?**
   Click here to enter text.
   ☺ Click here to enter text.
   ☹ Click here to enter text.
3. **How do you motivate the team?**
   Click here to enter text.
   ☺ Click here to enter text.
   ☹ Click here to enter text.
4. **What are obstacles for an open communication style within an cross organizational team – how do you eliminate these obstacles?**
   Click here to enter text.
   ☺ Click here to enter text.
   ☹ Click here to enter text.

1.1.4 How were/are the results of the use case exploited?

What happened/happens after the project's end?
Give YOUR EXPERIENCE from the USE CASE for the following topics:

- PROJECT END – END OF COLLABORATION?
- SUCCESSFULLY EXPLOITED?

1.1.4.1 Project End – End of Collaboration?

1. **How do you end the project? (communication and actions in this phase of the project)**
   Click here to enter text.
   ☺ Click here to enter text.
   ☹ Click here to enter text.
2. **What are beneficial procedures to further use the project results AND the synergies of collaboration after the projects end?**

Click here to enter text.

😊 Click here to enter text.

☹ Click here to enter text.

1.1.4.2 Successful Exploitation

1. What are the main drivers for successful exploitation of the project results?

   Click here to enter text.

   😊 Click here to enter text.

   ☹ Click here to enter text.

2. How is successful exploitation ensured during/after the project?

   Click here to enter text.

   😊 Click here to enter text.

   ☹ Click here to enter text.

1.1.4.3 Behavioural outcomes and impacts

1. Has the innovative behaviour of the other actors changed and how? ....Choose an element.

   Click here to enter text.

2. Have practices been established to overcome bottlenecks and which? ....Choose an element.

   Click here to enter text.

3. How would you estimate the sustainability of the common project activities after the project end? ....Choose an element.

4. How would you estimate the knowledge build-up during the project? ....Choose an element.

5. Has the number of project partners changed since the project end? ....Choose an element.

6. Has the number of projects changed since this project finished? ....Choose an element.

7. Has the size of the competence network increased? ....Choose an element.

1.1.5 How was the communication within the project structured?

Give YOUR EXPERIENCE from the USE CASE for the following topics:

1.1.5.1 Tools/Software and Usability

1. Which communication tools are used within the project team how would you rate their usability?

   Click here to enter text.

   😊 Click here to enter text.

   ☹ Click here to enter text.

2. Who decides which tools are used?

   Click here to enter text.

☺ Click here to enter text.

☹ Click here to enter text.

3. **Do you think that the used tools were useful?** .... Click here to enter text.

   ☺ Click here to enter text.

   ☹ Click here to enter text.

4. **Which tool would have preferred instead?**

   Click here to enter text.

5. **How would you rate the user friendliness of the communication tools used within the project team?**

   Click here to enter text.

   ☺ Click here to enter text.

   ☹ Click here to enter text.

1.1.5.2 Communication

1. **Which communication channels do you use for networking activities and to build up new initiatives, especially on funded R&D projects? Please assess their importance?**
   1. **Conferences** .... Choose an element.
   2. **Fares** .... Choose an element.
   3. **Memberships** .... Choose an element.
   4. **Social Media** .... Choose an element.
   5. **Outreach events (scientific, educational, public):**

      please specify .... Choose an element.
   6. **Webinars** .... Choose an element.
   7. **Publications in Industry Media** .... Choose an element.
   8. **Scientific Publications** .... Choose an element.
   9. **Innovation Ecosystem (e.g. automotive cluster)** .... Choose an element.
   10. **Brokerage Events** .... Choose an element.
   11. **Educational Activities:** Choose an element. .... Choose an element.
   12. **Others:** Choose an element. .... Choose an element.

5.6.2 Appendix B

Social Aspects

Interpersonal Relationship [SAIR]

001 Meet project team members in person

002 Physical distance between partner organization(s)

003 Interpersonal skills of project team members

004 Personal compatibility of project team members

005 Team building session in Face2Face meeting(s)

006 Opportunity for informal conversation in Face2Face meetings

007 Common project culture (beliefs, attitudes, and behaviours in a project)

008 Size of each partner's project team

Trust & Motivation of Persons [SATM]

009 Appropriate work distribution among project team members

010 Honourable behaviour

011 Responsible behaviour

012 Respectful communication

013 Incentives for fairness in the working environment

014 Honesty

015 Acceptance of individual work styles

016 Alignment of individual objectives with project's objectives

Communication Aspects

Communication Methods & Tools [CACMT]

017 Roundtable/Subgroups of domain experts

018 Email

019 Conference calls

020 Phone calls

021 Video calls

022 Face2Face meeting(s)

023 Online collaboration tools

024 Chat tools

025 Glossary on technical terms

026 Central platform for project documents

Communication Procedures & Characteristics [CACPC]

027 Training on software and tools

028 Versioning of project documents

029 Effective handling of software & tools

030 Usability of online collaboration tools

031 Usability of communication tools

Organization of Communication [CAOC]

032 Adapt frequency of meetings (online and offline) depending on condition and phase of project

033 Alignment of communication medium with purpose

034 Definition of communication rules

035 Adapt communication to condition and phase of project

036 Regularity of Face2Face meetings

037 Interactive/conversational kick-off meeting

038 Regularity of coordination calls

039 Bilateral Face2Face meetings

040 Communication exclusively in one language

041 Timely circulation of Minutes of Meeting

042 Circulation of meeting agendas before meetings

043 Consideration of cost of communication (transaction cost)

044 Selection of appropriate communication tool

045 Selection of appropriate communication methods

046 Coordinator decides on communication structure in agreement with partners

047 Coordinator decides on communication tools in agreement with partners

Implementation of Communication [CAIC]

048 Request instant feedback to avoid misunderstandings

049 Immediate resolving of misunderstandings

050 Stimulation of open communication (e.g. share hidden agendas)

051 Define rules concerning responsiveness of partners

052 Possibility of sharing thoughts, opinions and doubts

053 Balance between agenda and meeting duration

Continuous Flow of Information [CACFI]

054 Continuous sharing of information about next steps in project

055 Continuous highlighting and sharing of emerging problems

056 Ad hoc sharing of open questions

057 Involvement of whole consortium for problem solving

058 Continuous information about decisions

059 Regular project status updates

060 Ongoing distribution of project outcomes in consortium

061 Regular bilateral communication between partner and project coordinator

062 Continuous publication of project results on internal platform

Management Aspects

Project Organization [MAPO]

063 Establish a cooperation manager for strategic tasks

064 Establish a communication manager for administrative and/or proposal tasks

065 Establish a technical/scientific lead

066 Precise definition of interfaces between partners

067 Split project into administrative, strategic and technical/scientific part

068 Project timeline available before kick-off meeting

069 Define quality criteria for project outcomes

070 Agreement on common timeline

071 Install subgroups on specific topics

072 Transparent organizational structure of the project

Project Execution [MAPE]

073 Strict meeting of deadlines

074 Responsible person actively pushes partners on meeting the deadlines

075 Continuous quality check of project outcomes

076 Continuous risk assessment

077 Continuous cost controlling

Decision-making [MADM]

078 Collective decision-making in coordination meetings

079 Preference for democratic decisions within consortium

080 Project coordinator takes final decisions in case of disagreement

081 Adaption of decision-making process during project according to project status

Management Methods & Tools [MAMT]

082 Consider aspects of inter cultural management

083 Active and adaptive Risk Management

084 Consider aspects of diversity management

085 Definition of one responsible person per partner

086 Adaption of project plan if required

087 Hold debriefing meetings

088 Detailed Work Breakdown Structure

Capabilities and Skills of Project Coordinator [MACS]

089 Technical knowledge of project topic

090 Expertise in the project topic

091 Visibility in the project

092 Knowledge of communication tools

093 Communication skills

094 Conflict resolution and mediatorial capabilities

095 Knowledge of funding application process

096 Expertise in coordinating projects

097 Motivation skills

098 Conviction on project topic

099 Ability to adapt management style

100 Commitment to project

101 Responsiveness

102 Time-management skills

103 Flexibility to adapt to changing environment and conditions

104 Global view on project

105 Diplomatic skills/neutral behaviour

106 Goal-orientation

107 Project Coordinator is responsible for exclusively one project

Strategic Aspects

Project Scope [SAPS]

108 Alignment of consortium’s research interests and call topics

109 Precisely define scope of initial idea

110 Illustrate entire project in one picture

111 Create user story for common understanding

112 Initial Idea provided by Coordinator

113 Crystallize project idea(s) in core team

114 Crystallize project idea(s) in consortium

115 Communicate clear project idea to partners

116 Iterative approach for elaborating on project scope

117 Democratic development of project scope

118 Elaboration of the relation between project scope and state-of-the-art

119 Alignment of project scope with partners' competences

120 Consensus between core team partners on project scope

121 Consensus between all consortium partners on project scope

122 Build common ground in consortium regarding project scope

123 Establish a shared vision in consortium

124 Consortium shares a clear project idea before kick-off meeting

125 Hiring an external project proposal consultant

Project Objectives [SAPO]

126 Collective development of project objectives

127 Interactive formulation of common project objectives

128 Alignment of project objectives in Face2Face-meetings

129 Quantification of objectives

130 Common understanding of project mission

131 Alignment of project objectives and call topics

132 Common agreement on project’s objectives beyond state-of-the-art

Building the Consortium [SABC]

133 Integration of partners known from existing network(s)

134 Integration of new partners

135 Type of coordinating organization (Academia, Industry, RTO)

136 Inclusion of partner(s) from different domain(s)

137 Size of partner organizations

138 Avoid partners being rivals in business

139 Corporate structure of partner organization(s)
140 Project budget of partner organization(s)
141 Experience of organization in cross-organizational projects
142 Infrastructure and resources brought in by organization(s)
143 Clear definition of partner's role in consortium
144 Partners complement each other
145 Management of expectations of individual partners
146 Number of partners in consortium
147 Elaborate on partner's benefits of project participation
148 Commitment of partner organization
149 Composition of core team

Strategy of Individual Partners [SAIP]

150 Establishment of new partner network(s)
151 Access to new technologies
152 Access to innovative research
153 Access to partners' knowledge
154 Access to new customers
155 Leveraging partner's research interests
156 Innovation potential of project outcomes
157 Match of call topics with organization's interests
158 Risk-minimization as a result of funded project(s)

Strategy of Coordinating Partner [SACP]

159 Strategic interest of coordinating organization
160 Coordinating organization controls strategic direction of project
161 Coordinating organization orientates content of project
162 Coordinating organization provides drafts on project scope for initiating discussion

Cross-Organizational Relationship [SACR]

163 Set up a nondisclosure agreement (NDA)
164 Consortium Agreement (CA) between all partners
165 Facilitate bi-/multilateral knowledge transfer
166 Partner's influence in project depends on size
167 Work distribution among partners
168 Number of partners in consortium
169 Level of knowledge/competencies/qualification of partners
170 Promoting Open Innovation activities in consortium

Dissemination & Exploitation [SAEX]

171 Promote project externally
172 Plan exploitation of project right from the start of the project
173 Alignment of partner's individual exploitation and partner's individual strategic interests
174 Alignment of partner's individual exploitation with consortium's exploitation strategy

175 Definition of external communication channels

176 Exploitation of project outcomes individually by partners

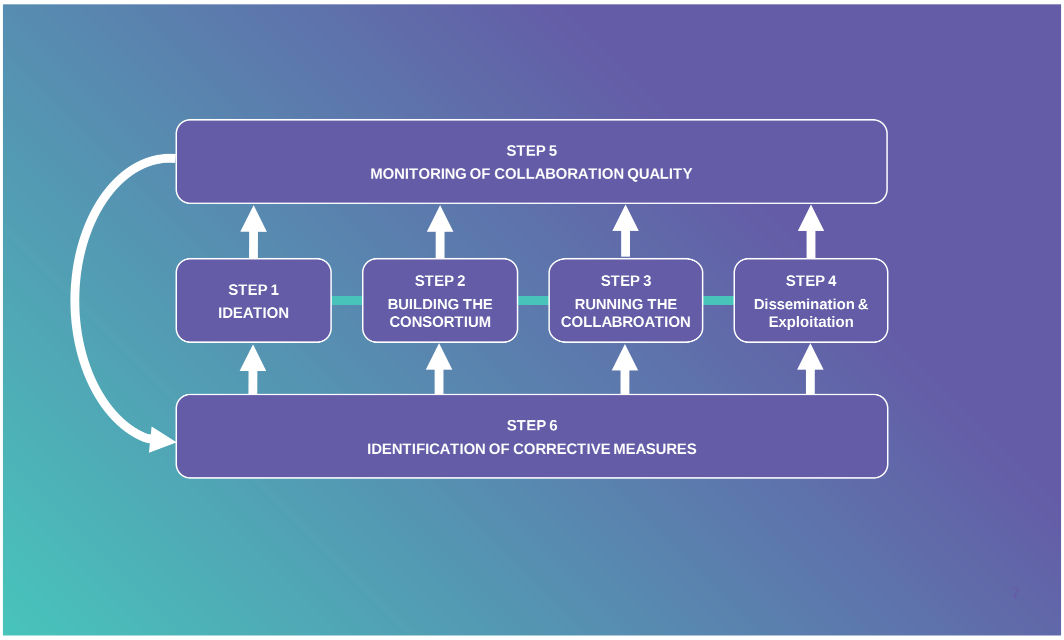
177 Integration of external stakeholder(s) in project

178 Access to project results for all partners

5.6.3 Appendix C

COLLABORATIVE R&D&I

Process overview



COLLABORATIVE R&D&I

STEP 1

Ideation

- Develop a clear project idea within a small core team
- Find a consensus between core team partners on project scope
- Communicate project idea to other partners
- Ensure a common understanding of project mission
- Align project objectives and research goals (e.g. call topics)

MAIN ACTORS

- Coordinator
- Initial Core Team Partners

ENABLING ELEMENTS

- Creativity Techniques (e.g. Brainstorming)
- One-Page-Proposal
- Graphical Representation of Idea
- continuous communication: frequent conference calls

CHALLENGES & TIPS

- Form an agile core-team of domain experts (max. 3-5) to effectively develop the idea
- A very clear graphical representation of the project idea is useful
- A One-Page-Proposal facilitates the communication of the idea

STEP 1 — STEP 2 — STEP 3 — STEP 4 — STEP 5 — STEP 6

8

COLLABORATIVE R&D&I

STEP 2

Building the consortium

- Ensure that partners complement each other
- Get the commitment of partner organisations
- Clearly define the partner's role in consortium
- Compose an adequate core team
- Build/maintain trust & motivation among in the consortium
- Build common ground in consortium regarding project scope

MAIN ACTORS

- Coordinator
- Core Team Partners

CHALLENGES & TIPS

- Reflect on how the partner's expertise will be combined to address the project's objectives
- Consider level of knowledge, competencies and qualification of partners
- A legal basis is necessary to build trust among partners (e.g. CA; NDA)
- Maintain the commitment of partners: e.g. constant access to project results. explicit individual exploitation plan /added value

ENABLING ELEMENTS

- Conference Calls
- Face2Face meetings
- Develop a „Map of Expertise“
- Draft of Consortium Agreement (CA)
- IPR principles
- Draft of exploitation plan

STEP 1 — STEP 2 — STEP 3 — STEP 4 — STEP 5 — STEP 6

9

COLLABORATIVE R&D&I

STEP 3

Running the collaboration

Science2Society

- Stimulate Trust and Motivation of persons
- Choose a proficient project coordinator
- Maintain a good cross-organisational relationship
- Use appropriate communication tools with good usability
- Ensure a continuous flow of information (decisions, project status, problems)
- Force immediate resolution of misunderstandings

MAIN ACTORS

- Coordinator
- Core Team Partners
- All partners

CHALLENGES & TIPS

- Foster responsible behaviour, honesty, respectful communication and honourable behaviour
- Meet project team members in person
- Ensure a full commitment of the project coordinator to the project – he/she has immense impact on the project success
- Project Coordinator needs a good conflict resolution and mediatorial capabilities, responsiveness and good project management skills
- Know and respect individual working styles and personalities
- Perform interactive and conversational meetings

ENABLING ELEMENTS

- Face2Face meeting
- Social events
- Conference calls
- Email
- Online Collaboration Tools
- Definition of one responsible person per partner
- Transparent organisational structure of project

STEP 1 — STEP 2 — **STEP 3** — STEP 4 — STEP 5 — STEP 6

10

COLLABORATIVE R&D&I

STEP 4

Dissemination & Exploitation

Science2Society

- Ensure access to project results for all partners
- Plan exploitation of project right from the start of the project
- Define external communication channels
- Promote your project externally

MAIN ACTORS

- Coordinator
- Core Team Partners
- All partners

ENABLING ELEMENTS

- Online Collaboration Tools
- Open Innovation Platforms
- Exploitation Plan
- Dissemination Plan
- Social Networks
- Conferences
- Journals

CHALLENGES & TIPS

- Making use of online collaboration tools facilitates the dissemination of detailed results
- Keep the exploitation plan updated during the whole project
- Open Innovation Platforms help to disseminate the project's results

STEP 1 — STEP 2 — STEP 3 — **STEP 4** — STEP 5 — STEP 6

11

COLLABORATIVE R&D&I

STEP 5

Monitoring of collaboration quality

- Use the survey template from Science2Society to gain insights into the satisfaction level of your collaborative project
- Translate the satisfaction levels into a KPI for measuring the collaboration quality

MAIN ACTORS

- Coordinator
- Core Team Partners
- All partners

ENABLING ELEMENTS

- Survey Template
- Template to calculate KPI

CHALLENGES & TIPS

- Let a neutral/external person perform the interviews to gather project feedback

STEP 1 — STEP 2 — STEP 3 — STEP 4 — **STEP 5** — STEP 6

12

COLLABORATIVE R&D&I

STEP 6

Identification of corrective measures

- Use DOS AND DONTS to identify actions improving the satisfaction level of your collaborative project

MAIN ACTORS

- Coordinator
- Core Team Partners
- All partners

ENABLING ELEMENTS

- Document containing DOS AND DONTS

CHALLENGES & TIPS

- Satisfaction level as key success factor for successful collaborative interaction

STEP 1 — STEP 2 — STEP 3 — STEP 4 — STEP 5 — **STEP 6**

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5.6.4 Appendix D

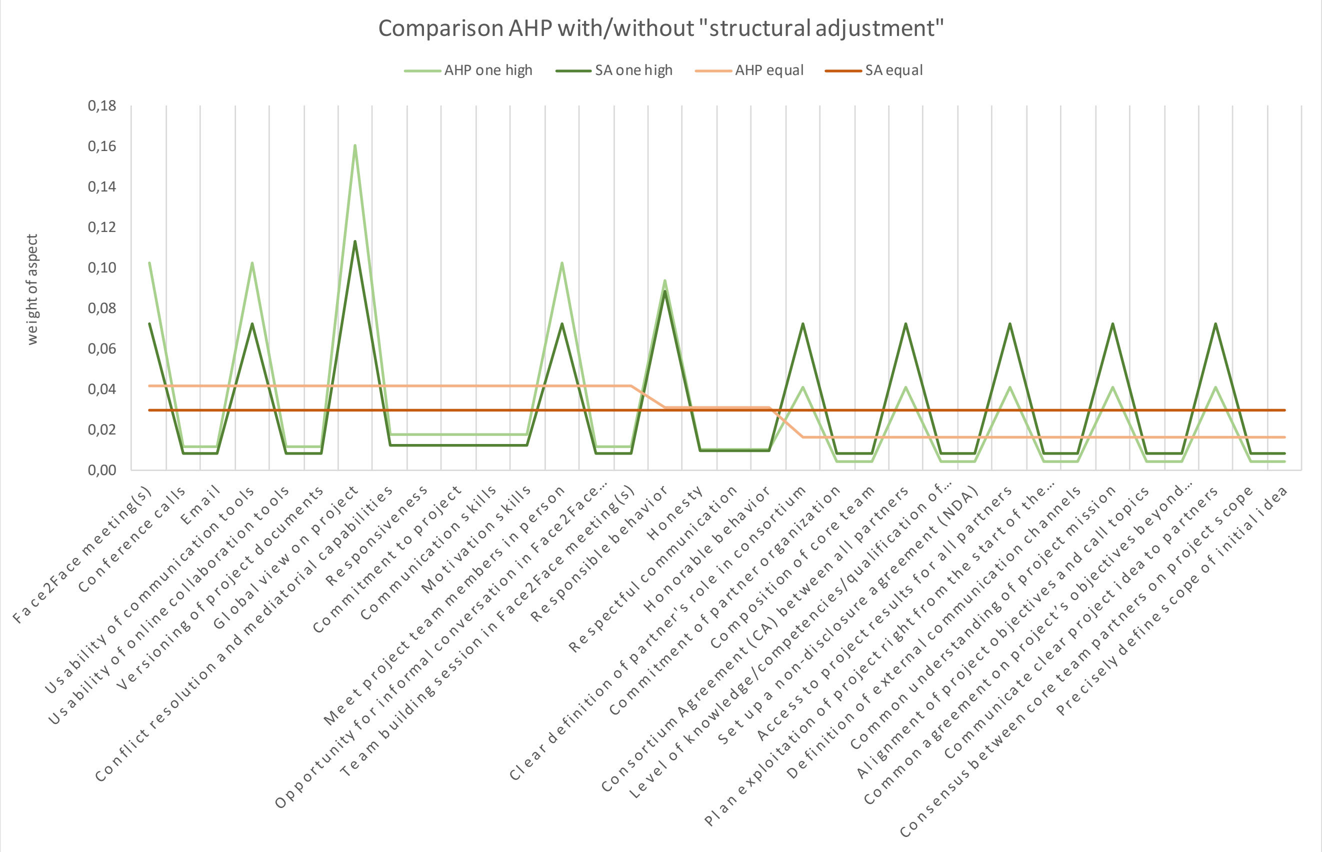

Figure 26: Comparison of AHP with/without “structural adjustment” (SA) based on fictious data

5.6.5 Appendix E

Table 6: Rank importance of aspects from the AHP process including structural adjustment – full hierarchy

Level 0 – Groups	Level 1 -Subgroups	Level 2 -Aspects	
Communication	Communication Methods & Tools	Face2Face meeting(s)	1
Strategic	Project Objectives	Common understanding of project mission	2
Strategic	Cross-Organizational Relationship	Level of knowledge/competencies/qualification of partners	3
Communication	Communication Procedures & Characteristics	Usability of communication tools	4
Strategic	Building the Consortium	Clear definition of partner's role in consortium	5
Management	Capabilities and Skills of Project Coordinator	Communication skills	6
Management	Capabilities and Skills of Project Coordinator	Commitment to project	7
Strategic	Building the Consortium	Composition of core team	8
Strategic	Project Objectives	Alignment of project objectives and call topics	9
Management	Capabilities and Skills of Project Coordinator	Global view on project	10
Social	Trust & Motivation of Persons	Responsible behavior	11
Strategic	Project Objectives	Common agreement on project's objectives beyond state-of-the-art	12
Strategic	Project Scope	Communicate clear project idea to partners	13
Communication	Communication Methods & Tools	Email	14
Social	Trust & Motivation of Persons	Respectful communication	15
Communication	Communication Procedures & Characteristics	Versioning of project documents	16
Social	Trust & Motivation of Persons	Honesty	17
Strategic	Building the Consortium	Commitment of partner organization	18
Management	Capabilities and Skills of Project Coordinator	Conflict resolution and mediatorial capabilities	19
Management	Capabilities and Skills of Project Coordinator	Responsiveness	20
Communication	Communication Procedures & Characteristics	Usability of online collaboration tools	21
Strategic	Cross-Organizational Relationship	Consortium Agreement (CA) between all partners	22
Strategic	Project Scope	Consensus between core team partners on project scope	23
Strategic	Project Scope	Precisely define scope of initial idea	24
Communication	Communication Methods & Tools	Conference calls	25
Management	Capabilities and Skills of Project Coordinator	Motivation skills	26
Strategic	Cross-Organizational Relationship	Set up a non-disclosure agreement (NDA)	27
Social	Interpersonal Relationship	Meet project team members in person	28
Social	Trust & Motivation of Persons	Honorable behavior	29
Social	Interpersonal Relationship	Opportunity for informal conversation in Face2Face meetings	30
Social	Interpersonal Relationship	Team building session in Face2Face meeting(s)	31

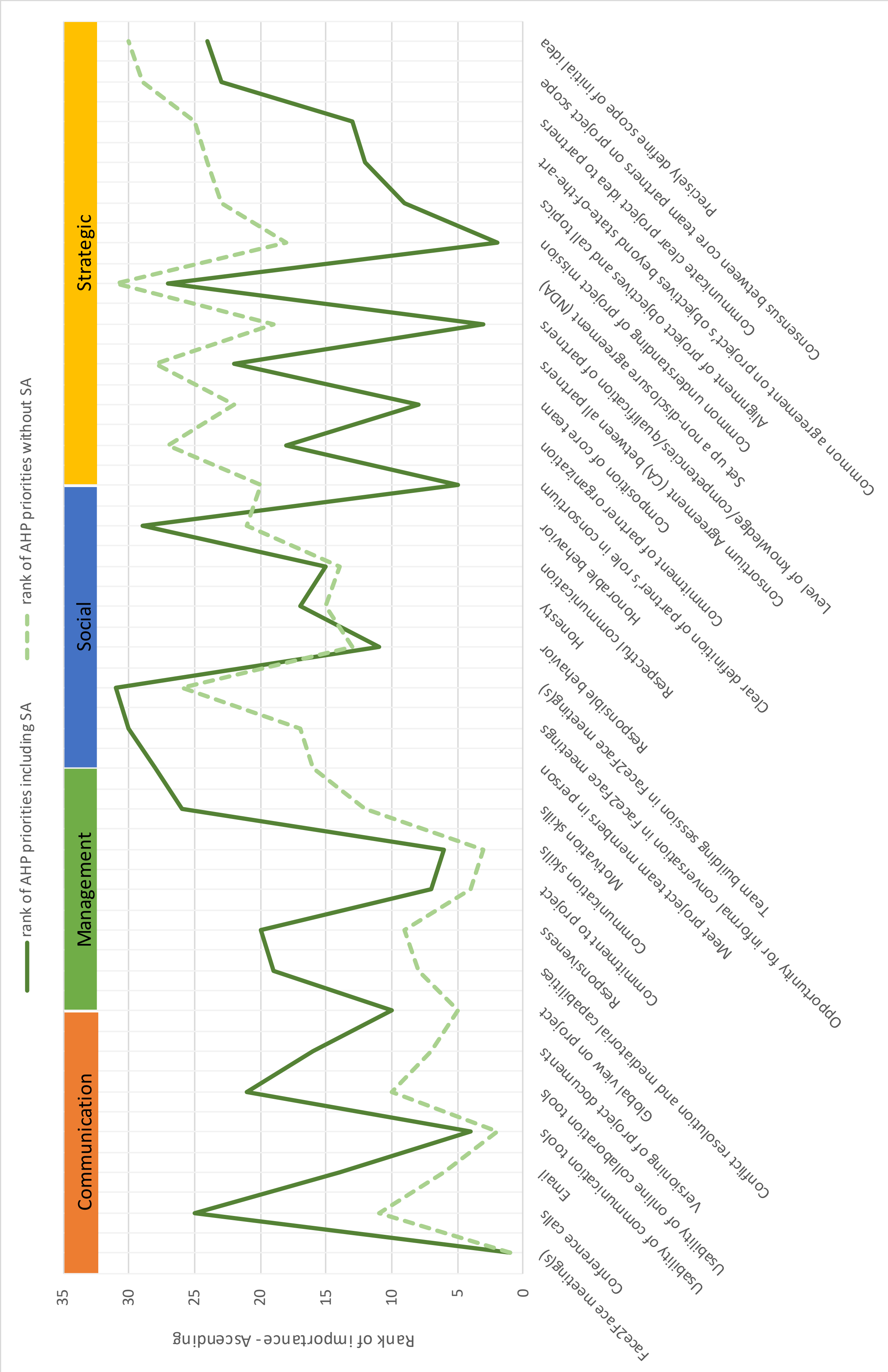

Figure 27: Rank of importance of aspects from AHP process – graphical representation

6 PILOT 4: INTER-SECTORAL MOBILITY AS AN ENABLING TOOL FOR OPEN INNOVATION/SCIENCE

Executive Summary

Inter-sectoral mobility (ISM), the physical temporary mobility of researchers from one sector (academia, research industry, social sector or industry) to another sector and return mobility back to the original sector, is a well-known **tool to foster collaboration between sectors**, e.g. academia and industry. This pilot focuses specifically on ISM as key enabler for open innovation. Through a series of stakeholder interviews, programme reviews, compilation of guidelines and validation of these guidelines in running ISM projects a set of recommendation is derived.

ISM can be a key enabler for open innovation and therefore easily conflicts with traditional (IP focused) innovation approaches and administrative procedures. The success of ISM will be driven by the people and their attitude (personal connections), but this attitude is heavily steered by the organisational culture and can be facilitated by the existence of agreements between organisations (organisational connections). Governmental funding schemes often act as a catalyst to grow open-innovation ecosystems by lowering the (financial) barriers to engage in ISM and by, in some cases, setting guidelines for the interaction intensity and knowledge sharing. The strong dependency on existence of both personal and organisation links, explains the importance of adapting to local habits and explains the wide variation and scatteredness of ISM schemes.

The most common bottlenecks found for ISM are confidentially and IP strategies together with the lack of culture of collaboration, the difference in time horizon between industry and academia, lacking the right network and channels to set-up collaboration, especially for smaller SMEs, and the preparation effort for proposals.

To **facilitate (the initiation of) ISM** it helps to have people around the table that were inter-sectoral researchers themselves to increase mutual understanding, have fixed administrative and contractual procedures or have a playbook for ISM, comprising welcome procedures, collaboration scripts and IP templates. Furthermore, from an organisation perspective, it helps to build a culture of collaboration and educate researchers with respect to IP and collaboration such they know what they can share. It should also be remembered that ISM collaborations are continuously evolving and can be boosted by out of the box thinking and continuously trying novel approaches, but always with clear IP and administrative agreements.

ISM is often also a part of strong interwoven relationships with universities as part of a joint innovation DNA or ecosystem. Therefore **it is encouraged to go for gradual approaches to build this joint innovation DNA**: start small and build trust with low risk, short term research, such as student internships or master theses and gradually built towards a higher risk long term collaborations. Combine connections on individual level and build bridges on institutional level (alliances, base funding, …).

From a government perspective, the hurdle to start ISM projects can be furthered lowered by **reducing risk** for single projects with low level entry fees for the start of research, but gradually increasing fees when the research becomes more tangible or by **easing administrative loads by setting up focused framework agreements** for groups of companies, such as SMEs in a sector, and make templates available as starting point for discussions on administration issues.

The approaches resulting from this pilot lead to both improved ISM through faster project set up by reduced administrative loads and easier project negotiations through risk spreading as well as improved innovation by better collaboration and by building a research DNA through stepwise increasing intensity of collaborations.

6.1 Introduction to the pilot

Inter-sectoral mobility (ISM) is defined as “the physical (temporary or permanent) mobility of researchers from one sector (academia in particular) to another (industry in the first place, but other sectors of employment as well) and return mobility from industry/other sectors back to academia” [4.1]. This pilot investigates industry-RTO-academia mobility as a key mechanism to transfer knowledge and create inter sectoral collaboration and hereby focusses on mobility cases in which the mobile person returns to his/her host institute.

ISM can be implemented in a wide range of manners and can be supported in various ways by governments at different levels (European, national, regional or local). Sometimes, however, no public intervention is in place and ISM evolved organically on its own. For example in Germany, there is intensive cooperation between universities, a dense network of research institutes and industry both in regional clusters and on a national level without any major national-level publicly supported ISM schemes in place [4.2].

At the European level, the European Commission (EC), sees ISM not as a goal in itself, but as an instrument to resolve the “European Paradox”, i.e. that Europe is unable to sufficiently turn research results into globally competitive products [4.3]. ISM at the same time adds to the employability of and career development for researchers and is a tool to train the innovation leaders of tomorrow, required in the knowledge economy. Multiple reports with respect to mobility of researchers and the evaluation of ISM can be found, for example on Euraxess.

- The More 1 (2010), 2 (2013) and 3 (2017) ‘studies on mobility patterns and career paths of EU researchers‘ focusses on providing internationally comparable data, indicators and analysis in order to support evidence-based policy development on the research profession at European and national level. As such it clearly focusses on the mobile researcher and the impact on the researcher’s carrier.
- ‘Mobility of Researchers between Academia and Industry – 12 practical recommendations (2006)’ is a report that gathers best practices and guidelines based on reports of four expert groups on ‘knowledge and skills development‘, ‘career appraisal‘, ‘remaining legal and administrative obstacles to mobility‘ and ‘structure initiatives‘.
- ‘Study on Fostering Industrial Talents in Research at European Level (2018)’ is a study that focusses on the identification and analysis of examples of ISM at international, national, regional and sectoral levels and also investigates more broadly the framework conditions and key enablers that help to support and encourage ISM.

The goal of this pilot is to derive guidelines and best practices to boost inter-sectorial mobility of researchers as key enabler for open innovation by fully exploiting on the potential of inter-sectorial mobility programmes. The design and implementation of inter-sectoral mobility programmes can still be improved, lowering barriers and removing overhead bottlenecks, to allow beneficiaries to fully leverage on the inherent potential of bringing cooperating people from a different sector together. Therefore this pilot activity within S2S and presented in this report complements previous works in that is specifically targets the enabling aspects for open innovation, whereas most previous studies focus on the (enabling elements of) training of innovative researchers. Nevertheless, valuable lessons are learned from previous reports.

The degree to which the current inter-sectoral mobility programmes enable open innovation is analysed through one-on-one interviews with stake-holders in a set of past and current ISM programmes (EU/national/regional). Collection of past experiences from both the different parties involved in the programmes as the same parties in different stages of the programme, allow to compile bottlenecks and facilitators for open innovation. The pilot brings together a unique mixture of cross-sectoral, cross-regional, cross-programme and cross-cultural experiences, all feeding into open innovation guidelines for future programmes and best practices on

- how to initiate, facilitate and reward staff mobility;
- how to deal with barriers and overhead bottlenecks;
- how to profit from staff mobility as individual and organization;
- how to further improve on existing staff mobility programmes.

To validate the guidelines, a part of the guidelines are applied in pilot-cases. **Figure 28** gives a schematic overview of the activities in this pilot.

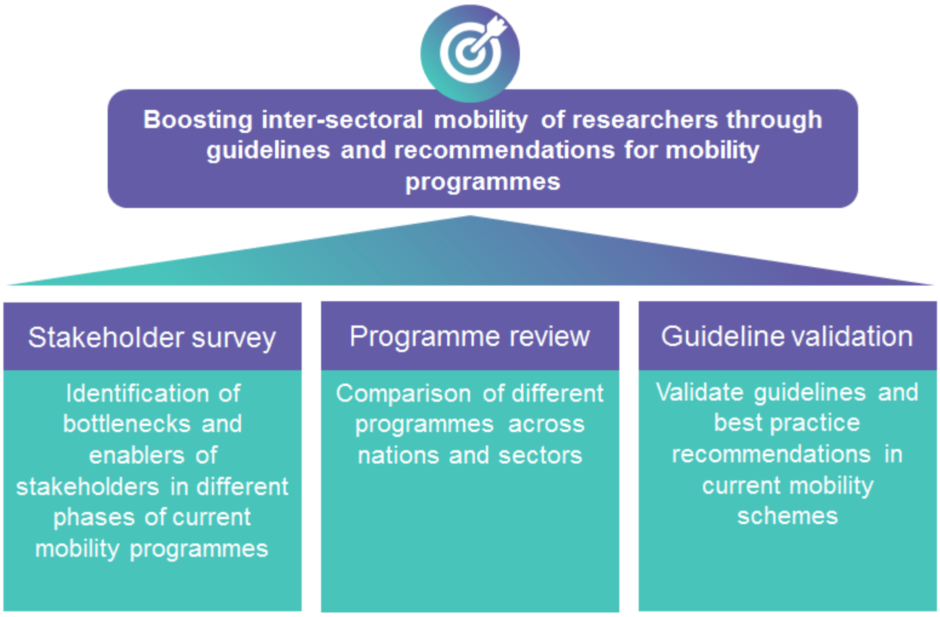

Figure 28: Main objectives of Pilot #4

6.2 Description of the Open Innovation Scheme

ISM leads to open innovation benefits such as increased efficiency of knowledge circulation, increased knowledge build up and training in innovation behaviour and is as such known to be an enabler for Open Innovation/Science [4.4]. This section describes the roles of ISM in the open innovation paradigm, the benefits it brings and the schemes most commonly applied.

The open innovation model conceptualises innovation as a non-linear and fluid process instead of linear process, e.g. a process taking the fixed stages universities producing knowledge, transfer to industry and product innovation by industry. In the open innovation model, the different actors share different roles and as such private actors co-create knowledge with public sector researchers and public sector researchers bring innovation to products together with private actors. This leads to an innovation ecosystem with shared knowledge and ISM plays a crucial role in tackling the hurdles related to integration of knowledge and skills between different sectors [4.5][4.6].

Modern innovation processes require firms to master highly specific knowledge about different users, technologies, and markets. Research results strongly suggest that searching widely and deeply across a variety of search channels can provide ideas and resources that help firms gain and exploit innovative opportunities. However, 'over-search' may hinder innovation performance due to, amongst others, high costs and dissipation of search efforts over too many channels [4.7][4.8]. ISM can alleviate this search problem by bringing people with specific knowledge to a setting of market and user knowledge or vice versa. Furthermore, ISM facilitates similarity of knowledge bases: research on growth of spin-off companies shows that both too small and too great a knowledge overlap hinders growth, the first because limited knowledge overlap hinders knowledge assimilation and the second because great knowledge overlap hampers the creation of novel knowledge combinations [4.9].

ISM schemes or 'interaction mechanisms' come in various forms but always one or more researchers spend a limited period of time in other sector in order to gain sector-specific experience and share research expertise. Governments often take a facilitating role to promote ISM by (partially) funding this placement of researchers. The motivation for this government support are driven by, amongst others, the improvement of knowledge access for private companies, researchers' employability, increasing the commercial perspective of researchers and increasing the role of the region in the knowledge economy.

There are multiple examples of existing staff mobility schemes that exist and in most member state of the European Union some dedicates ISM schemes exist, although there are some gaps in country coverage. For example, a number of smaller countries both within the EU-28 and in associated countries do not have any dedicated formal ISM schemes (e.g. Malta), but informal mobility and EU schemes offer alternative mobility opportunities in these countries [4.10]. Two examples, which also are investigated within this pilot, are the MSCA actions and the Baekeland-mandates. Both programmes are aiming at innovation through inter-sectoral staff exchange, the first on a European level, the second on a regional level and different initatives exists in different regions: e.g *CIFFRE* in France or *Doctorats Industrials* in Catalonia.

Marie Sklodowska-Curie actions (MSCA):

> There are grants which encourage transnational, inter-sectoral and interdisciplinary mobility for all stages of a researcher's career, from PhD candidates to highly experienced researchers. Endowing researchers with new skills and a wider range of competences, while offering them attractive working conditions, is a crucial aspect of the MSCA. In addition to fostering mobility between countries, the MSCA also seek to break the real and perceived barriers between academic and other sectors, especially industry. Prime focus in pilot 4 will be on the MSCA initiatives that promote the involvement of industry in doctoral and post-doctoral research such as the Research networks (ITN) and Research and Innovation Staff Exchanges (RISE) [4.11].

Baekeland-mandates:

> Baekeland mandates are personal grants of the Flemish government to support basic research in collaboration between a university and a company that – if successful – has clear economic objectives and offers added value to the company involved in the project. However, the research should be directed towards achieving a doctorate (PhD) diploma and meet the accepted criteria for doctoral research. In other words, the project should fit within strategic basic research with an economic finality, defined as high quality research that is innovative and provides the PhD student with ample intellectual properties. It aims to build up scientific or technological knowledge as a basis for economic applications [4.12].

Besides the governmental funded schemes, also bilateral schemes directly between academia and industry without governmental support exist. Also examples of these schemes are investigated in this pilot.

6.3 Implementation of the pilot

The implementation of the pilot[17] is visualised in Figure 29 and the steps were outlined in deliverable 3.1.

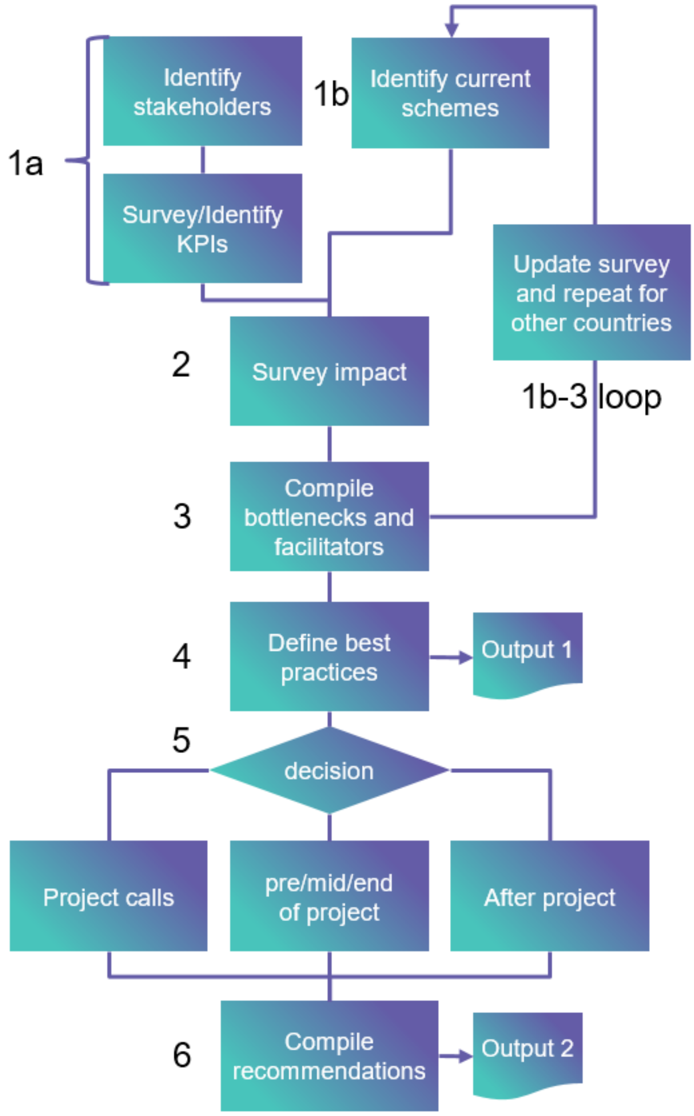

Figure 29: Implementation process of Pilot #4

Step 1-3 comprised stakeholders surveys and with these surveys, representatives of the four core groups were reached (Industry, RTOs, Academia and governmental agencies). Actors of both the core teams, the ISM researchers and its collaborators and supervisors, as well as the support team (legal, HR, finance) were surveyed. In total over 27 respondents were surveyed in depth, spanning over 9 companies, 3 research centres and 4 universities. The stakeholders were involved in various kinds of schemes (European, National, Regional and bilateral).

Besides surveys of stakeholders and people in support functions, an in depth analysis was done on two specific cases:

- The dual desk PhD practice implemented between SISW and KU Leuven which is an open innovation best practice which can be supported due to various ISM schemes.

[17] A.o. the following researchers actively contributed to the implementation of Pilot 4: Claus Claeys, Bert Pluymers, Wim Desmet, Luis Zapata, Ali Kadar, Antonio Ammirati, Dennis Janssens, Emin Inci, Maria Gracia, Matteo Kirchner, Philip Becht, Rocco Adduci, Sjoerd van Ophem, Herman van der Auweraer, Henri Karhula, Giorgio Pulverenti, Fabien Chauvicourt, Xueji Zhang, Davide Giorgoretti

- The regional Baekeland PhD programme: an industrial PhD schemes in which the the PhD researchers is mobile between industry and academia.
- An analysis of the collaboration between the university of Leuven and Siemens Industry Software.

Based on the surveys a list of bottlenecks, facilitators and KPIs was compiled (step 4), the complete list can be found in appendix 6.6.1 to this chapter, and the best practices derived. Next the guidelines were validated through a series of test cases (step 5) after which the final recommendation are compiled and disseminated (step 6). The next two subsections discuss further on the validation and dissemination steps.

6.3.1 Validation of guidelines in piloted test case

Based on the lessons learned, several test cases were piloted to validate the best practices and fine-tune the guidelines.

Entrepreneurial skill training in Marie Curie Sklodowska training networks from different projects

Based on the often heard complaints in the survey lack of skill of collaboration, lack of understanding of industry mind set by academic partners and lack of insight in IP leads to people that are afraid to share data, an entrepreneurial skill training for Marie Curie inter-sectoral mobile researchers was organised. In this training, 46 ISM researchers spend three days at one location during with lectures, testimonials and hands on do-sessions on topics as Innovation management, IP management, Business modelling, Technology Marketing and Setting up a business plan. The complete agenda can be found in the appendix 6.6.3.

Setting up bilateral PhDs with Automotive OEMs and Tier1 companies based on the lessons learned from the surveys.

The importance of template agreements for fast IP negotiation was underlined in multiple interview. Therefore, an IP portfolio was built which can be used for different cases, depending on who owns the IP, the degree. This usefulness of this IP portfolio was validated during the set-up of different collaborations for joint PhDs with OEMs and Tier1 companies and proofed to lead to a fastened convergence during IP negotiations.

Implementing best practices from the surveys in setting up a new project with a multinational with a division in Flanders.

The best practices of the interviews were applied in setting up a joint PhD with a multinational with a local division in Flanders. The connection with this company was made at an international matchmaking event at which universities and companies introduce their solutions and needs respectively. While the discussion was ongoing for a joint PhD trajectory, small consultancy projects were performed for the company in order to build trust and get to know each other. The company representative during the discussion, has a PhD himself, facilitating the discussion and the understanding of the university viewpoints in the discussion. Furthermore, the IP templates were used to set-up the IP agreement between both parties.

Improving guiding MSCA fellows and Baekeland PhD students, with a focus on the guiding of research in case of joint supervision.

Collaboration scripts were proposed as KPI of good open innovation ISM. Therefore, in the newly started PhD positions both within a MSCA network as in a Baekeland programs with supervisors from different organisations, a script for collaboration was agreed upon from the onset of the PhD trajectory. In this project, a monthly two-hour conference call with the mobile researchers and both supervisors is foreseen, as well as one face to face meeting every 6 months.

Welcome procedure including buddy system

A welcome system was implemented in which, besides the official welcome procedure of the university, a script was developed of arrangements that have to be made by certain dates with respect to the first arrival of the mobile researchers. The steps include: arranging a desk-space and laptop, arranging meetings with supervisors and assigning a buddy. The buddy is a peer who acts as a first point of contact for the mobile researcher in cases of question on procedures or how things are done in the organization. A summarised version of the procedure can be found in the appendix 6.6.4.

6.3.2 Dissemination of the survey results

Presentation, publications and posters

The key learning of the dual desk PhD researchers and the Baekeland PhD programme case, were compiled in best practice cases on the Science2society knowledge database. Furthermore the dual desk PhD case was disseminated through a presentation at the UIIN 2018 conference in London. The collaboration between Siemens Industry Software and the KU Leuven was disseminated through poster presentations at the MCAA General Assembly Conference 2018, Leuven and at the R&D Management Conference 2017 in Leuven.

Workshop on inter-sectoral mobility for mobile researchers

A one hour workshop with 27 participants was organized during the 2018 Leuven Conference on Noise and Vibration Engineering (ISMA 2018) which was tailored add gathering information from and disseminating information to active mobile researchers and teaching the mobile researchers about the key findings from this project. On the one hand, brainstorm session were held in small groups concerning IP and knowledge transfer, understanding organisation culture and collaboration, and practicalities and administration concerning mobility. On the other hand best practices were shared for the entire group such that findings were disseminated.

Figure 30: Impression of the workshop on inter-sectoral mobility for mobile researchers

Social media

The bottlenecks, enables and solutions of ISM, resulting from the surveys, are summarised in an infotainment movie (https://www.youtube.com/watch?v=9qDgNbi72fg&feature=youtu.be) and disseminate through the social media channels of both Science2Society as the KU Leuven Noise and Vibration Research Group.

6.4 Conclusions & Recommendations

6.4.1 Conclusions

The different stakeholders participate to ISM with different agendas. Academic partners try to advance the state-of-the-art ensuring industrial relevance at the forefront of academic excellence. The industry partner is searching to boost the state-of-the-use with innovative technologies, continuously innovating products and services and training researchers or students focused on their activities. Governments invest in innovative researchers of the future with a complete skill set to ensure the supply of highly-skilled professionals needed in the competitive labour markets of the "knowledge economy". Lastly, the mobile researcher themselves are looking for combination of the critical mind-set of universities combined with a commercial mind-set of industry and gain company experience to speed up their learning curves.

The most common bottlenecks for ISM were confidentially and IP strategies together with the lack of culture of collaboration, the difference in time horizon between industry and academia, lacking the right network and channels to set-up collaboration, especially for smaller SMEs, and the preparation effort for proposals.

To facilitate (the initiation of) ISM it helps to have people around the table that were inter-sectoral researchers themselves to increase mutual understanding, have fixed administrative and contractual procedures or have a playbook for ISM, comprising welcome procedures and collaboration scripts.

ISM is often also a part of strong interwoven relationships with universities as part of an innovation DNA, further building blocks can be student exchanges for small projects, lectures (both direction) and research team leaders in boards of universities to discuss curriculum.

Key Findings

Mobility is a key enabler for open innovation and

- can conflict with traditional (IP focused) innovation approaches and administrative procedures;
- can be boosted by out of the box thinking and novel approaches with clear IP and administrative agreements;
- is at the end driven by the people and their attitude (individual level connections);
- but is heavily facilitated by the existence of agreements between organisation (institutional connections);
- governmental funding schemes act as a catalyst.

This strong dependency on existence of both personal and organisation links, explains the importance of adapting to local habits and explains the wide variation and scatteredness of ISM schemes

6.4.2 Recommendations

Key takeaways

Go for gradual approaches to build a joint innovation DNA and ecosystem. Start small and build trust with low risk, short term research, such as student internships or master theses and gradually built towards a higher risk long term collaborations. Combine connections on individual level and build bridges on institutional level (alliances, base funding, …) [4.13].

Reduce risk for single projects with low level entry fees for the start of research, but gradually increasing fees when the research becomes more tangible.

Ease administrative loads by setting up focused framework agreements for groups of companies and make templates available as starting point for discussions on administration issues.

Educate researchers with respect to IP and collaboration such they know what they can share.

Learn on the go and compile best practices (welcome procedures, collaboration scripts, IP templates) in a recipe book that can be used as guide towards further collaborations.

Impact on the pilot

The approaches resulting from the pilot leads to improved ISM

- Faster project set up through reduced administrative loads leading to cost reduction.
- Easier project negotiations through risk spreading and clear view on investment cost versus expected return.
- Improved innovation by better collaboration.
- Building a research DNA by stepwise increasing intensity of collaborations.

Furthermore, the LIA as central point for sharing best practices can be a catalyst for improving ISM through sharing framework agreements, script for collaboration or methods of collaboration with varying intensity, such as e.g. the examples use case of KUL and SISW on dual desk PhD researchers.

Key Performance Indicators (KPIs)

In all surveys, suitable KPIs were discussed following were most heard:

- Follow up projects on the same topic or with the same partners
- Joint publications and patents
- Outcome of project after x years in terms of
    - Achieved TRL
    - Income generated
    - Impact on research methodology of the company
    - Impact on dissemination (teaching method or material, layman outreach to society, sharing of general models, …)
- Diary of interaction moments (meetings, trainings, … with mixed inter-sectoral groups)

6.5 Future line of research

Future lines of research can focus on the effectivity of KPIs for the evaluation of ISM, both for the research partners, as for the government. Researchers at both sides, industry and academia, indicated the difficulty to measure the impact of a certain ISM-project on the total innovation of a company or research group, especially when this needs to be reported in concrete numbers.

Due to the difficulty of finding relevant metrics to measure the degree of collaboration and innovations, governments often ask to report secondary effects such as (joint) publication and filed patents. Often these can, however, by costly, time-consuming and contradicting to the strategy of the company. Furthermore, measuring these, can lead to dilution of publications, and as such, leading to a less efficient spreading of innovative ideas.

6.6 Appendix to Pilot 4

6.6.1 Questionnaire

The questionnaire is tailored for the different core stakeholders

- Supervisor
- Mobile researcher
- Funding representative

For each group the questionnaire is be divided in three parts

- General questions about the their professional goals, open innovation and ISM
- Specific questions on the programme(s) they are experienced with
- General questions for improvements

The questions are always asked live, either face to face or by telephone.

General

Name:

Position:

Role on the ISM-project:

Phase in the project (start, middle, end finished):

What is your view on OI, what do you consider bottlenecks and what do you consider advantages?

What is your view on ISM of researchers, what do you consider bottlenecks and what do you consider advantages?

What are the goals that you try to achieve with ISM?

In which programmes are you currently active. (For these programmes please answer the next questions)

Does ISM take place: how many, from where to where and what is the trend?

Specific for Industrial supervisor/Academic supervisor/RTO supervisor

Is ISM and knowledge exchange supported in this programme, how do you support this (are there fixed procedures set in place), what are bottlenecks for this exchange and how would you improve it in the current situation?

Is the outcome (research and process of the project) of the ISM-project analysed, are there KPIs on the project, and specific on the innovation and the open innovation part?

Are innovations of project shared with partners inside the project and/or with partners outside the project (maybe through publication)?

Specific for funding representative

Which programmes do you offer for ISM?

What is the motivation behind these projects?

How is innovation versus open innovation in these programmes?

Is the outcome of the project analysed?

If yes, is the outcome assessed with respect to the proposal or to the ‘open’ innovation achieved?

Are there KPIs on the project, and specific on the innovation and the open innovation part?

Specific for mobile researcher

Where you treated equal to your peers in the university/ in the company or were you treated ‘as a special kind’?

How straight forward was it to get information you needed for the project?

How straight forward was it to get information that is not strictly required? (this in view of cross fertilization of research)

Is the outcome of the project analysed?

Are you aware of KPIs that you have the achieve for the project, and specific on the I and OI part?

Do you see a benefit of OI to your career?

General ideas for improvement

Do you have a suggestion for KPIs linked to open innovation through ISM?

What do you think of setting targets on

- (joint)-papers
- (joint)-patents
- Conference participations
- Non-scientific publications
- Follow up projects
- Number of partners involved and length of the secondments to different partners

Do you have suggestion to improve OI through ISM (without considering the current boundary conditions)?

6.6.2 Complete list of summarised findings from the surveys

Bottlenecks with respect to culture and collaboration

- Lack of **culture of collaboration** and focus on threats instead of possibilities, especially towards other companies, but sometimes also towards knowledge institutes.
- Lack of **culture of innovation**, some people want to stick to known technologies (especially an issue with SMEs) or lack the open mind for **collaboration between different fields**.
- **Gap in TRL level**: this applies on the collaboration itself as the expectation on the outcome of the project
- **Gap in degree of specialisation**: a certain knowledge overlap facilitates collaboration, this can be both seen as missing specialised knowledge to innovate or missing practical knowledge to transfer the innovative idea to applications.
- **Difference in processes,** e.g. the hurdle to start collaborating within self-organising teams following agile development strategies is very high and often not in line with the processes followed in research settings
- **Difference in time horizon**: the horizon in research institutes is often longer then horizon of expected return in industry, especially for SMEs the time to market is often said to be too long,
- **Difference in focus**: in industry the focus is often more on daily operations (fixing issues) then focus on long term innovation (investigating research question) and allowing for serendipity.

- **Difference in goals, and the bias of the current job**: e.g. publishing results can be frowned upon from a product development point of view
- **Little academic recognition** for ISM activities or industrial experience can lead to low priority for mobility from academic side.
- As an SME it is very difficult to get in European projects without **knowing the right channels/partners** (who can help with which research).
- Openness only works in **complementary consortiums**, as soon as there is competition, everyone stops sharing. Both in research as in industry.

Bottlenecks with respect to IP and knowledge transfer

- **Confidentiality and IP** (depending on strategy of company):
  - Being afraid to lose ownership.
  - In case there is no ownership, collaboration is hindered by the urge to keep things secret.
  - Sometime IP cannot be arranged upfront due to the uncertain outcome of research.
- **Afraid of given away IP**:
  - not all researchers know what they can disclose
  - the evaluation of IP is not always made correctly.
- **Time to set up project agreements.**

Bottlenecks with respect to administration and practicalities

- **Preparation effort** for a proposal, especially collaboration projects require more effort than writing purely academic PhD projects.
- **Process of setting up a project**: time between idea, concept, application and granting is too long. There is an upfront personnel cost for writing while the return is not immediate. Furthermore, the delays make it difficult to keep people motivated for a project, by the time the project is granted, they might already committed to other projects.
- Finding the **right candidate** that is (i) willing to participate in ISM, (ii) knowledgeable in the field (iii) and willing to commitments for multiples years.
- **Change in staffing**, is becoming an increasing issue: people are changing more rapidly from company. This can hold both for the researcher, as for the supervising team.
- **Finding funding to wrap up the** project: there is often additional time that funding is required after the projects finishes (e.g. if the PhD is not yet completely finished).
- Data sharing can be an issue from legal perspective: e.g. medical data cannot be freely shared.
- **Geographical distance** and large differences in **time zones** can hinder collaboration.

Facilitators

- If multiple companies are participating, the collaboration is easier if the collaboration is between companies with **different positions in the value chain**.

- **Having people that did ISM before around the table**, they know both the academic and the industrial side of the story and they know how to make the bridges between academia and industry.
- **Funding** is a facilitator by itself since it means that there are deliverables and commitments that need to be fulfilled, this reduces the risk that short term **deadlines** lead to neglecting the ISM goals.
- **Proximity of partners helps**: e.g. being close to university to facilitate internships (JA)
- **Having a history with either ISM or with the research partners**: this often implies that both organisation understand each other's points of view and that mutual trust is present.
- **professional guidance in drafting the IP agreement for SMEs** with no experience in grant agreements

Best practice example

- **Preliminary preparation**: e.g. read up on literature in advance such that the knowledge gap is acceptable at the start and have a concrete plan in place for the first months.
- Clear **IP agreements made up front**.
- **Fixed meetings dates to**
  - Can be between the supervisors to align vision
  - Can be with the three parties, the research institute, the candidate and the company to check progress and probe for (practical problems).
  - Every half a year formal meeting, with presentation and more people involved, e.g. CEO and evaluation of what has been done to get a broad approval of the progress.
- **Have strong interwoven relationships with universities**: student exchange for small projects, lectures (both direction), be in boards of universities to discuss curriculum: let universities know what industry need.
- **Joined selection** of the ISM candidate for long projects.
- **Having welcoming procedures on institute level** to help with administration (city, country, housing) augmented with a **buddy system for helping** with (office related) accommodation, administration, …
- **Matchmaking events to build a network**: this can be industry-academia get-togethers concentring certain topics or this can occur through organisation that facilitate match-making in certain industry sectors (e.g. strategic research centres)
- **Have a step wise approach to let companies built an innovations DNA**: start with small projects with non-full time man months for universities.
- **TTO offices that can facilitate the legal parts** such that a framework for the researchers is available and that they are able to share

Solutions

- Clear **explanation of the IP to the researchers**, otherwise they might not dare to share.
- Easing up the **administrative and contractual procedures** to send out people to organisations, allow more sabbatical for academic or make it easier to organise this.
- Have general **framework agreements between industry and universities**: right of publications, cost of overhead, wage costs, …

- **A close link between education and industry:** if the educational system understands industry needs, then the required knowledge fields are will be better represented in the curriculum, hence facilitating the required knowledge overlap.
- **Have a gradual approach to projects**: for basic research this can be free entrance, but the fee rises when the research becomes more applied. E.g. participation for the first 2 years is free, for year 3 25% of the researchers cost hast to be paid and 50% for year 4.
- **Lectures on dissemination and communication of results in the**: learn to explain in layman terms and demonstrate the impact of research
- For larger companies, it helps to have a **fixed follow up committee** for each partner and programme for all running projects

Ideas for KPIs

- Contract income generated as follow up of joint projects to measure the success of the collaboration.
- Number of internal presentation, joint meetings, … .
- Number of business units interested.
- Follow up projects on the same topic or with the same partners.
- the ‘script’ for the reception of the mobile researcher and the interactions: who is tutor, point of contact, … what is the plan, … such that the mobility is not just a presence of 3 months, but that there is interaction.
- Revenue generated based on the innovation or contribution of the project to an increase in TRL.
- Industrial or academic uptake of the results: are the methodologies picked up by the company in some way and are the research results used by the academic partners (e.g. in teaching).
- General publications: papers are expensive and often not very accessible without a lot of background information. Share simple models/demo’s such that people can play around a bit.
- Degree of uptake of the publications (citations of that work by non-partners)

Comments on KPIs

- Joint publications doesn’t trace the quality of the collaborations or the mobility, and some companies don’t want to publish. Some publications are just a waste of time – it has to be valuable and interesting to others.
- KPIs on outcome can be very bad and taking the project in the wrong direction.
- Patents are expensive and sometimes it is not a strategy of the company to take patents. This is also difficult in case of multiple companies working together.
- Measuring follow up projects is not always relevant: If a project was very successful and all the research is done, it might be that there is no reason for a follow-up project.

6.6.3 Agenda entrepreneurial skill training

Wednesday 21 February 2018

12:00 – 14:00 *Arrival, registration and sandwich lunch*

14:00 – 14:10 *Welcome by Bert Pluymers and Nicole De Smyter*

14:10 – 15:40 Innovation management :

- Sources, white paper, triggers
- How to work as a team?
- Where to find useful information?

Wim Fyen, Investment Manager, KU Leuven R&D

15:40 – 16:00 *Short coffee break*

16:00 – 17u30 Business modelling (do-session)

How to get started ?

- Valorisation strategies
- Business model generation

Wim Fyen, Investment Manager, KU Leuven R&D

Thursday 22 February 2018

09:00 – 09:45 Case InsPyro

Els Nagels, Managing Director InsPyro

09:45 – 10:45 Technology Marketing – part 1

Wim Bens, Managing Director, Bens & Partners

10:45 – 11:15 *Short coffee break*

11:15 – 12:15 Technology Marketing – part 2

Wim Bens, Managing Director, Bens & Partners

12:15 – 13:30 *Lunch*

13:30 – 15:00 Starting a high-tech company :

- key success factors and basic introduction to the start-up process.

Rudi Cuyvers, Investment manager, KU Leuven R&D

15:00 – 15:20 *Short coffee break*

15:20 – 16:20 General Introduction to IPR

Isabelle François, IPR Officer KU Leuven R&D

16:20 – 17:15 Introduction to patents

Isabelle François, IPR Officer KU Leuven R&D

Friday 23 February 2018

09:00 – 10:30	How to make a business plan - The basic elements of a business plan, followed by a do-moment - How to structure a business plan **Wim Wets, COO Venture Spirit**
10:30 – 10:45	*Short coffee break*
10:45 – 12:15	How to pitch a business plan **Wim Wets, COO Venture Spirit**
12:15 – 13:30	*Sandwich lunch*
13:30 – 14:00	Case SoundTalks **Dries Berckmans, Founder SoundTalks**
14:15 – 15:15	The investor's view **Marc Lambrechts, Senior Investment Manager, Capricorn Venture Partners**

6.6.4 Welcome procedure

One month in advance

- Assign/clarify *responsible person/supervisor* (most of cases will be the *Project Manager* of the related project) and organise meeting in the week of arrival:
  - In the case of **post-doc**: hosting professor
  - In the case of **phd**: Post-doc
  - In case of a **visiting scholar** (either master student from abroad, of visiting phd student): post-doc, or a senior phd
- Assign *buddy* (person for daily questions, similar profile as newcomer but with experience)
  - In the case of **post-doc**: post-doc
  - In the case of **phd**: more experienced phd
  - In the case of **visiting scholar**: phd
- Initiate search for a desk location: contact the responsible of that research group.

Is new computer system required?

  - Yes: request budget with and contact responsible to arrange a system
  - No: see '1 week before'
- Verify administrative process with HR (this should have been initiated before!)

One week in advance

- Clear out and set up desk space (buddy)
- Arrange (old or new) computer system (this is to be organized with the Laptop manager)

    - if a new system is required, push this forward
- Print welcome procedures and put on desk:
- Email newcomer with address and person to report to upon arrival and starting time
    - make sure responsible and/or buddy are available at this time.
    - E-mail:
      Dear NEWCOMER_NAME,

      Welcome to the MOD research group!
      We are expecting you on *DATE* at *TIME*. When you first arrive, you can go to the secretary's office at the second floor (room 02.72) at the mechanics building on the Celestijnenlaan 300, 3001 Heverlee. Ask the secretary for me and I will pick you up and get you started.
      If you have any more question, you can always email me or contact me on *PHONENUMBER*.

      See you soon,
      BUDDY_NAME

Arrival day

Welcome upon arrival (duration +- 2 hours)

- in case of phd: by responsible
- in case of post-doc: by buddy
- Content
    - Overview of group structure and newcomer's position in this structure (what group, meetings etc)
    - Overview of working theme and start-up work
        - give starting literature and discuss a possible first assignment
        - Set up the collaboration script for the PhD (plan first joint conference calls /live meetings with both supervisors)
    - Overview of the group rules: working hours, what to do in case of illness, holidays, working from home …
    - Check whether administrative procedures are fine, if not, introduce to the HR office.
    - Buddy shows desk and shows newcomer around building, secretariat

One week after arrival

Introduce to information on productivity tools (version control, file sharing system, …) and double check enrolment to all appropriate mailings lists:

6.7 References Pilot 4

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[4.5] Chesbrough, Henry. "Open innovation." (2003).

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[4.9] Sapienza, Harry J., Annaleena Parhankangas, and Erkko Autio. "Knowledge relatedness and post-spin-off growth." *Journal of Business Venturing* 19.6 (2004): 809-829.

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7 PILOT 5: COLLABORATION THROUGH BIG DATA AND SCIENCE 2.0

Executive Summary

Big data can provide immense economic, scientific and social value. New value and information can be derived from big data by integrating existing data sets. This has pushed organisations to pursue open data initiatives. These initiatives can be found among government, industry and academia. While organisational benefits are clear to pursue open innovation in the field of big data, individual researchers' motivation for opening their big data sets have not been addressed in previous work despite that this is the prerequisite to make open science realise its true potential.

The aim of pilot 5 “Collaboration through big data and open science” is to tackle this critical challenge how to motivate researchers to open their big research data repositories as well as the industry to take advantage of them. The primary research question is to how to develop sustainable business models for big research data that benefit both data owners and the external data users. In order to answer this question a literature review and two case studies have been conducted. We chose two different kinds of case studies. The first case illustrates a closed database of a Finnish foundation, where our role was to facilitate a co-creation process between the database owners and the potential users in order to develop commonly acceptable open ecosystem around the database. The second case illustrates a GCAT database in Spain, where our role was to analyse the specific business model through stakeholder interviews and to derive lessons learnt on critical factors underlying sustainable business models for big data sharing.

As key findings from the literature review we found that the researchers' data sharing behaviour is largely driven by perceived career benefits and risks, effort needed to share data and the availability of data repositories. These are the factors that need to be considered in open science initiatives. Furthermore, we found that the opportunities for open big data collaboration include organisational transparency, accelerated and reproducible research and new businesses. These opportunities are hindered by key stakeholder's unwillingness to participate in collaboration due to perceived risks, privacy and ethical issues and technical issues related to the complexity of big data. Once the barriers have been solved, there are several business models for commercialisation of big data such as patenting, licensing and spin-outs. Virtual research environments and boundary organisations are two examples of potential big data ecosystems fostering open innovation collaboration.

As key conclusions from the case studies, we develop two frameworks that support the development of sustainable business cases for big research data sharing. The first framework is for opening the big research database. It emphasizes that the starting point for opening big data should always be a clear foreseen opportunity. This gives the motivation needed for the researcher to opening the database. Our framework provides a tool for analysing and evaluating the potential of sharing a specific big research database. It serves as the bases for making a justified decision whether it is worth of an effort to open a specific database or not and if yes how to open it. The second framework is for the management of an open big research database. It provides best practices on how to efficiently manage a big open research database.

As a conclusion, pilot 5 provides recommendations for opening and managing big research data. Based on the case of the Finnish Foundation, we recommend that the data owners make the decision whether to open or not the database based on careful assessment of the underlying opportunities, barriers and alternative business models, and we provide a generic process model for doing that assessment. Based on the GCAT case, we provide lessons learnt and best practices how to operate a big research database. We also illustrate the underlying business model of GCAT case that demonstrates the underlying value proposition, profit formula and the key resources and processes required to manage the open database.

7.1 Introduction to the pilot

Pilot #5 aimed to support organisations and research groups to develop sustainable business models for sharing big research databases with potential external users, and thus to strengthen open innovation. The pilot also investigated best practices to manage an open big research database. Pilot consisted of three parts: (1) Literature review, (2) Case study of Finnish Foundation and its close database and (3) Case study of GCAT and its open research database in Spain.

The objective of the literature review was to understand the current state of the literature in relation to open research (big) data. Our key research questions for the literature review were:

- How to motivate big research data providers to open their data?
- What are the opportunities and obstacles for big research data transfer?
- What type of big data strategies and business models can be used to capture value from big research data transfer?

The purpose of the first research question was to form an understanding on what makes researchers willing or unwilling to open their data sets. The second research question was to assess the opportunities and obstacles for opening big data sets. The final research question explored which strategies and business models are used to capture value from big data repositories.

The objective of the case study of a Finnish Foundation was to provide guidance how to develop sustainable business model for big research data sharing. The objective of the GCAT case study was to provide best practices how to successfully manage an open big research database.

The main actors of this pilot were Aalto University (Finland) and ATOS (Spain). The pilot was supported through feedback from JIIP (Brussels) and Virtual Vehicle (Austria). The expected outputs of this Pilot included:

- Generic framework and guidance how to develop sustainable business models for big research transfer
- Best practices for successfully managing an open big research database

The results of the pilot have been disseminated through the following publications.

- Roman, M., Liu, J., Nyberg, T. 2018. Advancing the Open Science movement through sustainable business model development. Industry and Higher Education, 32(4): 226-234.
- Roman, M., Liu, J., Nyberg, T. 2017. University-Industry collaboration through big data and open science. In Proceedings of the 10th International Conference for Entrepreneurship, Innovation and Regional Development ICEIRD 2017, pp. 371-378, Thessaloniki, Greece, 31 Aug – 1 Sept., 2017.
- Liu, J. 2017. Big data strategies in an open innovation context. Bachelor‘s Thesis. Aalto University, School of Science. Department of Industrial Engineering and Management.

The results have been presented in ICEIRD conference in Thessaloniki, Greece, August 2017 and two workshops held in Barcelona, Spain in June 2018 and in Espoo, Finland in September 2018. They will be also presented in the Final Conference for S2S project to be held in Cambridge, U.K. in the beginning of 2019.The results will be further disseminated via pilot booklet including all Science2Society pilots.

7.2 Description of the Open Innovation Scheme

There are several issues that hinder big research data transfer. First of all, there are too little incentives today for research groups and researchers to share big research data. Second, there are obstacles related to big research data transfer stemming e.g. from legal, confidentiality and technical issues. Third, additional attention needs to be given to increase current understanding related to business models and strategies for big research data sharing. This chapter presents key findings from prior literature in regard to these key issues.

7.2.1 How to motivate big research data providers to open their data?

Big research data transfer requires that research groups and researchers are willing to share their data. Personal motivations, e.g. perceived career benefits and risks, expected effort and personal attitude towards data sharing, have been identified as primary drivers for scientists' data sharing behaviour (Kim and Adler, 2015; Kim and Zhang, 2015). In their research, Kim and Zhang (2015) notice that the attitude of researchers towards data sharing directly influences their data sharing behaviour. In other words, positive attitude on data sharing would lead to more data sharing. Kim and Zhang (2015) identify factors that positively influence researcher's attitude towards data sharing such as perceived career benefits and normative influence. Career benefits are considered academic rewards like recognition and reputation while normative influence is a researcher's perception on whether others in their field think he or she should share their research data. Another factor significantly affecting researcher's attitude toward data sharing and data sharing behaviour is the perceived availability of data repositories. This is important since good, uniform community norms for data sharing are yet to be deployed by the scientific community. To develop researcher's data sharing behaviour, the scientific community needs to develop standardised data repositories, make it available and promote them to researchers. (Kim and Zhang, 2015)

Factors that negatively influence scientists' attitude towards data sharing are perceived career risks and effort required to share data. This means a researcher believes data sharing can possibly have undesirable consequences on their career or data sharing requires valuable work and time from their part. This is time they spent on making data available in a viable format that could be spend on something that has direct scientific contribution (Kim and Zhang, 2015). In their paper, Tenopir et al. (2011) make note that researchers are reluctant to share their data due to concerns with legal issues, misuse of data, and incompatible data types. This issue is linked to researchers' perception on available data repositories and guidelines for data sharing not being compatible with the complexity of their data. This can lead to misinterpretation in their data or may be used in other ways than intended.

There are perceived benefits for researchers participating in open science practices (McKiernan et al., 2016). As evidenced by Viseur (2015), this includes open publications gaining more citations and attention as well as reproducibility of open research boosting a scientist's credibility. In addition, there are also perceived risks from scientists' perspective for data sharing. These include perceived effort and negative career influences from data sharing. Benefits and risks are factors that affect scientists' attitude on data sharing which in turn affects their data sharing behaviour (Kim and Adler, 2015; Kim and Zhang, 2015). A perceived lack of available data repositories and clear guidelines for data storing can also negatively affect their data sharing behaviour. To encourage data sharing behaviour in scientists, organisations and the scientific community need to understand the personal motivation for scientists to participate in open science and find ways to address them. The positive and negative factors influencing scientists' motivations are presented in Table 8 below.

Table 7: Factors affecting data sharing behaviour (Kim and Adler, 2015; Kim and Zhang, 2015)

Positive factor	Negative factor	Varies among fields
Boosted reputation through data sharing	Perceived career risks	Normative influence (others perception on whether data should be shared)
Academic rewards through data sharing	Perceived effort in making data sharable	
Availability of repositories for data sharing	Unavailability of repositories	

Thomas and Leiponen (2016) note that organisations progress through stages in their big data commercialisation activities. Organisations opening their data for commercialisation typically first experiment with certain quantity of data. With perceived success, they move up the value chain and start collaborating with more partners and suppliers. Once comfortable with the notion of commercialising data, they will begin releasing more data and move from simple data supply to more complex business models. These complex business models generate more revenue but are harder to execute, prompting more open collaboration and co-creation.

This progression of organisations could also apply to individual researchers with data repositories that have interest in commercialising it. However, this would require them also to be willing to open their data first place where their attitude towards data sharing would have to be positive.

7.2.2 Opportunities and obstacles in opening big research data

In the era of internet, researchers have less restrictions than before to share their data, especially in a raw format (Kim and Zhang, 2015). According to Liao (2015) the rise in prominence of big data means new opportunities will arise for universities. Liao (2015) argues it is important to integrate business and technology when considering the big data opportunities in higher learning institutes.

First of all, by having open access to data, the rate of scientific discovery is accelerated in different research fields (Sadiku, Tembely and Musa, 2016). Second, aside from increasing government and research transparency open data can also have potential economic value in improved public service at a lower cost and value for society and businesses through accessing and combining data in new ways (Cowan, Alencar and McGarry, 2014). Third, in addition to economic benefits, open research data can also support public policy-making when integrated with open government data (Zuiderwijk et al., 2016). Fourth, researchers can also use open research practices to gain more citations, media attention, potential collaborators as well as job and funding opportunities (McKiernan et al., 2016).

In his paper, Hand (2013) argues that the economic growth driven by open data initiatives are more subtle. The author lists accountability and empowering communities as two key enablers of open big data. Both factors are related to transparency of conducted work and people being able to see where actions are needed and how effective they are. The author indicates that people are inherently not interested in the data but rather want answers from the data available. Value from the data comes from the fact that it can be processed and lead us to these answers. Opening access to data provides anyone with the opportunity to generate value out of the data (Jetzek, Avital and Bjorn-Andersen, 2014).

There are some advantages for industry to look for university intellectual property (IP) for innovation purposes. The advantages suggested by Minshall, Seldon and Probert (2007) in licensing university IP to lay in the low investment, potential for multiple revenue streams and limited need to use complementary resources. While licensing university is one option, the creation of a spin-out firm brings the opportunity to capture a high proportion of generated value and building the entrepreneurial image of the university.

There are also several obstacles for big research data transfer. Minshall, Seldon and Probert (2007) identify the challenge for industry adopting the open innovation model as the significant investment and time required to generate value out of the university IP due to its low technology readiness. According to Minshall, Seldon and Probert (2007) the cons for licencing university IP relate to the need for finding and managing multiple licences as well as the limited engagement with the actual value creation. For university, there exists the possibility that by encouraging the creation of spin-outs based on university IP, the university engages in higher risk and may lose "star" researchers thus dampening its organisational scientific output. This can prove as an unwillingness for university to support opening data sets.

Commercialisation of public research is a major goal of policy makers. Cervantes and Meissner (2014) explain that weak commercialisation of research can be down to several bottlenecks. They state that information on university inventions is not available enough to potential users, industrial partners' risk and unwillingness to engage with university inventions is compound by unclear ownership of said inventions as well as different missions leading to misaligned incentives and coordination problems.

A critical challenge in opening up big data is addressed by Katal, Wazid and Goudar (2013). The authors present the potential privacy and security issues related big data collected from user (people) information. They argue the secretive information that a person does not want revealed might come out once their personal information is linked up with data from other sources. Another noteworthy ethical issue with linking up open big data sets is the consequence of using predictive analysis on the newly formed information to identify underprivileged and subsequently treating them worse. The authors also bring up the issue of managing and governing the shared data. The data made available needs to be accurate and complete with standardised API, metadata and formats. The "metadata challenge" is also touched upon by Grabowski and Minor (2017). They imply that simply making data public does not guarantee its usability without the essential metadata. Metadata as referred by the authors means knowing the identity of the sample and data collection parameters.

Katal, Wazid and Goudar (2013) list multiple technical issues regarding the storage and processing of the amount of data produced. Collecting and linking big data can cause both capacity and performance issue. Even when data is stored and linked correctly the next challenge lies in conducting analysis on the large amount data that can be unstructured, semi structured or structured.

Extracting useful information from large open data sets requires expertise and the need for skilled analysts presents its own problems (Hand, 2013). Big data is still a relatively young concept with new technologies emerging requiring new and diverse skill sets. These skills need to be developed in individuals, meaning organisations need to set resources to introduce training programs and universities curriculum on big data to produce skilled experts in this field for the future (Katal, Wazid and Goudar, 2013). Grabowski and Minor (2017) argue that while progress in storage technologies can help solve the issue of handling huge volumes data, one detrimental challenge for opening big data repositories remains the deep-rooted reluctance of researchers to share their data.

According to Aalto University research data management survey (2017) key barriers for openly publishing research data from the point of view of the researchers (N=133) were the following:

- Absence of incentives to promote open access to research data within the institution (e.g. absence of impact on researchers' performance evaluation and career progression)
- Issues and concerns over the legal framework (e.g. data privacy, copyright regulations)
- Technical complexity (e.g. lack of precise definitions, standards and procedures, variety of data formats)
- Securing first own interests regarding data analysis and results and exploiting them as widely as possible, and only after that opening data.

Based on the findings from literature used for this chapter, the opportunities and obstacles for opening big data sets are summarised in Table 8 below.

Table 8: Opportunities and challenges in open big data

Opportunities	Obstacles
Organisational transparency enables communities to feel empowered	Researchers unwillingness to share due to perceived risks (time, investment, different objectives)
Reproducible and accelerated research through open access data	Researchers unwillingness to share due to the absence of incentives
New, innovative business models from linking up different data sets	Technical complexity related to open big research data management, governance and processing
New products and services based on open data	Concerns about the legal framework (privacy, IPR and security issues associated with open research data

7.2.3 Big data strategies

This chapter lays out approaches that academia use to participate and collaborate with industry. Following this, the chapter explores big data strategies, referring to different methods through which big data is commercialised. This includes the assessment of best practices and business models related to big data. Lastly, this chapter present two forms of ecosystem to foster open science practices among researchers.

7.2.3.1 Commercialisation of big research data

In the article by Cervantes and Meissner (2014) approaches for commercialising public research are laid out. The authors suggest that patents, licensing income and spin-offs should be used as an indicator to determine the capability of an institution to turn research into innovation. Other channels for commercialising public research are collaborative research partnerships between the public and private sector, staff mobility and contract research and research staff consulting (Perkmann et al., 2013; Cervantes and Meissner, 2014). Universities can also directly exchange knowledge embedded in IP documents with industry to provide access to university inventions on royalty-free and free-free basis. To obtain a higher turnover rate of research-turned-innovations, universities may also encourage their staff to establish new ventures by providing actual incentives, e.g. granting leaves of absence, allow tenure clock stoppage. To promote commercialisation activities from within universities can also consider commercial track record when deciding on staff promotions (Cervantes and Meissner, 2014).

Exploitation routes of university generated intellectual property (IP) is touched upon by Minshall, Seldon and Probert (2007). In their paper the writers explore the pros and cons of two exploitation routes for said IP by either licensing to established firms or creating university spin-out firms. Minshall (2003) explores the conditions under which the option to create a new firm is most appropriate and claims this is true in cases where the technology is platform based and needs substantial investment to further develop.

As remarked by Drexler et al. (2014), when trying to combine internal and external R&D efforts organisations face difficulties in identifying external knowledge and see interaction with external knowledge sources as crucial for better innovative performance. To address this, organisations have conducted several activities to reach out to academia. This includes checking scientific publications, journals, analysing university patents and attending conferences and seminars.

An important practitioner of open innovation and commercialisation activities in academia are entrepreneurial academics. An entrepreneurial academic is an academic that engages in commercialisation activities that result in patent creations, license sales or new ventures in the form of spin outs. These individuals conduct technology transfer activities in industry collaborations with their goal being more than publishing their research but also the recognition that it has a wider purpose on society. Their involvement with industry may also result in financial benefits and entrepreneurial academics see this involvement as an extension on their research related role that can lead to access to new resources, funding and learning opportunities (Alexander, Miller and Fielding, 2015).

7.2.3.2 Big data business models

In their article on commercialisation of big data, Thomas and Leiponen (2016) see big data's value in its secondary use – the so called "data reuse" that enables creation of new products and services. The authors point to the increasing amount of available external open data for organisations to utilise and categorise big data commercialisation under six different models for value creation of big data. The models are listed as data suppliers, data managers, data custodians, application developers, service providers and data aggregators. The business models generally use freemium, premium and pay-per-use/view as a revenue stream (Thomas and Leiponen, 2016).

Zeleti, Ojo and Curry (2014, p.4) state that open data needs to be "structured, supported, timely, accurate and data releases need to be reliable and sustained over time" to be useful to businesses and for business models to be operational. The authors analyse open data business models found from literature and practice to better define how potential value can be harnessed from open data. In their study they conclude that premium and freemium models, also mentioned by Thomas and Leiponen (2016), are the most used models. The premium model requires customers to pay a premium price for access to the data while the freemium model offers the basic data free of charge but charges a price for more detailed data. The reason for this is its less complicated strategic focus and more successful cases being achieved leading to an increased adoption of these models.

A study by Hartmann et al. (2016) examines the data usage of 100 startup companies and the revenue model they are based on. The results point to 73% of startups using external data sources while 76% conduct data analytics as a key activity and 62% rely on a subscription based revenue model. The study (Hartmann et al., 2016) reveals six different business model cluster types of the startups based on their offering and what they do with the data. Two types identified as free data collector and aggregator and free data knowledge discovery collect and aggregate data from different, freely available sources. In these models data is normalised or analysed and is offered to customers with revenue coming from subscription and usage fees. For free data knowledge discovery, there also exists the possibility of relying on revenue from advertising and brokerage fees. The types analytics as a service and data aggregations as a service analyse and aggregate customer data, respectively. They have similar revenue models and charge based on subscription on usage fees. In the business model labelled as data generation and analysis, companies focus solely on generating their own data and may perform analytics on it while getting revenue from asset sales. In the final type, multi-source data mash-up and analysis, data from customer as well as external sources are combined, analysed and aggregated. Revenue for these typically comes from subscription fees (Hartmann et al., 2016).

Figure 31 below contains a summary of the six types of business models and of the key data sources from which data is drawn as well as the key activities conducted with the data.

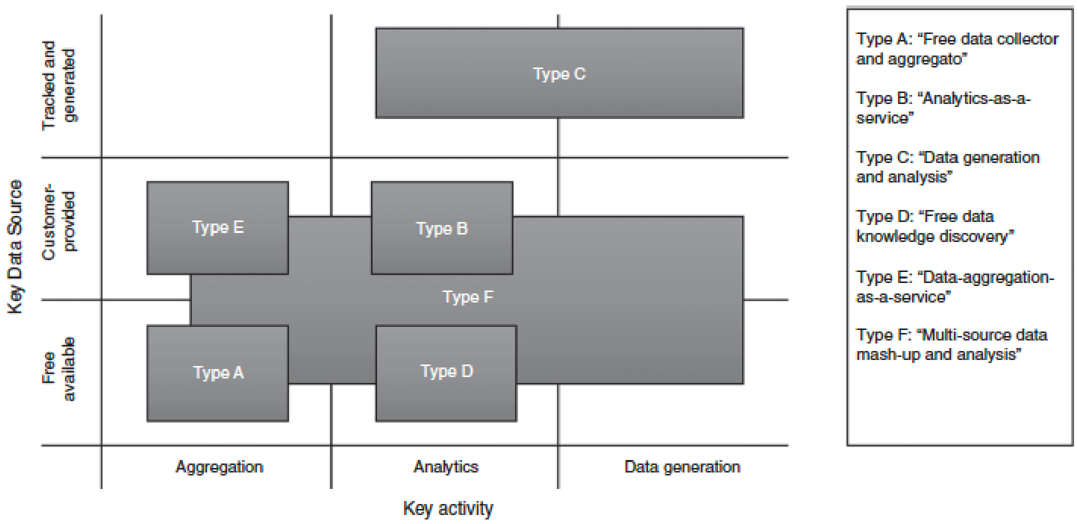

Figure 31: Matrix of data-driven business models (Hartmann et al., 2016)

Researchers looking to commercialise their big data repositories might find most viable use in the models as a data supplier, data generation and analysis or multi-source data mash-up and analysis. As a data supplier, researcher would provide data in the format it is made available in so others may reuse it without putting additional effort into processing the data. As a revenue stream of freemium or premium model may be easily implanted for these as they are not complex. Using data generation and analysis or multi-source data mash-up and analysis, researchers can use their self-generated data or mix their own data with other datasets and analyse them to provide value while charging based on subscription.

7.2.3.3 Big data ecosystems

A remark made by Thomas and Leiponen (2016) is the emergence and crucial role of data ecosystems in making the most value out of big data. This means shifting from "organisation-centric" data to a wider ecosystem where most value is derived from interconnectedness and interdependencies among the data. Such a proposed data ecosystem consists of private organisations, public institutions and end users. Data ecosystems are facilitated by technological platforms, meaning platform owners create standards for the technical system.

The amount of available open data sets is growing especially in the government side and also within publicly funded research projects that are increasingly required to make data openly available. Researchers can use these open data sets in various ways to come up with new data-driven research and generate new datasets, information and knowledge. To make this process easier for researchers a supporting system in the form of virtual research environment (VRE) may be employed. VREs act as an online system enabling collaborative research activities beyond geographical borders and providing researchers with tools managing complex tasks (Grayling, 2009; Candela, Castelli and Pagano, 2013; Zuiderwijk et al., 2016). Zuiderwijk et al. (2016) note that a big data-driven VRE should have integrated tools for search, accessing, integrating data and fostering collaboration among scientists. The authors propose several requirements for this kind of VRE, among others: data storage, data accessing, data computational services, data curation and data cataloguing. These requirements would allow VRE to provide researchers with integrated open data from different domains and provide open government data in combination with open research data.

Also, boundary organisations can be deployed as an effective tool to facilitate open data collaboration between industry and academia. Perkmann and Schildt (2015) highlight a case study of a boundary organisation in the Structural Genomics Consortium (SGC) that practiced an open data approach and encouraged innovators to build on the work of others that are deposited in a common data bank. The SGC allows pharma industry partners to disclose their research problems to an audience of innovators from academia by shaping the organisation's research programme. Each pharma company compiles a wish list of proteins they want resolved by scientists.

These lists are combined an anonymised into a master list that was never disclosed to the public and circulated for approval board of directors from the sponsor side along with a scientific committee. Confidentiality is regarded as a key factor and priority for companies as they want to avoid their R&D priorities becoming public knowledge. In addition to appealing to firms, the SGC also pursued strategies to attract and motivate participating scientists. First, they promote the opportunity to work on previously uncharacterised proteins in a state-of-the-art programme. Secondly, the SGC encourages researchers to engage in follow-on research beyond the proteins master list to pursue their scientific curiosity leading to more demanding research and higher scientific impact. This freedom allows scientists to publish high impact articles and facilitated the career progression of participants. The SGC also adopts academic practices by distributing funding to universities so they can employ the researchers on academic terms. The concept of boundary organisation as exemplified through the SGC by Perkmann and Schildt (2015) is working model for open data collaboration between parties with different interests. This model is visualised in Figure 32 below.

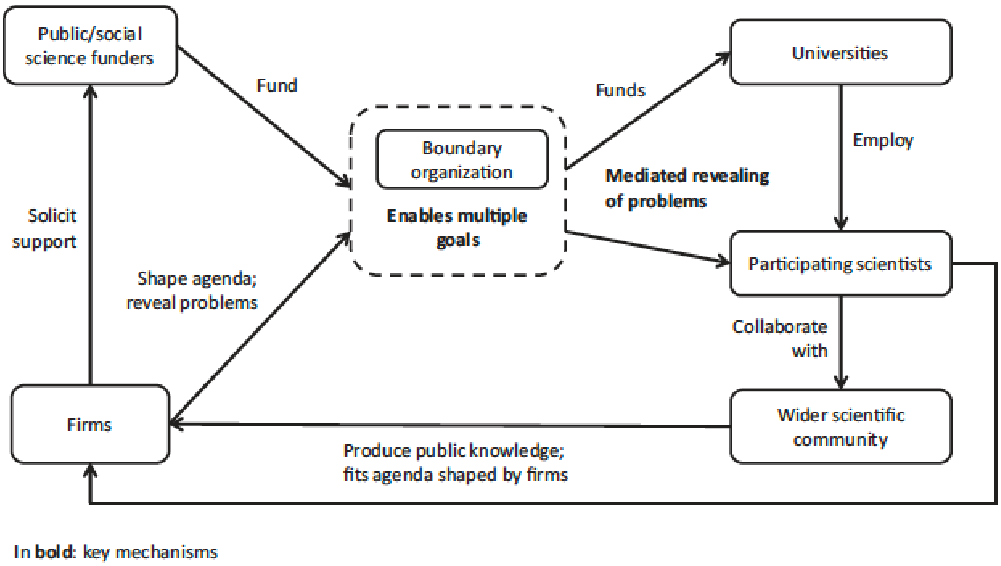

Figure 32: Boundary organisation model for open data partnerships (Perkmann and Schildt, 2015)

7.2.4 Conclusions on literature review

While the many benefits of open big data have pushed initiatives and models from an organisational level, it seems that actual open science approaches are still somewhat lacking. This can be attributed to several reasons. First, the scientists' personal motivations, the actual factors that drive their data sharing behaviour, are seemingly not addressed. Their reluctance to share research data stems from their attitude towards data sharing. The factors affecting the attitude are their expected return and worries in data sharing. Secondly, with big data being a recent phenomenon, the challenges that it brings must be addressed to fully enable data sharing. There exist potentially serious legal, privacy, ethical and security issues linked with open big data that are of real concern. Technical challenges are related to big data storing, management and processing.

Commercialisation and collaboration models for big data exist. Commercialisation of open government data has seen new business models emerge, some of which could possibly be applied to researcher's big data repositories. Researchers could potentially offer their data as supply, analyse it further for more value or link it up with other data sources to come out with new findings. VREs and boundary organisations offer researchers the opportunity to not only collaborate among themselves but also with government data and industry data, respectively. These two forms of ecosystems could allow scientists see the benefits of open science and open data.

7.3 Implementation of the pilot

This pilot implementation consisted of two use cases. The first one featured a currently closed database of a Finnish Foundation. We investigated how to open this database through interviews with data owners, potential users and open science experts. We looked at opportunities, obstacles and business models for opening the database with the aim to generate increased understanding how to develop sustainable business model for big research data sharing. The second case study featured currently open research database of GCAT in Spain. We looked at opportunities, obstacles and the business models used in this case with the aim to provide best practices how to manage and operate efficiently an open big research database.

7.3.1 Case 1 – Foundation

Our main criteria for the case was that it needs to provide potential to discover real challenges of opening big data, and to identify ways of overcoming these challenges. We selected a database of a Finnish Foundation as our case study, as it fulfilled the above criteria, and was readily available for us to study. The foundation has supported thousands of Finnish private persons and small companies with granting conditional pay-back funding since its founding in 1970s. The database features over 20.000 applications for funding, the funding decision documents as well as the progress reports related to the funded applications. The database is currently closed. It is used for tracking the applications to identify those inventors that fall under funding pay-back reimbursement.

7.3.1.1 Research methods

We developed three distinct interview questionnaires – one for database owners, one for potential users of the database and one for open science experts. We invited all board members of the Foundation (six persons) to represent the database owner in the interviews and one old employee being expert in the topic having worked over 15 years with the database to identify opportunities and constraints related to opening the database. We then invited potential external users to the interview based on the convenience sample, the first author knowing them as doing related research to clarify their interest and needs for database. Furthermore, we invited experts in open science at Aalto University in Finland to the interviews to provide their view on open science barriers and possible solutions. We conducted altogether 11 interviews in March-April, 2017 and three follow-up interviews in May-June 2017. The interviews were conducted face-to-face, when convenient, otherwise by phone. The interviews lasted approximately 30 minutes. The interviewees received a memo of the interview notes, which they were able to verify and add further information. Table 10 presents a list of the conducted interviews.

Table 9: List of interviews

Title of interviewee	Organisation	Interview date
Chairman of the Board	Foundation	23.03.17, 11.05.17
Board member	Foundation	20.03.17
Vice Executive Director	Foundation (until 2013)	04.04.17
Associate Professor	Aalto University, Department of Industrial Engineering	23.03.17
Research Scientist	VTT Technical Research Center of Finland	05.04.17
Assistant Professor	Hanken School of Economics, Entrepreneurship	21.03.17
Postdoctoral Researcher	University of Jyväskylä, Department of Computer Science and Information Systems	27.03.17
Legal Counsel	Aalto University, Research and Innovation Services	04.04.17
Grant Writer	Aalto University, Research and Innovation Services	05.04.17, 09.06.17
Specialist	Aalto University, Research and Innovation Services	06.04.17, 19.06.17
Senior Statistician	Statistics Finland, Research	04.04.17

We analysed the interviews through comparing the views of the owners, potential users and external experts in regarding the value and future use of the database. We also collected secondary research data regarding the database and open science strategies and the related business models at Aalto University. Having different data sources through triangulation we can validate our findings from interviews. Based on the interviews and secondary data sources we developed a proposal for possible solutions related to the future use of the database. We then asked feedback for our proposal from database owner and two open science experts. Based on these three follow-up interviews, we selected two of the solutions as sustainable business cases that can bring value to both data owners and potential users.

7.3.1.2 Key findings from interviews

Based on the interviews with database owners, the owners see the database to be unique and valuable, as it contains information regarding the impact of external funding for inventions and the progress of funded inventions. This information has been collected over 20 years and provides bases for researchers for example to examine the factors underlying the success of inventions. It also has potential value for inventors to understand what related inventions have been made and to search for potential partners. The database enables the owners to collect conditional pay-back reimbursements.

There are many barriers for data sharing such as confidentiality and technical matters. This is why the database owner would only share the data for research purposes with those researchers that that sign non-disclosure agreement (NDA) with the foundation for the use of the database. The primary motivation for database owners for sharing the data is the possibility to share the costs associated with the database maintenance with external researchers. Other motivations could be share this data for society to support the development of increased understanding on how to promote invention activity and what is the impact of this activity.

Based on the interviews with potential users of the database, there is initial interest towards the database from two users. They value the database as being comprehensive, unique and large. The real research value of it would come from linking the database with other datasets e.g. from Statistics Finland, to understand the connections of individual people and companies and the influence of this. The willingness to pay for it depends on how well the data suits to researchers’ specific research questions and objectives and how easy it is to use the database to collect the data needed. Typically, in commercial databases there is a person working with administrating the database, who researchers can contact for guidance and further information regarding the database. The data is then often anonymous for a researcher, and the administrator handles the raw data that is confidential. Our interviews reveal that when the following conditions are met, fit to the users´ specific research questions, easiness-of-use and the administrator support available, the researchers would be ready to pay for the access to the database. If only the first criteria is met, the researchers would pay less.

Based on our interviews with open science experts at Aalto University, researchers today have too little knowledge about open science. Some researchers think that open research data means the data can be accessed by anyone whenever and for whatever purpose, similar to government data. However, this is not true as researchers can themselves decide who can use their data and how. They can restrict the usage to only the members of their research team and give conditional access to others e.g. if they develop a joint publication with the data owners. In this way, the researchers can also verify that the external user understands the nature of the data and its limitations. Furthermore, it is possible to define that the research data can only be used for research purposes, and in certain levels. More training is needed to get the researchers to realise the benefits of big data sharing. One solution currently thought at Aalto University would be to assign one person – a researcher also – for supporting other researchers in his/her department for sharing research data and to get funds for doing that. It is important to develop communities with specific research fields that support the research data sharing, as this would also motivate further researchers to share their research data as they would see that the benefits associated with data sharing would be realized in practice through active communities around the data sharing.

According to open science experts researchers need also further incentives to open their research data that are aligned with their career development. One incentive can be getting an additional publication as open research database. Opening research data also enables others to get interested in the work of the researcher, read it, cite it and possibly to develop joint collaboration around the research data. The problem today seems to be that the researchers don’t often consider these additional benefits that can occur through publishing the research data. Regarding the case of the Finnish Foundation, an important motivation to open the big database would be to get an additional party to take part of paying the maintenance costs.

According to open science experts at Aalto University it is very likely that in the future the financing of the universities is partly dependent on their research data publication rates, which will certainly force the researchers to open their data. However, the ultimate decision how widely to open the data would rest on the researcher and thus also clear incentives are needed for researchers for data sharing. These incentives would need to be such that they support the career development of the researchers e.g. to start and advance in tenure track system.

Open Science experts highlight that it is important for a researcher to make a plan for open research data before starting the research. In this way, many of the barriers related to legal, IPR and usage issues are taken care of during the research process. Regarding the case study of the Foundation, many of the barriers are due to that the database has not been developed from beginning for research purposes. For instance, the data would need to be anonymised for sharing it in a way that it is not possible to identify the names of the persons, only their work titles. Furthermore, IPR issues could have been solved through asking the permission of the inventors that the foundation has the right to publish their invention related applications e.g. after 10 years as anonymised data. Regarding the technical issues, it would have been required to have different types of user rights – at least two kinds - for reading and editing. In this way, it would be less risky to integrate new users to the database as they would not be able to accidentally delete any of the contents.

7.3.1.3 Development of alternative solutions for data sharing

Based on the interviews, we identified three distinct user groups for the database of the Foundation to be researchers, policy-makers and entrepreneurs. Accordingly these three different user groups have different opportunities for exploiting the database. The researchers may exploit the database to examine the issues such as “What determines the success of inventions” or “How the geography of inventions evolves and why?” and to develop high-quality publications based on it. The policy-makers may examine the issues such as “What is the impact of policy changes on invention type/rate?” and thus to enhance current innovation policies. The entrepreneurs and small business could exploit the database through investigating “Has similar ideas been invented before and if so, how?” in order to enhance their own ideas and “Who has made inventions in similar areas?” to search for potential partners.

There are though remarkable barriers (legal, IPR and technical) for opening the database for external users. First, the database contains confidential information regarding individual people and companies. Second, there are technical barriers due to the database not being developed for external purposes and thus there are no guidelines, no classification of data contents and no separate copies of it, which all are necessary requirements for external use purposes. These barriers lower the motivation of the Foundation to share their database for external users, as there is a risk that the external user would not treat confidential information accordingly and could accidentally destroy the database, as it is not possible to define different usage groups with different usage rights. This is why the data owners emphasized that their prerequisite for database sharing is that it is used only for research purposes and for researchers that sign non-disclosure agreement (NDA) with the foundation for the use of the database. The primary motivation for database owners for sharing the data is the possibility to share the costs associated with the database maintenance with external researchers.

Based on the interviews, we developed alternative solutions to overcome the barriers. All of our solutions provide access for database for researchers, as this was the prerequisite from the foundation for database sharing. First option is to give an access right for selected researchers who sign NDA to utilize the database for research purposes (either free of charge or with yearly subscription fee). Second option is to develop a passive database with separate copy with anonymous data and restricted contents. This would allow external users to use the database without any conflicts with confidentiality issues. Third option is to transfer (sell or give) the database to an external stakeholder such as Statistics Finland or National Archive. Figure 33 illustrates our findings from interviews regarding the underlying opportunities of the database, the barriers to open the database for external users and alternative solutions.

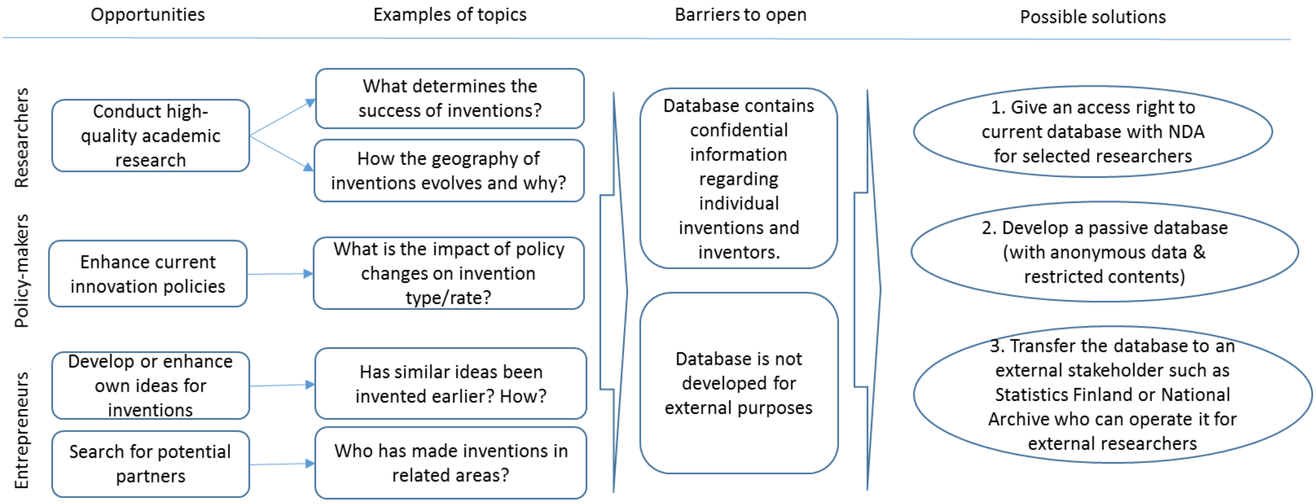

Figure 33: Opportunities, barriers and alternative solutions for opening the database of the Foundation

7.3.1.4 Feedback from stakeholders regarding the alternative solutions

When we compare the user requirements (contents, functionality and additional services) to our possible solutions we can conclude that our first and third solutions are viable. When we presented the possible solutions to the database owners and open science experts, they also regarded the first and third solution as viable. The first solution could work as an intermediate solution for the Foundation as long as it has needs for the database itself. Giving an access right to selected researchers with NDA would support it sharing some of the database costs and offer possibility for the Foundation to get better understanding about the real value of the database for researchers and other stakeholders. Our second solution about developing a passive database, is not very appealing to the researchers, as it is very relevant for research purposes to link the data to other data sets (on individual level). Thus, there would be no interest to pay for a passive database, and it would not be profitable for the Foundation to do that. Furthermore, this solution is not interesting to policy-makers and industries, as they also need the in-depth information in order to get value of the database. Our third solution to transfer (sell or give) the database to an external provider to administrate is also a viable one. In our interviews, two of the researchers would see this as a good solution of which they would be ready to pay, when they have closely related research projects. In this option the new owner of the database would act as an administrator taking care of the confidentiality issues according to high-quality, standards. Foundation was also positive about this solution and regards that they could sell or give the database to a 3rd party when the foundation no longer itself has needs for the database.

7.3.1.5 Conclusions

The case study of Finnish Foundation demonstrates how it is possible to define sustainable business cases for big data sharing that would benefit both data owners and possible users. As a result of the case study, we recommend a similar process to be taken in other organisations to strengthen open science efforts related to big research data sharing. Figure 34 presents a generic process model for big data sharing.

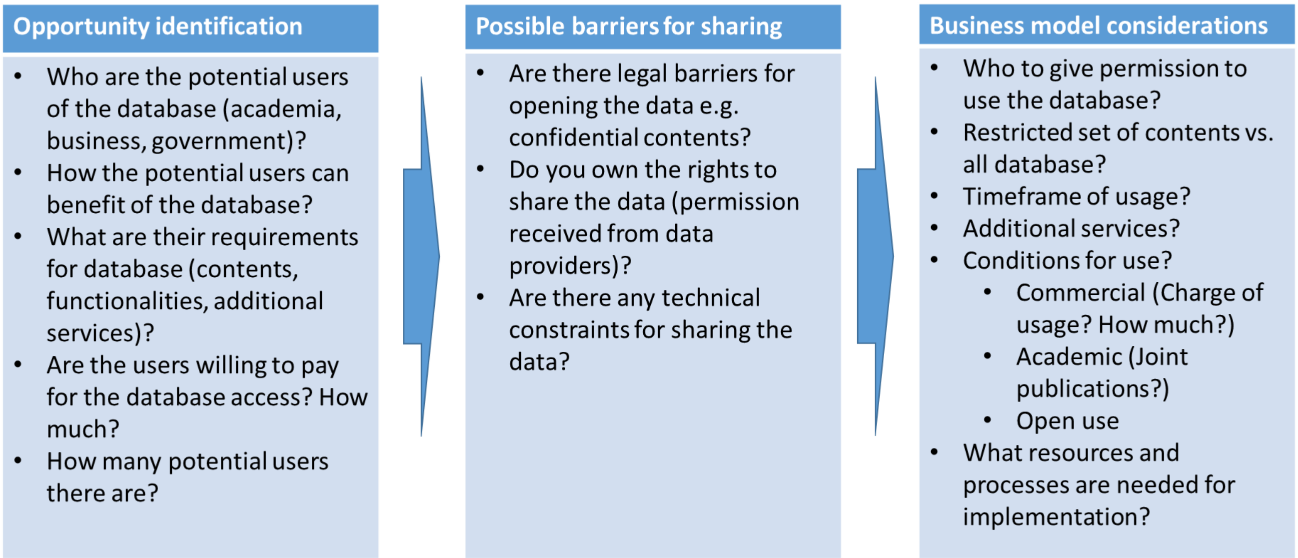

Figure 34: Framework for opening big research database

The first step in the process is opportunity identification. This is a crucial step that ultimately determines whether the benefits of opening research database overcome the effort and cost of doing it. If there are clear foreseen benefits of the data owner to share the research database, this will provide key motivation needed for him/her to do that. It is important first to understand who would be the potential users (academia, business, government) for the database and what opportunities they have in relation to the database usage. Second, one needs to clarify what are the specific requirements that the potential users have towards the database and their willingness to pay for the database access. Finally, it is important to estimate the size of the potential user base.

Once the opportunity has been identified, it is important to investigate whether there are any legal, IPR or technical barriers for sharing big research data. These barriers may provide constraints for whom the permission can be given to the database and whether it is possible to share all contents or only restricted set of them e.g. anonymised data. It might be needed also to do technical adaptation and new functionality when sharing big research data for external users.

Final, the last stage is related to the business model consideration. First, one needs to define to whom and how to open the big research database. The owner can furthermore define restrictions for usage regarding the contents, the timeframe of the use and the conditions for use (price vs. academic reward). After this, it is important to test with a few potential users that the identified business model is seen sustainable by both data owners and users, and to adjust if needed. It is also important to consider what resources and processes are needed for the implementation. This may require technical adaptation to the database, new functionality or services, guidelines for users etc., before it is possible to share the data. Researchers need to consider in which data repository to publish the data, which metadata to utilize and where to store it so others find the data set and how to select a proper license for a data set. Once the database has been opened, it needs continuous resources and processes for maintenance e.g. accept new user requests, respond to user questions etc. The data owner can do this or select an external person to do this.

7.3.2 Case 2 – GCAT

The role of the GCAT case study was to capture the experience of a research big database from a biomedical research project in their approach to share the data (and biological samples) gathered in the course of the project. Exchange of biomedical research data is one of the fields where these types of information exchanges are already happening, so it can provide useful information and lessons learnt from their experience. Our main criteria for the selection of this case study was that it was an open database with some experience in sharing data and with the possibility to interview both sides of the exchange. We selected the GCAT project because it has been running for a few years, and recently started to open their genetic data to other parties for further scientific research, directly and through what we call 'data brokers', therefore providing an extended view of the relation between the different actors participating.

The Genomes for Life (GCAT) project is a long-term prospective cohort study that was designed to integrate and assess the role of epidemiologic, genomic, and epigenomic factors in the development of cancer and other major chronic diseases. The GCAT project was designed to recruit general population from the northeast region of Spain, Catalonia, with a population of 7.522.596 inhabitants.

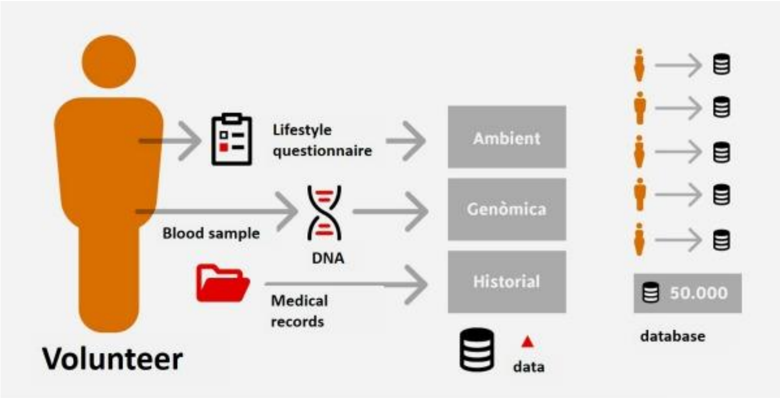

Figure 35: GCAT data structure (Source: GCAT website)

The project started in 2014 collecting data through a self-administrated computer-driven questionnaire, and underwent blood pressure, cardiac frequency, and anthropometry measurements. For each participant, blood plasma, blood serum, and white blood cells are collected at baseline according to standardized procedures. The GCAT study has access to the Electronic Health Records (EHR) of the Catalan Public Health Care System. Participants will be followed-up 20 for years after recruitment. The first active follow-up started in March 2017 and will end in June-July 2017. At the end of 2017, the GCAT study will have recruited 22.000 participants.

7.3.2.1 Research methods

We developed three distinct interview questionnaires – one for database owners, one for users of the database and one for data brokers. We invited the scientific director of the project, the scientific director of the research organization, a representative of the data broker organization, and two users of the project research data. We conducted altogether 6 interviews in March-July, 2017. The interviews were conducted face-to-face, when convenient, otherwise by phone. The interviews lasted between 20 to 60 minutes approximately. The interviewees received a memo of the interview notes, which they were able to verify and add further information. Table 11 presents a list of the conducted interviews.

Table 10: List of interviews

Title of interviewee	Organisation	Interview date
GCAT project Scientific Director	PMPPC-IGTP	31.03.17, 30.05.17
Head of the Molecular Diagnostic Unit, Hereditary Cancer Program	Laboratori de Recerca Translacional, Institut Català d'Oncologia	13.06.17
Lead of the Comparative and Functional Genomics group at the Institut de Biotecnologia i de Biomedicina (IBB)	Universitat Autònoma de Barcelona (UAB)	13.06.17
Head of the European Genome-phenome Archive (EGA) at the Centre for Genomic Regulation (CRG)	Centre for Genomic Regulation (CRG)	29.06.17
Scientific Director	Fundació Institut d'Investigació en Ciències de la Salut Germans Trias i Pujol (IGTP)	13.07.17

We analysed the interviews through comparing the views of the owners, users and data brokers in regarding the value, use, and hinders for the usage of the database. We also collected background information about the use case, and information about the researchers Data Access. Based on the interviews and the additional information collected we provided a set of best practices, barriers and success factors to be considered in similar big research data scenarios.

7.3.3 Key findings from the interviews

In the first place the GCAT database owners provided information about the key aspects in the management of the data, that is, Openness, Standardisation, and Anonymisation and data aggregation. GCAT data is open since 2017. GCAT is a supported access resource and supports making genetic data broadly available to further scientific research, increasing the scientific potential of the collection; making it reusable and efficient in terms of the resources that are used, and generating multiple gains to the volunteers and society through the use and sharing of public and personal health information given by the volunteers. Take advantage of synergies with the public health sector for which we generate knowledge through a collaborative framework. Controls over access will help ensure protection of the privacy of those individuals who have agreed to have their genomic sequencing data placed in the GCAT database, as well as that of their family members.

Access and transmission of data implies and acceptance of the intellectual property, both that generated by GCAT and that produced by the researcher. Access is defined in the terms and conditions established and accepted by the GCAT participants, including the fulfilment of the consent granted. Access to the data and/or samples is granted after a scientific and ethical examination of the research. The conditions and access procedure are established in the Data Access protocol. The GCAT samples and data can be used for biomedical research by universities and public institutions and profit and non-profit-making private companies. The shared use of the biological samples is one of the objectives of the GCAT.

All the proposals are evaluated by the relevant committees (scientific and ethical) to ensure that they are consistent with the consent of the participants, that they have the pertinent ethical approval and that they are up to the desired standards of excellence. The policy is to prioritize, for information sharing, collaborations with research projects on predisposition, evolution and treatment response of diseases, and advance in personalized approaches to manage chronic diseases; from prevention in public health to diagnosis, and predictive response to drugs.

Additionally, GCAT collaborates with two entities, which act as infrastructures for research institutions, to provide access to their biological samples and data.

The **European Genome-phenome Archive (EGA)**. EGA provides a service for permanent archiving and distribution -including standardization and data curation- of personally identifiable genetic and phenotypic data resulting from biomedical research projects. Data at EGA was collected from individuals whose consent agreements authorise data release only for specific research use to bona fide researchers. Strict protocols govern how information is managed, stored and distributed by the EGA project.

The Biobanking and Biomolecular Resources Research Infrastructure - Large Prospective Cohorts (BBMRI-LPC[18]). GCAT is an invited collection in the BBMRI-LPC catalogue. This infrastructure is used to store and provide access to biological samples.

GCAT is not a profit organization but apply a cost for any sample and data requisition. A quota will be charged for access, with the possibility of higher charges for organizations which could be expected to make a profit from the use of the resource. Fees are charged for:

- Data / Sample Consultation (around 200€, not applied until 2018)
- Access data only (around 1.500€ bulk raw data, genetic data)
- Access sample (DNA, plasma, serum) depending of scarcity

Bespoke quote are for application that request customization of data sets.

Current fees are under evaluation. GCAT fees are updated taking in account the use and reuse of current data.

Information and metadata follows standards to guarantee interoperability and reusability.

- Pre analytical information about collected samples procedures with a SPREC code[19] for each sample.
- Laboratory Information Managing System (LIMS)[20], a system to track alls samples, subsamples and procedures in an automated mode.
- Genomic raw data from blood derived samples is based on ILLUMINA[21] platform, and genome variants in BAM Format[22] files.
- Lifestyle and health factors information structure, which is collected through a survey that is taken by all volunteers, uses standards set by BBMRI.

The GCAT project does not store any personal data. Personal information is managed by a public partner, the Tissues and Blood Bank (Banc de Sang i Teixits, BST) which is a fully owned public company in charge of collecting blood donations, processing and distribution to hospitals. This organization has the infrastructure and the legal framework to store personal information from blood donors. As a partnership, BST stores the personal consents from GCAT volunteers and all identification data. It serves as a bridge to obtain clinical data from the public health system from the PADRIS system, managed by AQuAS, which is a fully owned public company dedicated to manage the ehealt infrastructure in Catalonia region. Even if traceable, GCAT only stores an internal code for each individual, keeping confidentiality of data analysis. De-anonymized Electronic Health Record information is to be merged with the self-reported information that GCAT participants contributed at baseline. The EHR access will also allow to follow-up participants during a long period of time.

From the interview a few factors are identified as potential barriers for the external use of the data:

- Economic cost to generate the information is reflected in some minimum fees to access the information, and this effort is not always well perceived from the scientific community.
- More complex data, with additional layers of information are required to make the collection more appealing.

[18] BBMRI-LPC is one of the largest biobanking networks in Europe aiming to facilitate scientists' access to large prospective study sets on human health and disease.
[19] SPREC identifies and records the main pre-analytical factors that may have impact on the integrity of sampled clinical fluids and solid biospecimens and their simple derivatives during collection, processing and storage. http://www.isber.org/?page=SPREC **Es ist eine ungültige Quelle angegeben.**
[20] https://en.wikipedia.org/wiki/Laboratory_information_management_system
[21] Illumina, Inc. is an American company that develops, manufactures and markets integrated systems for the analysis of genetic variation and biological function. https://www.illumina.com/. **Es ist eine ungültige Quelle angegeben.**
[22] http://genome.sph.umich.edu/wiki/BAM. **Es ist eine ungültige Quelle angegeben.**

- The nature of the GCAT cohort it is erroneously seen as a caveat. As the samples come from the general population, there are not a large number of cases of a specific casuistry, so this is not appealing for research on specific diseases.
- There is a potential risk of identifying individuals from the information collected that prevents sharing the whole information.
- Our internal structure to support more collaboration is limited. It has to be strengthened.

As for the opportunities:

- A potential way to increase the reuse of the GCAT data is removing the access fees for the best projects submitted to a call to analyze the GCAT database information. This is similar to what the BBMRI-LPC does at European level. So far, GCAT is an invited cohort at the BBMRI Catalogue.
- To motivate further uses it is just required to expand the current types of collaboration. To boost this it may be required to strengthen communication with third parties, to stimulate collaboration from the public sector to provide facilities for innovators and entrepreneurs, improve protection for entrepreneurs, and an effective patronage law.

Based on the interviews with GCAT database users, they are interested in the Genomic and related data (epidemiologic, health records) for research on genomic variants as the origin of some diseases or to be used as control group for the genetic study on cancer. The value is perceived as a database containing a large amount of genetic information available in addition to phenotype, epidemiologic and health records information. Maybe more characterization of the samples (more data) would be good, as other similar collections provide this extra information. The access through the GCAT access committee, worked as expected, and the requirement to pay a fee is not found extraordinary, as it is a usual requirement in other databases, to be registered or the payment of a fee. However, legal barriers to access to health records are not yet solved. Barriers to access sensitive data, however, are understandable, as these are required barriers to avoid inappropriate uses, but they could be made more efficient in order to access data more quickly.

From the interview with GCAT database users, a few factors are identified as potential barriers for the external use of the data:

- Amount (details) and quality of data.
- Legal barriers to access sensitive data.

As for the opportunities:

- More efficient processes to solve access to sensitive data.

Based on the interview with the representative from the data broker EGA the following interesting insights were collected. The decision on providing access to the databases managed in EGA always relies on the Data Access Committee (DAC) from each project, so in this respect GCAT is perfectly aligned with the standard procedures in Europe. In the US and Japan there is a different approach, where the archiving entity has the decision power to provide or not access to each request. EGA’s goal is to avoid non controlled access to the data they manage on behalf of the projects that have generated it. So mainly the EGA is itself a (necessary) barrier. Usually the most common barriers and hinders to access data from other projects managed by the EGA come from the following topics:

- Quite often, the Data Access Committee (DAC) is the researcher itself, which it is not a professional on data management. Sometimes the DAC of a project is not responding the requests from a potential user.
- Informed Consent protocols are often quite complex documents to be applied in the right way. E.g., if the protocol establishes that no data can be shared with profit organizations, maybe it forbids sharing this information with the research branch of a pharmaceutical company which is looking for a new drug for a disease related with the goal of the research project that produced the data, which is not good.

- Quality of data. Research data is useful if it provides additional information on donors and the process to obtain the biological samples and the analysis methods used. This is not always true in some research projects.
- In some cases not all the information to make a proper use of the data is provided, because the researcher does not want any trouble for sharing some sensible information (personal related data).
- The amount of data is quite huge in some projects, like 0.5 petabyte of data, so this requires some data management capabilities that are still not solved as of today. However, most projects produce more manageable amounts of data.
- The information is not good enough, often because the post-doc who created that information is no longer in the project and it is poorly maintained by somebody else.

To overcome these obstacles the following approaches may be of help:

- Use standardized Informed Consent protocols with categorized ontologies for access conditions. The clearest the documents are for both parts, the easiest to obtain access to the data
- Availability of near and trusted cloud infrastructures. In this regard there is a plan to have a European Open Science Cloud available in the near future. In other regions like USA, they rely on private infrastructures like the ones provided by companies like Google or Amazon.
- Force the research projects publicly funded that part of the budget is duly devoted to data management, making data available through open public infrastructures beyond the projects life cycle.

From the interview with data broker, EGA, a few factors are identified as potential barriers for the external use of the data:

- Scarcity of resources in the projects especially in the data access committee and data management activities.
- Complexity of Informed Consent protocols.
- Quality and completeness of data.
- Management of huge amounts of data.
- Legal barriers to access sensitive data.

As for the opportunities:

- Standardised Informed Consent Protocols.
- Near cloud infrastructures to facilitate data interchange.
- Specific budget for data management activities in projects.

7.3.4 Best practices and lessons learnt

Based on the interviews to the three groups of stakeholders playing a role in the field of biomedical data sharing, we identified the following topics of interests for the successful collaboration through big research data.

Openness is required, but providing an access control mechanism is a must to avoid unwanted access and assure a minimum quality of the target projects that will reuse the data. Therefore, a Data access Committee that evaluates scientific and ethical aspects is desired. Furthermore, the standardisation of Informed Consent Protocols (the Data Access protocol in GCAT) with categorised ontologies is paramount to achieve a clear collaboration process and avoid issues during the course of the collaboration, including NDA agreements to avoid possible leakage of personal data after matching with additional data using Big Data technologies. However, in many cases, due to a lack of resources, the Access Committee task is assumed by a one-man band, likely the principal researcher, that has to deal with scientific, ethical, data management and legal issues with not much support.

In the biomedical area it is assumed that access to third party databases has a cost, and it is perceived as a way to sustain the data access, but not a profit mechanism. Establishing calls for projects to access research data for free (without access fees) seems to be a good way to increasing the competence among the best propositions for the reuse of information, similarly to what the BBMRI-LPC does at European level. This can act as a natural selection process, decreasing the need for resources to collaborate with many projects at the same time. Only the best projects are chosen.

The role of infrastructures that provide access to data from many different projects from the biomedical area, like the EGA, has not been emphasised much in the interviews, probably because it is seen as a commodity tool, but seems to play an important role in the process of providing standardised access to data, and at the same time releasing some tedious tasks to the projects that provide the data, and acting as a single entry point for those looking for research data. The availability of near cloud infrastructures is, as well, seen as an important component to facilitate the interchange of data for the collaboration. In this regard the deployment of the planned European Open Science Cloud or similar infrastructures could be a solution.

From the answers collected, the quality of data plays an important role for the users at the time of selecting one dataset for their research activities. Therefore, the scarcity of resources in the projects which generate the data has an important impact. In this regard, forcing publicly funded projects that part of the budget is duly devoted to data management, and making data available through open public infrastructures beyond the project life cycle seems an approach in the right direction.

From the point of view of users, the more complete and detailed the data, the better, as this could be a determinant aspect at the time of selecting one or other database. As well, any barriers to access some sensitive data needed to proceed to the further research or innovations, should be solved before opening the data, or otherwise could cause some loss of confidence and the collaborative process could be harmed seriously.

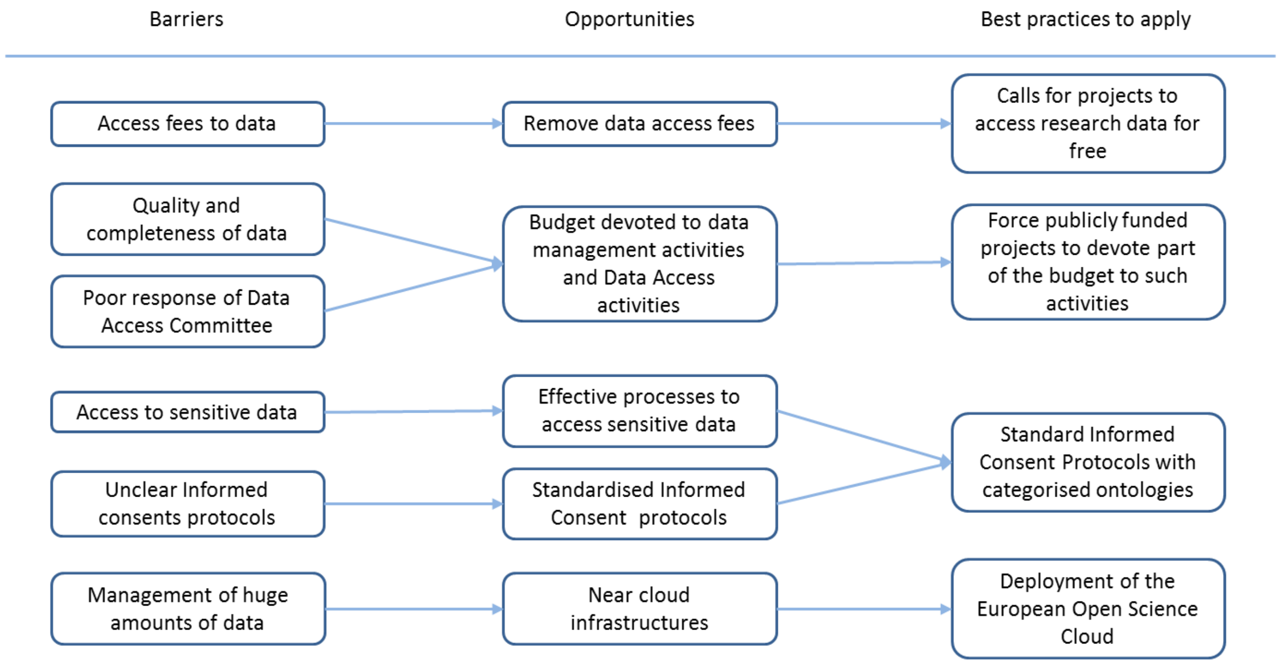

Figure 36: Barriers, opportunities and best practices from GCAT use case analysis

7.3.5 Conclusions

The case study on GCAT database demonstrated how to manage an open database for researchers. As a result of the case study, we have highlighted lessons learnt and best practices for managing big research database. Figure 37 illustrates the business model for GCAT (Adapted from Johnson, M.W., Christensen, C.M., & Kagermann, H. (2008) Reinventing Your Business Model. Harvard Business Review) with a clear value proposition for external researcher, profit formula and key resources and processes required.

The most important highlights from the analysis of this use case to achieve successful collaboration though data access are:

- Minimizing the data access fees and attracting the best researchers. This can be achieved through open calls for projects. With this approach, the openness and collaboration objectives can be achieved more easily. However the costs for sustaining data access must be funded in some way. At the same time, projects have limited resources to support collaboration with third parties and guarantee the quality of data and a responsive Data Access Committee, so some resources need to be allocated to provide the basic means to establish an effective collaboration.
- Access to personal information, even with anonymised data, is a risk that big data technologies have proven to be true, as data can be matched with other databases that may reveal some personal information that was not intended to be there. Some NDA agreement needs to be part of the informed consent protocols. In the same regard these protocols need to be standardised to avoid disparity of criteria among projects
- Infrastructures for data brokerage and big data sharing are important to ease the collaboration process. These infrastructures can be sector specific or more generic, even some public or industry tools or platforms (cloud data repositories) can be used for that goal.

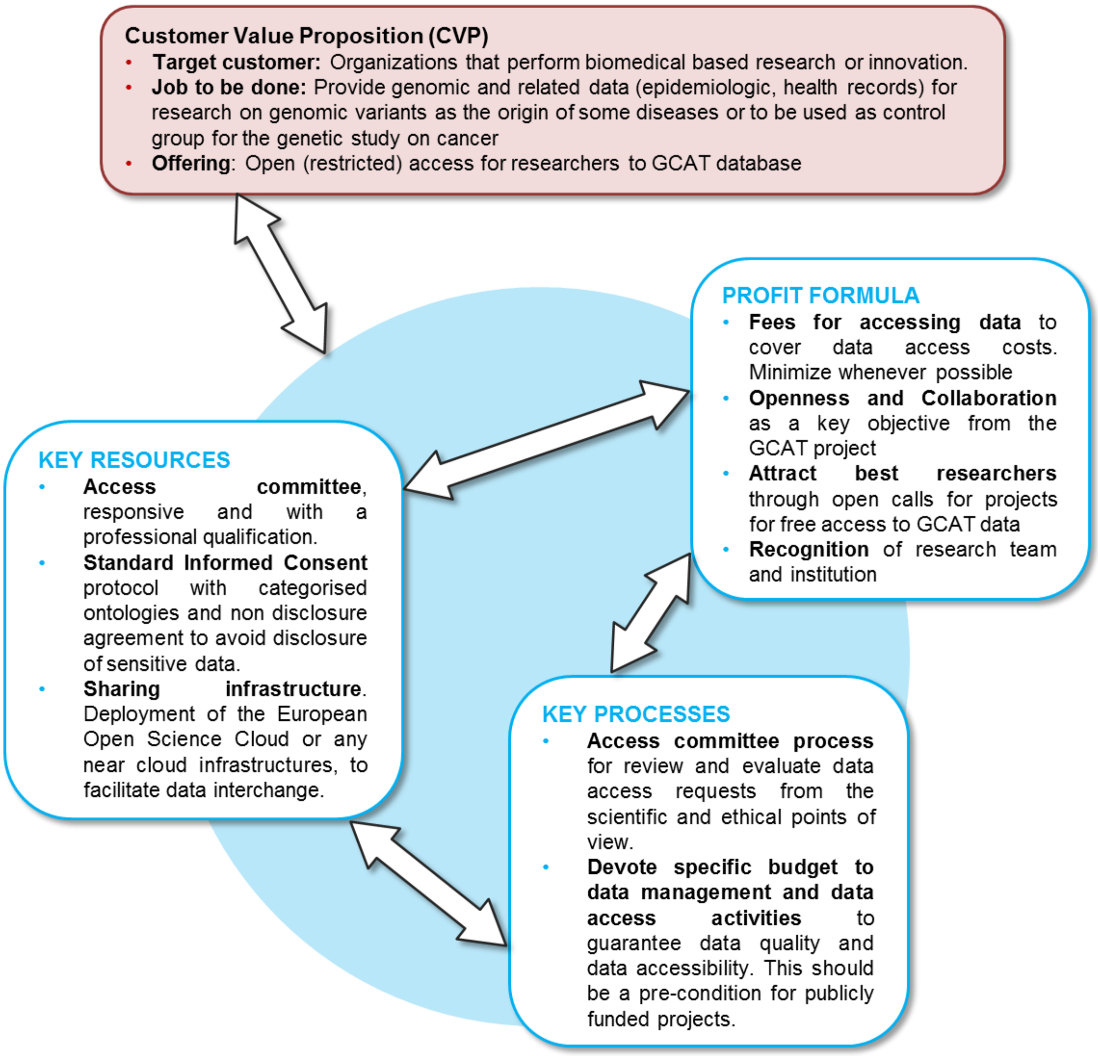

Figure 37: Business model applied for GCAT

7.4 Conclusions & Recommendations

7.4.1 Conclusions

There are a number of key opportunities related to big data sharing such as 1) reproducible and accelerated research through open access data, 2) new, innovative business models from linking up different data sets, 3) new products and services based on open data and 4) organizational transparency that enables communities to feel empowered. However, there are also key obstacles such as unwillingness of research groups and individual researchers to share big research data due to 1) perceived effort and cost of data sharing, 2) privacy and security issues when combining data sets, 3) management, governance and processing of big data. In order to strengthen open innovation through big research data sharing, it is essential to motivate researchers to share their data through the identification of sustainable business models for data sharing that benefit both data owners and the potential users. Our case study on the Finnish Foundation provided a systematic method for identifying such sustainable business models, while the case study on the GCAT provides best practices and lessons learnt for successfully managing an open research database.

Key Findings

The key findings from the case study of Finnish Foundation are:

- Sharing big research data doesn't mean giving it away for free - there are sustainable business models abound
- In addition to commercial benefits, there are possibilities to increase collaboration and recognition of the research group, and thus to enhance the research output and quality
- Joint research can be a put as a requisite for externals to access the research data
- The focus for the development of sustainable business models should be to the creation of win-win models between data owner and potential users to strengthen the motivation of researchers to share the data an potential users to take advantage of it
- The business model thinking supports bridging the gap between open science and open innovation

The best practices from the case study of GCAT are:

- Ensure quality and the completeness of the big research data to attract external users to exploit the database
- Use “Call for projects” to attract best researchers and provide them free access to data
- Allocate sufficient resources for data maintenance and handling user requests
- Openness through access control, management through a data access committee
- Standardised Informed Consent Protocols with categorised ontologies and NDA agreements to achieve clear collaboration rules
- Standardised access to data through near cloud infrastructures

7.4.2 Recommendations

Key takeaways

We recommend data owners to initiate a careful assessment of the underlying opportunities for big research data transfer to identify whether there is an opportunity for them to share big data. As a key result of pilot 5, we provide a generic process tool for developing sustainable business models for big research data transfer. The tool supports the consideration of the uniqueness and the comprehensiveness of the dataset to understand its usefulness and interest for external users, the barriers for big research data transfer and the selection of a business model.

This information should be identified based on the discussion between data owners and potential users, and possibly interacting with funding organisations and open science experts.

Once the business model has been identified, sufficient resources need to be allocates to implement big research data transfer, to maintain the database and to handle user requests. Data access committee, clear collaboration rules and standardised access to data through near cloud infrastructures should be developed and implemented.

Furthermore, based on pilot 5 additional incentives are needed in order to provide enough motivation for researchers to share big data in situations where the opportunity for big data sharing is not commercially attractive. We recommend the following specific actions for strengthening open innovation:

1) Funding organisations should utilize the contents of the research data management plan (how widely research data is shared and to whom) as one funding criteria.
2) Universities should set research data sharing as a criteria for tenure track career progress and when hiring new professors. Researchers should gain merit for both research data sharing as well as for evidence that external parties use their research data (similar to citations being a merit).
3) Public authorities should provide increased access to valuable, relevant, and comprehensive sets of open public data, allowing the researchers to use this data in their research and possibly enrich this data with own research and findings.
4) Promoted databases for research data (e.g. Zenodo.org) should make transparent, how often a particular dataset has been viewed and/or downloaded to provide feedback in terms of usefulness (for other researchers) to motivate the researcher for sharing it.

In order to fully benefit of open research data, there is need to develop further collaborative models that attract potential users for big data. Based on the literature review, such models could include the development of a virtual ecosystems and the use of a boundary organisation.

Impact on the pilot

The findings of the pilot 5 have been communicated to the database owners, potential users and the open science experts. According to the survey carried out by S2S partner organisation JIIP to all pilot stakeholders, pilot 5 stakeholders rated the impact of the pilot 5 through various measures, for example:

- The appropriateness and applicability of Pilot 5 concepts and solutions (n=8): Radical (1 partner), Major (4 partners) and Average (3 partners)
- The impact of Pilot 5 on academics' and researchers' innovation knowledge (n=8): Major (5) and Average (3)
- The impact of Pilot 5 on cross-area innovation networking (all participants) (n=7): Major (5) and Average (2)
- The impact of Pilot 5 on the attraction of other research organisations (n=7): Radical (2), Major (3) and None (2)
- The impact of Pilot 5 on innovation collaboration with other enterprises (n=7): Radical (3), Major (2) and Average (2)

In addition, the project results have been communicated and disseminated through three publications as well as conference and workshop presentations.

Key Performance Indicators (KPIs)

The replication of the pilot can be considered successful, if the given guidance and best practices lead to increased big research data transfer, and thus support strengthening the open science movement and open innovation. The individual research groups and researchers can consider their big research data sharing successful, if it provides commercial benefits for them and/or increase collaboration and recognition of the research group/researchers with external stakeholders. Thus, the researchers and research groups could benefit of increased research quality and output.

7.5 Future line of research

Our approach departs from other open science initiatives, as it shifts the attention from a pure open research data obligation to the recognition of underlying opportunities and the development of business models to capture them. This is an essential enabler for open science to lead to open innovation. We recommend future line of research to continue using this approach in order to focus on the “carrot” rather than the “stick”, and thus to generate the motivation needed for research groups and researcher to appraise open science and thus to boost its implementation. It would be important to demonstrate successful cases of opening research data that have led to open innovation in different research fields. This would serve as a model for researchers and encourage them to share their research data. For future research, we furthermore recommend testing the validity of our framework and identifying additional issues and lessons learnt in other contexts.

8 PILOT 6: DIRECT UNIVERSITY COACHING AND TRAINING TO SMES

Executive Summary

Small and medium-sized enterprises (SMEs) are classified as companies that typically employ less than 250 people and have an annual turnover of up to EUR 50 million [23]. Most of EU enterprises are SMEs (over 99%) and they are considered very important for the European economy, as they provide two thirds of all employment [24] and are generating 4 trillion EUR of value-added [25]. An overwhelming majority (93%) of these businesses are employing less that 10 people [26].

Increasing and improving the innovation capacity of SMEs is therefore important for the European economy and society. Universities can play an important role in innovation activities and clear advantages have been recognised when industry and universities collaborate (Cockburn & Henderson 1998, Fabrizio 2009). Studies suggest that there is more likely for SMEs to launch new-to-the-market innovations [27] when they collaborate with universities in innovation activities [28].

While there are several studies on the benefits to Universities and SMEs on research and technology transfer, there is little literature on knowledge transfer of business processes (e.g. strategy process, general management knowledge, innovation process) from Universities to SMEs. For this type of knowledge transfer the importance of one-to-one interaction and coaching is proposed as an effective mechanism [29, 30, 31, 32, 33]. Literature suggests that three dimensions are important to knowledge transfer: the process of transfer, the tools deployed and used during the transfer and the facilitator(s) that organises and implements the transfer.

This pilot explored predominantly the coaching and one-to-one training delivered to 10 SMEs using university-developed knowledge on different business processes. The ten SMEs were based in UK, Austria and Spain. In addition, it compares also SME learning of business processes achieved through an open course involving 20 Irish companies.

The following were identified as knowledge transfer enablers:

- The transfer process needs to be designed to be time-efficient. That means that each engagement should not last more of 1 day and ideally less to ensure that each interaction does not put heavy burden on SMEs limited resources.
- The transfer process should have a clear logic and sequence of activities. For example, data and outputs from one process step should be used in subsequent steps to facilitate analysis and decision making.
- The SME participants need to be actively involved in the transfer process following a "learning-by-doing" transfer model. This may involve providing the participants with opportunities to apply the new knowledge

[23] https://ec.europa.eu/eurostat/web/structural-business-statistics/structural-business-statistics/sme
[24] http://siteresources.worldbank.org/CGCSRLP/Resources/SME_statistics.pdf
[25] In EU-28 non-financial business sector
[26] Annual report on European SMEs 2016/2017, EU
[27] http://dera.ioe.ac.uk/26434/1/2016_unisme.pdf
[28] **Innovation activities** are all scientific, technological, organisational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations. Some innovation activities are themselves innovative, others are not novel activities but are necessary for the implementation of innovations. Innovation activities also include research and development (R & D) that is not directly related to the development of a specific innovation. (https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Innovation_activity)
[29] Alstrup, L. 2000. "Coaching continuous improvement in small enterprises." *Integrated Manufacturing Systems* 11 (3):165 – 170.
[30] Gray, D. and H. Goregaokar. 2008. Executive coaching in SMEs - experiences and impact of the coaching process. The leadership skills programme. University of Surrey. www.ufhrd.co.uk/wordpress/wp-content/uploads/2008/06/**gray-224-fp**.pdf
[31] Iles, P. and M. Yolles. 2002. "Across the great divide: HRD, technology translation, and knowledge migration in bridging the knowledge gap between SMEs and Universities." Human Resource Development I 5 (1): 23–53
[32] Leitch, C.M., C. McMullan, R.T. Harrison. 2009: "Leadership development in SMEs: an action learning approach." *Action Learning: Research and Practice*, 6(3):243-263.
[33] Philpott. E. and K.Bevis. 2005. "Innovation needs of manufacturing SMEs: evidence from an EU region." Proceedings EuROMA – Operations and Global Competitiveness Conference, Budapest July, 1661-1667.

they acquire in practical and real situations that relate to their organisational issues. The process should also allow the participants to express their views in a neutral environment.
- The transfer process, associated tools and supporting material should be clear of academic jargon and terminology.
- Having external (to SME) facilitators who have industry experience and can relate to real business issues. The ability of facilitators to offer several examples to clarify concepts was also highly valued.

The elimination of academic language from the transfer process and the knowledge of the facilitator were particularly valued in both one-to-one interactions and open courses.

The following were identified as barriers to knowledge transfer to one-to-one engagements:

- There is a need to put more emphasis upfront to explain to SMEs what is required from them in terms of data and time and providing examples of potential outputs that the SME could have at the end of the knowledge transfer process.
- The expected outputs should be clear and having examples, case studies etc. can be very useful. There is a time lag for tangible outcomes and benefits to be realised, so managing the SME expectations is critical.
- Consideration needs to be placed in designing and developing better tools for facilitating the transfer process. Aspects such as and ease of use, embedded guidance, clear explanation of what is required in each step etc. are useful and reduce the need for users to follow complicated instructions.
- Insights are normally reached after sufficient reflection time, so the engagement process should allow SMEs to achieve this. For example, the pace of overall engagement, the time elapsing between different interactions etc. and the overall level of knowledge transfer should be considered carefully.

Some differences were found in the barriers identified for knowledge transfer via open courses. In open courses, especially when they are publically funded, there is often pressure to introduce and present a lot of material in the allocated time period. Therefore, it becomes difficult for participants to easily to follow, understand and reflect on the new content they are presented with. The examples a facilitator tends to provide in an open course to clarify new concepts tend to be generic and not company specific and although useful may reduce the relevance and impact the new knowledge may have on a particular company i.e. the relevance of how this example may have to a specific organisational issue may be lost. A common barrier between an one-to-one engagement and an open course is that the SME requires a lot of information in advance to understand the expected learning outcomes, as well as examples of potential outputs and relevant case studies.

The recommendations from this pilot as follows:

- RTOs need to employ facilitators who combine both academic credentials (in order to understand the research knowledge and methodologies) and industrial experience (in order to gain the trust of the SMEs).
- The knowledge transfer process needs to be time-efficient ideally implemented in small steps of a maximum of one day duration for each step.
- Tools are an important element of the transfer process as the codify and summarise the academic knowledge in a suitable form. The tool development is an iterative process that requires both the academic and the practitioner to work together over a period of time; it also needs to involve SMEs in the pilot phase to ensure relevance.
- The tools that are used for the transfer process need to be user-friendly with minimum academic jargon.
- The transfer process needs to allow sufficient reflection time for the SME team for refinement and alignment before decisions are made.
- Engage participants into the process by asking them to provide data, analyse information, use the tools and make decisions, etc.
- Explain in advance what outputs are expected, in what format and within what timeframe and manage expectations.

8.1 Introduction to the pilot

This pilot explores the coaching and one-to-one training as a method for knowledge transfer of business processes (e.g. strategy process, general management knowledge, innovation process) from Universities to SMEs. This is done in the form of case studies [34] with 10 SMEs based in UK, Austria and Spain.

The coaching and training method employed in this pilot could be considered as a form of up-skilling. The company actively participates in the process, provides the data, takes the decisions and also dictates the pace of engagement. The University provides the companies with tools, frameworks and examples to help them use this data to make better strategic decisions and operational improvements. Any suggested changes by the SMEs on the tools and frameworks are communicated back to the academic community and have the potential to inform future research.

This knowledge-transfer model is underpinned by three fundamental dimensions that impact success in transferring knowledge to SMEs, as suggested by literature:

1. Process of engagement – having a clear process of engagement, the outputs that could be achieved and the overall time the process to be completed.
2. Tools and frameworks – the way the academic knowledge is packaged is important to improve SME understanding and dissemination. The tools need to be user-friendly, have jargon-free language and a clear logic and outcomes.
3. Facilitator – the facilitator must be knowledgeable, impartial and trusted.

The pilot objectives are to understand the factors that are important for making direct knowledge transfer from universities to SMEs and increase this type of interaction. Specifically, the following activities were undertaken:

- Analyse existing research on the factors that influence direct knowledge transfer from universities to SMEs.
- Conduct 10+ direct knowledge transfer initiatives with SMEs.
- Monitor effectiveness of approach and barriers to transfer.
- Monitor any long-term impact of transfer to SMEs performance.

The pilot also explored differences between direct knowledge transfer via an one-to-one engagement and knowledge transfer through open courses.

The results of the pilot have been disseminated through the following academic research publication in a scientific conference: *"How inbound open innovation helps SMEs learn and improve: knowledge transfer from university to industry through direct coaching",* Clare Farrukh, Nicky Athanassopoulou and Imoh Ilevbare, R&D Management Conference, Milan, Italy 30 June- 04 July 2018. Additional publications are planned in the future.

[34] The method applied in this pilot is based on case studies and it is not statistical. For a reference please see "Case study research, design and methods", Robert K. Yin, Applied Social research methods, Vol. 5, SAGE Publications

8.2 Description of the Open Innovation Scheme

There are very few academic studies that have investigated the dimensions, enablers and barriers of business processes knowledge transfer from academia to SMEs. Most academic literature focuses mainly on technology transfer processes often to large organisations. Also, most literature assumes longer term collaborations between Universities and companies, usually on high-tech research projects.

A review paper that directly looks at the issue of processes knowledge transfer from academia to SMEs by Durst and Edvardsson 2012 [35]. It reviews six studies of internationalising SMEs, four companies based in the UK, one in Italy and one in Switzerland. The main findings from the six studies show that while the characteristics of the SME are important, knowledge sharing is beneficial for SMEs that wish to grow and innovate:

- SMEs with a cost-focused strategy are likely to have weak synergy and leverage, and hence an ambiguous attitude to knowledge sharing.
- SMEs have very strong needs for external knowledge and inter-organisational knowledge transfer.
- The use of knowledge management tools can support the creation of knowledge sharing networks, to help share ideas, experiences and knowledge relating to the implementation of best practices and improvement tools that can help SMEs to become more competitive.
- Firms that can efficiently access all relevant sources of knowledge are likely to thrive, while those that fail struggle.
- Family firms transfer knowledge between generations by means of trust, commitment and seeking outside experience.
- Knowledge sharing, especially highly formalised assimilation of knowledge is important for rapidly internationalising SMEs.

In general, three main dimensions that influence knowledge transfer are identified in literature:

- How the knowledge transfer is organised [36, 37].
- How the knowledge is packaged in order to be transferred [38].
- Who is facilitating the knowledge transfer and how trust is established [39, 40].

These were explored in more detail in pilot 6 in the context of business process knowledge transfer to SMEs.

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[35] *"Knowledge management in SMEs: a literature review",* S. Durst and IR Edvardsson, Journal of Knowledge Management, Vol. 16, issue 6, pp.879-903, 2012

[36] *"Knowledge transfer from research to industry (SMEs) – An example from the food sector*", Braun and Hadwiger, Trends in Food Science and Technology, 22:S90-S96, November 2011

[37] *"What We Measure, Why We Measure and How We Encourage Collaboration? – Two Faces of Place-based R&D and Absorptive Capacity Reconsidered"* Fumi Kitagaw, R&D Management Conference, 2016

[38] *"How firms source knowledge from universities: partnerships versus contracting",* Perkmann, M. and Walsh, K., *In Creating wealth from knowledge*, J. Bessant and T. Venables, Eds. Cheltenham: Edward Elgar, 2007

[39] *"Investigating the factors that diminish the barriers to university-industry collaboration",* Johan Bruneel, Pablo D'Este and Ammon Salter, https://core.ac.uk/download/pdf/36033718.pdf, 2010

[40] "The Institutionalization of knowledge transfer activities within industry–university collaborative ventures", Michael Santoro and Shanthi Gopalakrishnan, J. Eng. Technol. Management, Vol. 17, p.299, 2000

8.3 Implementation of the pilot

Ten different SMEs were selected to participate in this pilot. The selection criteria were the ambition of the SME to learn and grow, the availability of its management team to participate in the pilot and its willingness to provide the required data to the RTO and the academic team for the pilot evaluation. There were also considerations around the geographical spread of the SMEs, their relative size and maturity. Finally, there were six UK, 3 Austrian and one Spanish SME selected to participate in the pilot. There was an almost equal spread of the size of these companies (three having less than 20 employees, three having between 21-50 and four being larger). Most of the SMEs were matured and were established more than 20 years ago and only two were relatively young with less than 10 years of operations. The graphs below summarise the selected SME profiles.

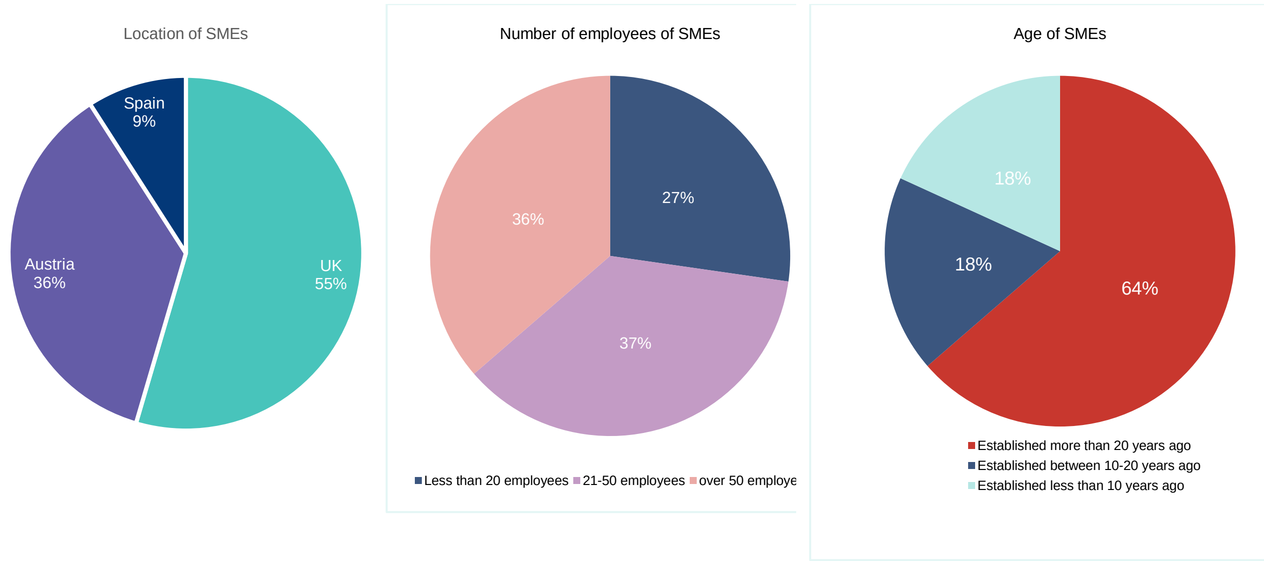


Figure 38: Profiles of the SMEs that participated in Pilot 6

There were five different facilitators conducting the pilot and in total five different tools were applied across the different SMEs to acquire better insights on the impact of the two important dimensions of "*facilitator*" and "*tool*" in the knowledge transfer process. The tools were specially designed questionnaires and/or templates along with defined procedures for their application. They have been developed through research and have been refined by piloting and applying them to SMEs over a period of years. The primary process of transfer of these tools is through their application in a workshop setting, to the SME's own business context

The five tools used were: Prioritisation, Marketing planning, Strategy, Portfolio selection and Roadmapping.

- Prioritisation: This is a questionnaire that identifies business priorities and analyses the business performance across eleven different business areas via interviews with senior managers and functional leaders. The findings are presented graphically and reviewed in detail with the management team. This is a powerful communication tool which helps to build consensus within the SME management team and across the business [41].
- Marketing planning: This is a modula, workshop-based tool that helps companies take a systematic approach to market analysis and strategic marketing. It involves aspects as product, market and competition analysis and helping SMEs make a business case for new ideas [42].

[41] "*In-Site: the development of a new diagnostic and action planning tool for small and medium-sized manufacturers*", Ford DW, Caldwell PJ and Stevens TE, n: 7th International Conference on Stimulating Manufacturing Excellence in Small and Medium Enterprises, 2005-6-12 to 2005-6-15, Glasgow, Scotland pp. 252-259.

[42] https://www.ifm.eng.cam.ac.uk/uploads/Resources/Briefings/v1n3_ifm_briefing.pdf

- Strategy: This is a series of four workshops that helps SMEs agree on future business objectives, develop a shared understanding of which markets and products to focus on, and their key capabilities. It helps SMEs identify clear strategic options and an action plan that help them execute the strategy [43, 44].
- Portfolio selection tool: This is a workshop-based tool that helps SMEs identify a set of suitable criteria for ranking projects and selecting an appropriate portfolio [45, 46].
- Roadmapping: This powerful technique enables organisations to create and deliver innovation strategy and supports alignment and dialogue between different functions. This technique has been adapted for use in SMEs [47, 48].

Table 11 below lists the types of SMEs that took place in the pilot, the tools used and the facilitators who lead the engagement (listed as A to E).

Table 11: Companies in coaching pilot

Company	Type	Country	Size (people)	Year formed	Tools used	Facilitator
1	Precision contract manufacturer	UK	70	1998	Prioritisation	A
2	Scientific instrument sales/distribution provider	UK	10	2003	Marketing planning	B
3	Electronics enclosures	UK	70	1987	Prioritisation & Strategy	C
4	Control systems	UK	43	1986	Prioritisation & Strategy	C
5	Machining	UK	75	1994	Prioritisation & Strategy	C
6	Machining	Austria	75	1994	Prioritisation & Strategy	D
7	Technology consulting service provider	Austria	6	2014	Prioritisation, Portfolio selection & Strategy	D
8	Industrial machines & tools	Austria	13	2010	Prioritisation	D
9	Design & building cutting machines	UK	28	1965	Roadmapping	E
10	R&D consultancy	Spain	23	1987	Prioritisation	A

Data was captured using a structured questionnaire that was designed to have two parts, based on the Kirkpatrick (1994) training evaluation model: reaction, learning, behaviour change and results [49]. The first part (30 questions) assessed the immediate reaction, relevance, learning and satisfaction SME experienced after the end of the engagement. The second part (17 questions) was designed to assess any longer-term impact in terms of changing of behaviours and results the SME may have achieved. Each question was scored using a Likert scale

[43] https://www.ifm.eng.cam.ac.uk/ifmecs/for-smes-startups/business-strategy/

[44] "*Creating a winning business formula*", John Mills, ken Platts, Andy Neely, Huw Richards, Mike Bourne, ISBN 0-521-75029-6

[45] https://www.ifm.eng.cam.ac.uk/research/ctm/ctmpublications/ctmworkingpapers/scoring-methods-for-evaluating-and-selecting-early-stage-technology-and-innovation-projects/

[46] "*A scoring method for prioritizing and selecting innovation projects*", Rick Mitchell, Rob Phaal, Nikoletta Athanassopoulou, Proceedings of the Portland International Conference on Management of Engineering and Technology (PICMET), Kanazawa, 27-31 July

[47] https://www.ifm.eng.cam.ac.uk/uploads/Research/CTM/working_paper/2015-08-Farukh-et-al.pdf

[48] "*Light-Weighting Innovation Strategy: A Roadmap-Portfolio Toolkit*", Clare Farrukh, Clive Kerr, Rob Phaal, Nicky Athanassopoulou, Michèle Routley, Proceedings of the Portland International Conference on Management of Engineering and Technology (PICMET), Kanazawa, 27-31 July

[49] *Kirkpatrick, D.L. 1994. Evaluating training programs: The four levels*. San Francisco: Berrett-Koehler. http://www.kirkpatrickpartners.com

of 1-5 with 1 being low and 5 being high. The two parts of the questionnaire and detailed question sets are shown in the Table 12 and Table 13 below.

Table 12: Part 1- Question set for immediately after the Engagement/Workshop

Questions about the company							
Generic	1	Year company was established					
	2	Number of employees					
	3	Annual Revenues					
	4	Gross profit					
	5	Investments on R&D (over the past 1 year)					
	6	Investments on new equipment (over the past 1 year)					
	7	Investments on facilities (over the past 1 year)					
	8	Number of collaborations or projects established with outside organisations					
	9	Awareness of importance of Management techniques					
	10	Number of people in management team					
	11	MD experience outside company (previous employment)					
	12	Management team experience outside company (previous employment)					
Questions about the process							
			1	2	3	4	5
Generic	13	Was the length of the process correct	Too Long/short – (indicate which)		A little bit too Long/short (indicate which)		Correct length
	14	Was the process easy to follow/ understand	Difficult to follow		OK to follow		Easy to follow
	15	Was the process structured or appropriately to achieve outcomes (i.e. enough guidance or too open ended?)	Too much/ little structure (indicate which)		Structure was adequate, a little bit too much structure/ fluidity (indicate which)		Level of structure was just right & worked well
	16	In your view, were the objectives of the process <u>achieved</u>?	None of the objectives were achieved		Some objectives achieved		The process achieved most/all of the set out objectives
Level 1 – Reaction and Satisfaction	17	I received helpful information prior to the process/workshop	Not much information received		Just about enough information		Sufficient information received
	18	I found my participation worthwhile	Not worthwhile		It was average		My participation was certainly worthwhile
	19	I would recommend this process/workshop to other organisations	I would not recommend this process		I might recommend this process		It will certainly recommend this process
Level 2 – Learning knowledge	20	I believe the output of the process/workshop is important to succeeding as an organisation	Output not important		Output is slightly important		Output very important
	21	The workshop provided useful insights	Not useful insights were derived		Some useful insights were derived		Very useful insights were derived
Questions about the tool							
			1	2	3	4	5
Level 1 – Reaction Engagement	22	I found the tool engaging	It was not very engaging		It was somewhat engaging		It was very engaging
	23	Was the tool easy to follow and understand?	Difficult to follow		It was ok to follow		Very easy to follow/understand
	24	Was the language used appropriate?	Too much jargon		It was ok to follow with some difficult aspects		Easy to follow/not much jargon
Level 1 – Reaction Relevance	25	How easy was to see the purpose/aims of the tool	Difficult to understand purpose of the tool		Average to understand		Easy to understand purpose of the tool
	26	How relevant was this tool to your company?	Not relevant at all		Somewhat relevant		Extremely relevant
Questions about the facilitator							
			1	2	3	4	5
Level 1 – Reaction and	27	Facilitator knowledge	Not knowledgeable enough		Average knowledge		Very knowledgeable
	28	Ability to provide examples/clarifications	Not many examples were provided		Some examples were provided		Many examples were provided

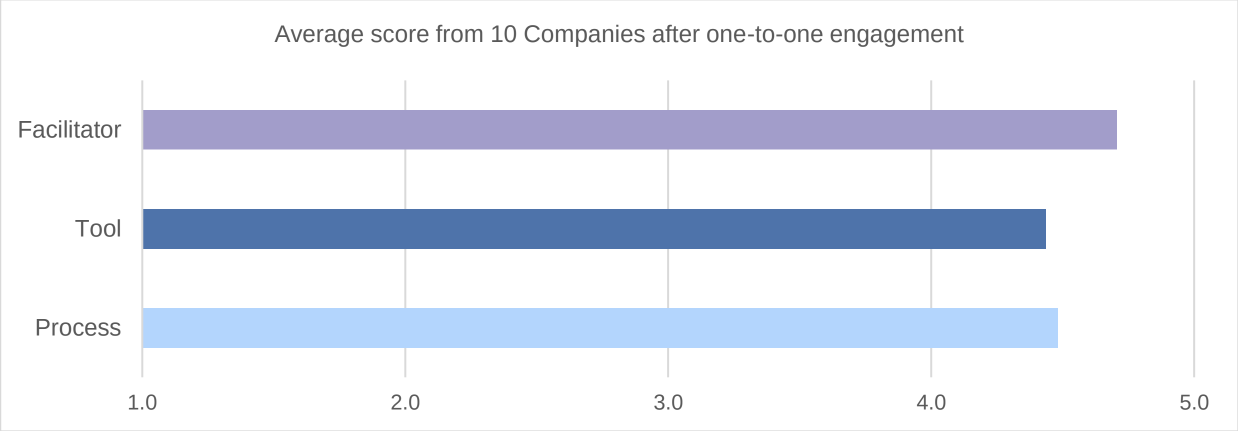
Satisfaction	29	Neutrality	The facilitator was biased		The facilitator gave opinions but did not force a particular direction		The facilitator was totally neutral
	30	Organised/disorganised	The facilitator was disorganised		The facilitator was neither organised or disorganised		The facilitator was very organised
	31	The facilitation style of the consultant contributed to my experience	The facilitator's style was not appropriate for us		The facilitator's style was adequate but could improve		The facilitator style was very appropriate for us

Table 13: Questionnaire Part 2- Question set for 6-18 months after the Engagement/Workshop

Questions about the company								
Company questions -Generic	**1**	Number of employees	**6**	Investments on facilities				
	2	Annual Revenues	**7**	New products developed				
	3	Gross profit	**8**	New processes implemented				
	4	Investments on R&D	**9**	New markets entered				
	5	Investments on new equipment	**10**	New services deployed				
Questions about the process & tool			**1**	**2**	**3**	**4**	**5**	**N/A**
Level 3: Behaviour	**11**	Since the initial workshop(s), have any of the company's behaviours changed in a way that positively enables or influences your strategy?	No change in behaviour		Some changes have been made but additional changes are required		Major behavioural change	
	12	Do you now have a clearer picture of your goals and expectations as a result of the process?	The goals are still unclear		Some clarity has been obtained		Major behavioural change	
	13	Are you applying what you learnt during the workshop(s) to your work?	I have not applied anything to my work		I have applied some new knowledge to my work		I have applied a lot of new knowledge to my work	
	14	Is anything being done differently as a result of the workshop(s)?	Nothing		Some small changes have been introduced		Some major initiatives have started as a result of the workshop	
Level 4: Results	**15**	Are there any positive results or impacts that result from the workshop(s)?	No positive results have been noticed		Some positive results have been noticed		Many/all positive results have been noticed	
	16	Are there any measures / KPIs linked to your strategy as a result of the workshops?	No new link between KPIs and strategy		Some KPIs linked to strategy but not all		Very clear link between KPIs and strategy	
	17	To what degree do you expect targeted outcomes to occur as a result of the workshops?	No targeted outcomes will occur		Some targeted outcomes will occur		Many/all targeted outcomes will occur	

The feedback collected from the SMEs immediately after the one-to-one engagement is presented in the top chart of Figure 39 below. This feedback was collected by using the part 1 of the questionnaire. The average score collected across all ten companies from questions 13-21, is presented under the heading “process”. The average score from questions 22-26 are shown under the heading “tool” and from questions 27-31 is shown under the heading “facilitator”.

The pilot results are compared to those obtained from 20 Irish SMEs after an one day open course in the lower chart of Figure 39 below. The open course was designed and conducted by facilitators A and B, using the tools of Marketing planning and Portfolio selection. The comparison shows the average SME scores obtained from the Part 1 questions only.



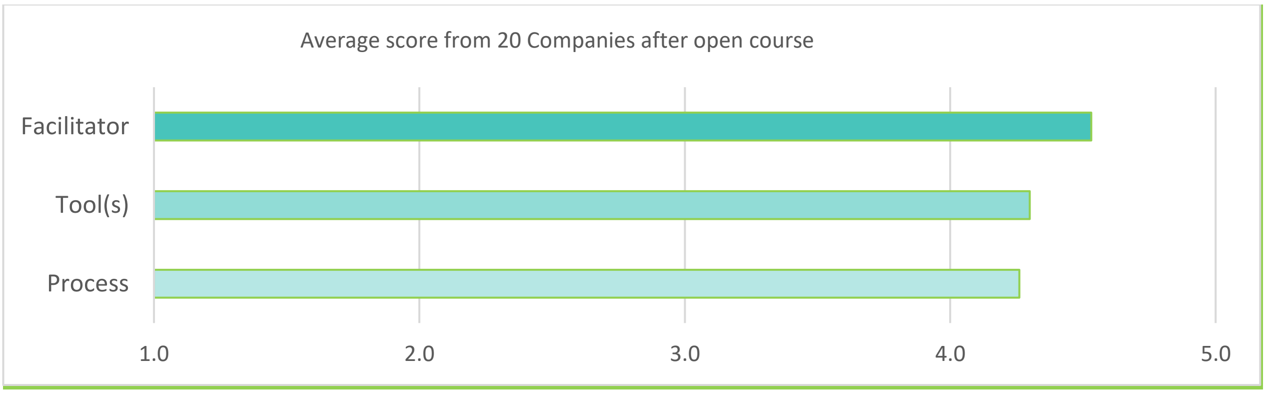


Figure 39: Immediate feedback collected from the SMEs

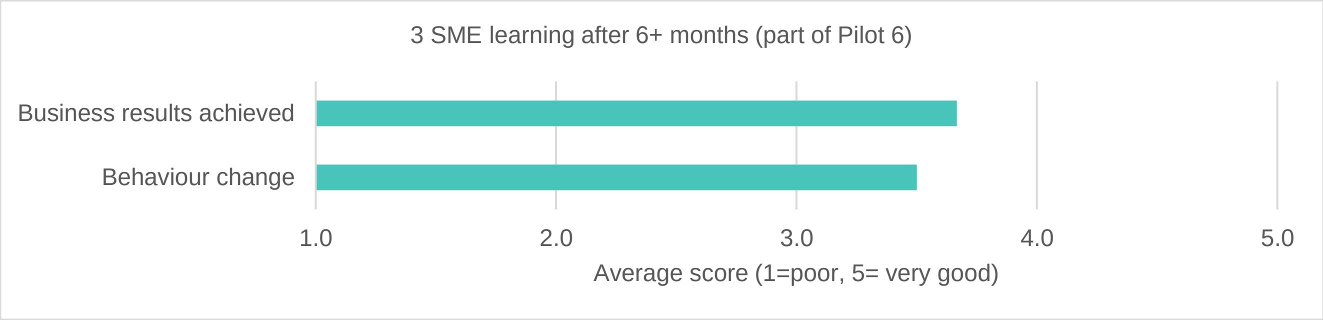
Top chart shows average feedback immediately after the engagement. The bottom chart shows the average feedback scores obtained from 20 SMEs after an one day open course

There is an indication that although both the process of transfer and tools used are important, the facilitator has a central role in the transfer process in both circumstances, one-to-one engagements and open courses. This is probably because the facilitator is key for establishing trust with the SME's management team, by demonstrating knowledge and understanding of SME issues, and having depth of experience including relevant examples of what other companies have done in similar situations. The facilitator is also important for explaining the overall process, expected outputs and managing the pace of the transfer process to match with the SMEs resources and time-limitations.

Tools, i.e. the packaging of the knowledge to be transferred also appear more important for open courses than one-to-one facilitated knowledge transfer, as probably in the latter the SME spends more time with the facilitator and he/she can be used to explain any underlying knowledge that is not immediately understood.

Longer term feedback was collected from three of the participant SMEs after six to eighteen months. This feedback was collected by using part 2 of the questionnaire, and it is shown in Figure 40. The average score collected across all three companies from questions 11-14, is presented under the heading "behaviour". The average score from questions 15-17 is shown under the heading "results".

The part 2 pilot results are compared to those obtained from two SMEs that had also gone through a similar knowledge transfer process prior to the initiation of this pilot. The time elapsed between the one-to-one engagement of these two SMEs and the feedback collected was between 12-18 months.



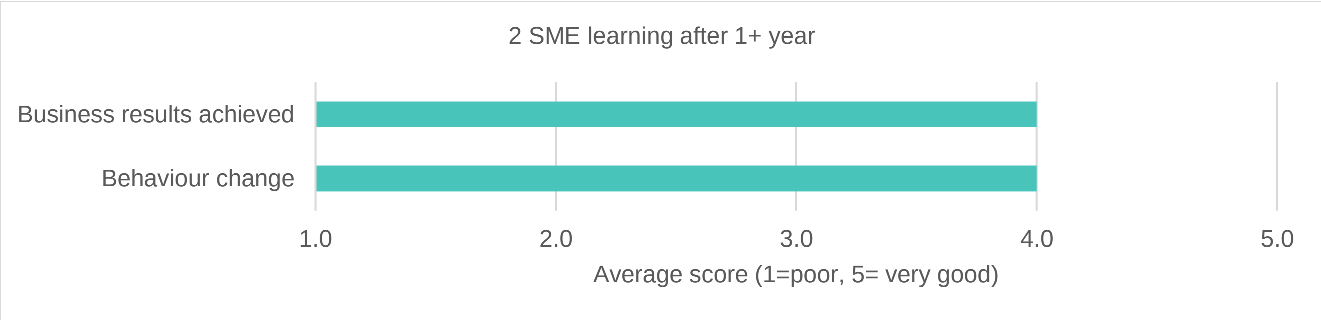


Figure 40: Longer term feedback collected from the SMEs

Top chart shows the average feedback scores obtained from three SMEs participating in Pilot 6, 6-12 months after the engagement (top figure). Bottom chart shows the average feedback scores obtained from two SMEs that had also gone through a similar knowledge transfer process prior to the initiation of this pilot.

The results show that the overall knowledge transfer process is effective. Both dimensions explored, the "business results achieved" and the "behaviour change" show above average scores. The time elapsed between the engagement and the results achieved and behaviour change seem to be important. The two SMEs that had a larger time gap between the engagement and the feedback (bottom figure) seem to have performed better. This may indicate that any knowledge transfer program need to allow sufficient time for SMEs to implement the learnings and achieve positive change.

8.4 Conclusions & Recommendations

8.4.1 Conclusions

SMEs are important for employment and growth in EU. They make up over 99 % of all enterprises, account for around 66% of total employment, and contribute 57% of value added in the EU.

Innovation management is an integral part of strategic thinking in firms, but there is a lack of practice-based knowledge about innovation management in smaller firms. This pilot explored in a structured manner the business process knowledge transfer process to SMEs, the aspects that influence the transfer, the enablers and barriers that can facilitate or reduce its effectiveness and to what extent coaching can be considered an effective form of inbound open innovation.

Three key dimensions of business process knowledge transfer to SMEs were investigated: the actual transfer process, the facilitator and the tools used to package and deliver the academic knowledge. This pilot supports the important role the one-to-one knowledge transfer process has for SMEs and highlights the key role that experienced facilitators, who combine both academic knowledge and industrial experience, play in the process.

Both the tools and the transfer process need to be designed to be SME-friendly and respect the limited time SMEs normally have to engage in knowledge exchange activities. Although the data collected on behavior change and business results is not extensive, initial indications show that the SMEs need time to reflect, learn and implement changes in their business. Any coaching and knowledge transfer process will need to need to allow sufficient time for SMEs to implement the learnings and achieve positive change.

Although one-to-one engagements are a useful knowledge transfer method for SMEs, these are not easily scalable. Open courses could be used as a reasonable and more scalable alternative. For open courses tools become more important and should be designed to be “self-facilitating” as possible [50] and incorporate suitable explanations and examples to aid SME learning.

Key Findings

The main success factors and enablers for an one-to-one knowledge transfer process to SMEs were:

- The facilitators should have industry experience so that they can relate to real business issues. They should also have the ability to offer several examples to clarify concepts. The facilitators should also combine good academic knowledge and credentials to be able to engage with the academic community, understand the new knowledge to be transferred and facilitate the knowledge packaging in appropriate forms.
- The knowledge transfer process needs to be designed to be time efficient, to follow a clear logic and facilitate a clear analysis between data input, data output and decisions.
- The participants should have the opportunity to express their views in a neutral environment.
- There should be minimization or ideally elimination of academic jargon and terminology.

The main bottlenecks and hurdles for an one-to-one knowledge transfer process to SMEs were:

- Initial lack of understanding by the SME as to what the potential outputs from the process will be and the possible business benefits. More emphasis needs to be placed in explaining upfront what is required from an SME in terms of data and time and examples of potential outputs.
- Related to the previous point, information should be provided upfront with examples, case studies etc. of the potential business benefits an SME could achieve by engaging in such an activity. Also, there is a time lag for tangible outcomes to be realised, so managing expectations is critical.

[50] https://www.ifm.eng.cam.ac.uk/uploads/Working_paper/16_10_Phaal_et_al.pdf

- More emphasis needs to be placed on the tool design, and ease of use, without expecting users to follow complicated instructions.
- Insights are normally reached after sufficient reflection time, so consideration needs to be provided as how to achieve this.

The barriers for knowledge transfer through open courses were somewhat different. Generally, more time was required for learning and reflecting on new material, and the examples and cases provided are generic and not immediately related to specific company issues. SMEs still require a lot of information in advance of the open course to explain the expected learning outcomes, providing examples of potential outputs and relevant case studies was also important for open courses.

8.4.2 Recommendations

Key takeaways

The recommendations from this pilot are as follows:

- RTOs need to employ facilitators who combine both academic credentials (in order to understand the research knowledge and methodologies) and industrial experience (in order to gain the trust of the SMEs).
- The knowledge transfer process needs to be time-efficient ideally implemented in small steps of a maximum of one day duration for each step.
- Tools are an important element of the transfer process as they codify and summarise the academic knowledge in a suitable form. The tool development is an iterative process that requires both the academic and the practitioner to **work together** over a period of time; it also needs to involve SMEs in the pilot phase to ensure relevance.
- The tools that are used for the transfer process need to be user-friendly, possibly "self-facilitating" with minimum academic jargon.
- The transfer process needs to allow sufficient reflection time for the SME team for refinement and alignment before decisions are made.
- Engage participants into the process by asking them to provide data, analyse information, use the tools and make decisions, etc.
- Explain in advance what outputs are expected, in what format and within what timeframe and manage expectations.

Impact on the pilot

This pilot could be applicable to any University, and/or RTO in the EU that is interested in working with the SME community. Effort should be placed in selecting dedicated facilitators who can work between the academic community and SMEs as well the design of time-efficient knowledge transfer processes and supporting tools. The impact on the different stakeholders could be summarised as follows:

- For RTOs:
  - Easy to organise the engagement (most SMEs do not require NDAs, framework agreements and complicated legal contracts).
  - Access to a large number of companies.
  - Can develop deeper understanding of industrial needs quicker.
  - Can test and validate academic models and tools faster.
- For academics:
  - Enhance their knowledge about innovation management.
  - Access to a large number of companies.

- For SMEs:
  - Have custom-made and focused improvement plans that address their specific needs.
  - Grow their business without increasing costs.
  - Focus on real growth (jobs and revenues) rather than just productivity output.

Key Performance Indicators (KPIs)

The following KPIs have been used in order to establish whether the companies have improved their innovation activities in the time period examined (6-12 months). This is done by looking at the coached companies results against the main KPIs. The KPIs are split into the three main areas of a. Innovativeness, b. Growth, and c. Output (knowledge transfer) effectiveness and were derived as follows:

a. **Innovativeness**: SMEs responses to Part 2 questions 7-10.
b. **Growth**: Comparing SME responses to Part 1 questions 2, 3 and 4 to the equivalent Part 2 questions 1, 2 and 3. The "Contribution/employee" was calculated simply as "Turnover/No of employees".
c. **Output (knowledge transfer) effectiveness:** This was calculated by using the average scores from the Part 2 questions 15-17.

The table below shows the accumulative numbers obtained across all three SMEs from which longer term feedback data has been collected so far.

Table 14: KPIs for pilot 6. Te results shown are accumulative across all three SMEs

Innovativeness metrics	Zero (0)	1 to 2:	3 or more
New products		1	
New services		1	
New processes		2	
New markets			3
Growth metrics	**Less than 1%**	**1% - 5%**	**More than 5%**
No of employees	0		
Turnover increase	0		
Profit increase	0		
Contribution/employee	0		
Output (knowledge transfer) effectiveness metrics	**Average score 1-2**	**Average score 3**	**Average score 4-5**
Are there any positive results/impacts as a result from the workshop/engagement		3.5	
Are there any measures/KPIs link to the company strategy as a result of the workshop?		3.3	
To what degree do we expect targeted outcomes to occur as a result of the workshop/tool			4.3

Although the data collected so far are from a small number of companies they look very promising. In particular, the SME innovativeness appears enhanced and the implementation of the learning achieved is above average. More data and time is required to confirm these outputs.

8.5 Future line of research

This initial pilot demonstrated the effectiveness of one-to-one coaching as a method for knowledge transfer. Future research can expand this pilot to more SMEs to confirm the findings. It can also compare other knowledge transfer methods such as open courses and on-line processes to assess the effectiveness of these techniques.

9 PILOT 7: ONLINE KNOWLEDGE MARKETPLACES CONNECTING UNIVERSITIES, RTOS, INDUSTRIES, SMES AND START-UPS

Executive Summary

The research community at universities constantly produces new knowledge in the form of innovative technology, expertise and processes that usually generate new patents and potentially great innovations for the society.

There is a long debate going on about what Technology Transfer scheme would work better in order to canalize the commercialization efforts for this new generated knowledge to reach out to the market efficiently and on a timely basis. This is a task that is entrusted to the Technology Transfer Offices at the University. However, they do not have an easy time getting maximum performance out of the volume of solutions, products and technologies generated by their research groups because they often lack of effective tools to channel to the researchers the needs that come from businesses or to bring innovative technologies to the business sector. Thus, the “technology-push” versus “market-pull” debate is still open and advocates of the two approaches keep searching for new formulas and processes to better enhance technology transfer and commercialization while both the scientific community and the business sector are kept largely unconnected.

According to World Bank people on line will move from 2 billion in 2012 up to 5 billion in 2020. In the era of Digitalization, this Open Innovation Marketplace (OIMP) scheme introduces a new approach to cover the gap between market-pull and technology-push approaches by implementing a new online environment for Technology Transfer Offices to facilitate direct connections between their research groups and the business sector under a secure Open Innovation platform that guaranties Confidentiality and Intellectual Property Rights of all participants. The TU Darmstadt Open Innovation Marketplace truly is a peer-to-peer network where the research community can directly interact and connect with the businesses in order to explore opportunities for collaboration in R&D and Innovation by promoting their expertise and research output as well as responding to market needs published by the industry.

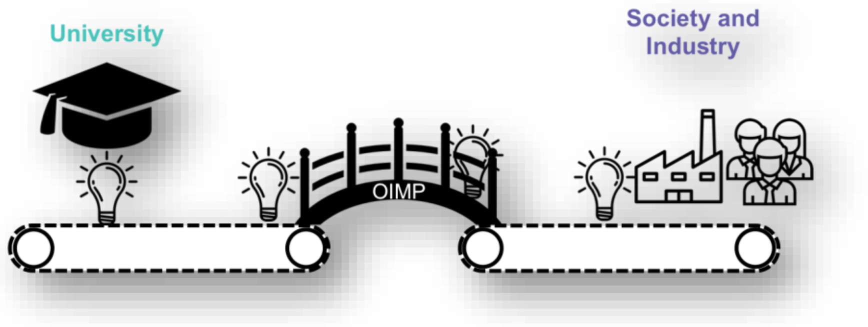


Figure 41: The idea of Pilot #7.

This pilot follows the trend initiated by the public and business sector where similar initiatives have been launched during the last decade. Thus, many large companies in all business sectors such as P&G, Unilever, or Beiersdorf[51] to mention a few have successfully developed and implemented online-supported Open Innovation initiatives aimed at connecting external crowds with their internal R&D, Innovation and business development teams to co-develop and launch new technology and products into the market. Also within the public sector, some organizations are running online technology transfer platforms such as Enterprise Europe Network (EEN), IPI in Singapore

[51] Unilever (Open Innovation program): https://oiportal.yet2.com/
Beiersdorf (PearlFinders): https://trusted-pearlfinders.beiersdorf.com/Group/Welcome/TrustedNetwork
P&G (Connect+Develop): www.pgconnectdevelop.com/

or the AUTM in the EUA[52] as well as privately held companies acting as “intermediaries” and offering access to online open innovation networks such as Innoget.com, NineSigma or Innocentive[53].

The pilot implementation consists of two main open innovation components, which are highly inter-connected:

1. The first one responds to the creation of a Trusted Network, through which the TU Darmstadt will be able to implement a tool that will allow their Technology Transfer Office to “know what they know”. By bringing their research community into the platform, they are offering their researchers a simple way to update their scientific profile as well as present their research output and initiate contacts with the industry.
2. The second component is the called “Extended Trusted Network access”. Innoget developed an API to connect the TU Darmstadt Open Innovation Marketplace automatically to its global open innovation network www.innoget.com.

Launching an Open Innovation Marketplace for technology transfer demands a high degree of combined expertise in the fields of Digital Platforms and Technology Transfer in order to be successfully and sustainably implemented and developed. The identified critical success factors of the pilot are:

1. The volume, accuracy and quality of content created (Technology Calls and Technology Offers).
2. Handling of confidentiality and intellectual property issues.
3. The size and engagement of the Open Innovation Marketplace community.
4. The selection of a Technology Transfer specific Open Innovation software provider that can provide both the Open Innovation tool and implementation support.

Six key findings have been identified out of the implementation of the OIMP scheme:

1. The opening of the platform for external partners strongly correlated with the degree of confidentiality of the information to be shared within the platform.
2. The first impression of a new online platform is a key decision factor for new users to sign up. A well-designed and intuitive user interface needs to be provided.
3. The platform is seen as the good place to identify the centers-of-excellence, start-ups, etc. From an industry perspective, the tool could develop into being the best place to identify the centers-of-excellence, start-ups, etc. which are currently performing state-of-the-art research in certain technology fields.
4. Freely distributed postings of technology calls and technology offers didn’t work out. There has to be one person in charge to coordinate the platform activities within the whole organization in order to control and assess the content that is going to be published.
5. The participation of both technology providers and seekers needs to be as wide as possible. As is the case with any internet-based search and comparison tool, the wider the forum, the more effective the tool. Conversely, restricting participation either side leads directly to limitations in the usefulness of the tool. Thus, linking the OIMP to an existing innovation network to automatically exchange content is very important.
6. Controlling access of users to the OIMP under the principle of a “managed community” hampered the motivation of new users to join the OIMP due to delay on getting access approval from the platform administrator

We strongly recommend making sure that besides selecting an appropriate Open Innovation tool, you have the expertise in-house and/ or sufficient external support to Manage, Create, Operate and Generate:

- **Manage** an online Open Innovation platform for technology and knowledge transfer.

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[52] Enterprise Europe Network (EEN): https://een.ec.europa.eu/
IPI – Singapore International Chamber of Commerce: www.ipi-singapore.org/online-marketplace
Association of University Technology Managers (AUTM): www.gtp.autm.net
[53] Innoget: www.innoget.com, Innocentive: www.innocentive.com, NineSigma: www.ninesigma.com

- **Create** high-quality level content.
- **Operate** under a peer-to-peer platform in order to become a partner of choice for innovation and R&D projects.
- **Generate** more and better contacts and collaboration projects while protecting Intellectual Property rights and confidentiality of participants.

The impact on the stakeholders could be summarized as follows:

- An easy and cost-effective way to launch, manage and maintain an Open Innovation Marketplace.
- An innovative scheme to enhance technology transfer and technology scouting among platform participants under a secure environment where Intellectual Property Rights and Confidentiality are guaranteed.
- An Open Innovation Marketplace that can be automatically connected to existing larger external Innovation networks so that OIMP participants can have access to a significant amount of open collaboration opportunities from day one.
- Get access to a set of KPIs to help manage and monitor an Open Innovation Marketplace.

For more information you can download the **Guidelines for the implementation of an Open Innovation Marketplace (OIMP) at University-level** and visit the online TU Darmstadt Open Innovation Marketplace at www.tuda-openinnovation.innogetcloud.com.

9.1 Introduction to the pilot

Pilot #7 is focusing on the design and development of a process and guidelines on how to efficiently implement an online Open Innovation Marketplace for technology transfer at University level in order to enable direct connections between their community of researchers and external partners (e.g. Industrial companies or RTOs). The pilot develops guidelines and processes to successfully replicate the implementation, as well as identifies key enablers and hampering factors to take into account.

Guidelines and processes are based on the set up and launching process of the online Open Innovation platform for TU Darmstadt, one of the partners of the Pilot #7, with the aim to facilitate the transfer of research results, patents and Knowhow (Technology Offers) generated by its Research Groups.

Furthermore, trusted external partners from relevant stakeholder groups including Large Enterprises, SMEs, RTOs and Start-ups will be invited to present both their innovation and R&D investment capacity and to post their needs for innovation (Technology Calls) in front of the TU Darmstadt research community.

The core IT software utilized for Pilot #7 is a customized version of the SaaS tool InnogetCloud, www.innogetecloud.com[54], an stat-of-the-art platform specifically developed for managing technology and knowledge transfer online that allows the University to open its access to an international R&D and Innovation community by automatically connect it to the global Open Innovation Network of www.innoget.com[55]

The pilot will work on to understand the current state of already existing open innovation marketplaces and in particular on what are the key operational aspects to consider in order to learn how to:

- **Manage** an online Open Innovation platform for technology and knowledge transfer.
- **Create** high-quality level content.
- **Operate** under a peer-to-peer platform in order to become a partner of choice for innovation and R&D projects.
- **Generate** more and better contacts and collaboration projects while protecting Intellectual Property rights and confidentiality of participants.

Figure 42: Structure of Pilot #7

[54] www.innogetcloud.com The cloud-based collaborative platform for sharing intellectual property and innovation under a secure environment.

[55] www.innoget.com is the trusted global Open Innovation, Science and Technology Network. The Innoget user community consists of thousands of specialists in their fields from 180+ countries who benefit from free access to both innovation opportunities and innovative technologies published by leading organizations from the scientific community and the business world.

The overall aim is to implement an Open Innovation Marketplace on university level (Figure 42) that can offer simple and secure means for making trustworthy contacts, initiate projects and share knowledge about technologies between the university's academic community and the Business sector with guaranteed protection of their Intellectual Property and confidentiality. For the carried out pilot, the Open Innovation Marketplace was implemented at TU Darmstadt. Furthermore, we want to analyse, understand and describe what the underlying success factors for getting such a system up and running are, and how to replicate it at other Universities.

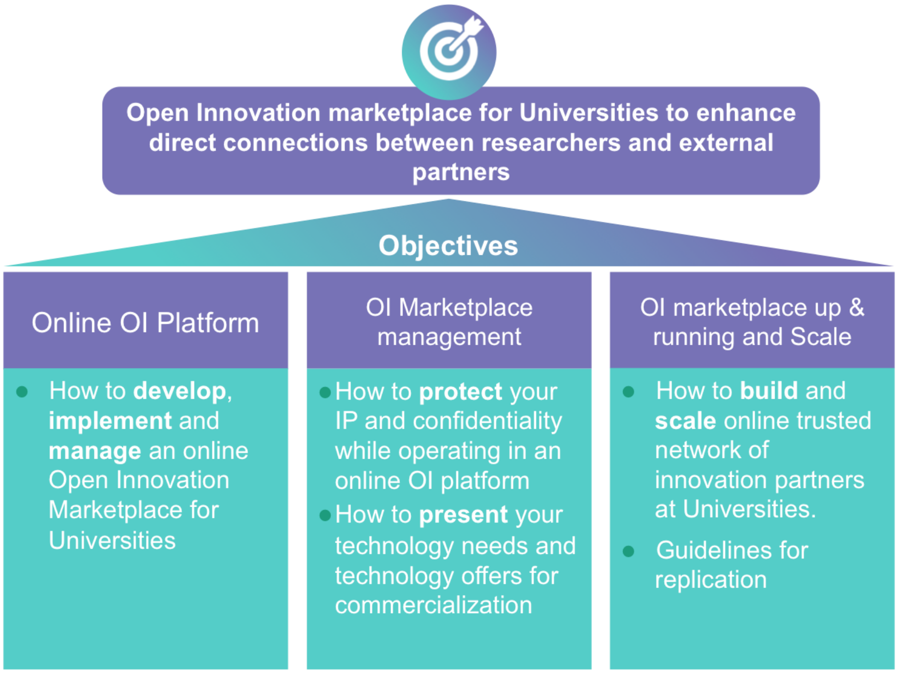

Figure 43: Main objectives of Pilot #7

Moreover, in order to draw the line for further development of an Open Innovation Marketplace at Universities and maintain the TU Darmstadt Open Innovation Marketplace operative, we run the following activities:

- Bax&Co and Innoget organized a Design Thinking session in Barcelona where external stakeholders were invited to participate in order to get their feedback and depict the technology roadmap and next generation of functionalities to be developed and implemented in the next generation of Open Innovation Marketplaces. Design Thinking tools used during the session included personas, customer journey maps and empathy maps.
- Supported by the Technology Transfer Office at TU Darmstadt, TU Darmstadt organized a Design Thinking session of the already launched TU Darmstadt Open Innovation Marketplace to get feedback from internal users of the University from the mechanical engineering, civil engineering, materials science and electrical engineering faculties.

The expected outputs of the Pilot include:

1. Guidelines on how to efficiently implement and operate an Open Innovation Marketplace at the University.
2. Free access to a fully operational Open Innovation Marketplace for TU Darmstadt (Figure 44):

https://tuda-openinnovation.innogetcloud.com/

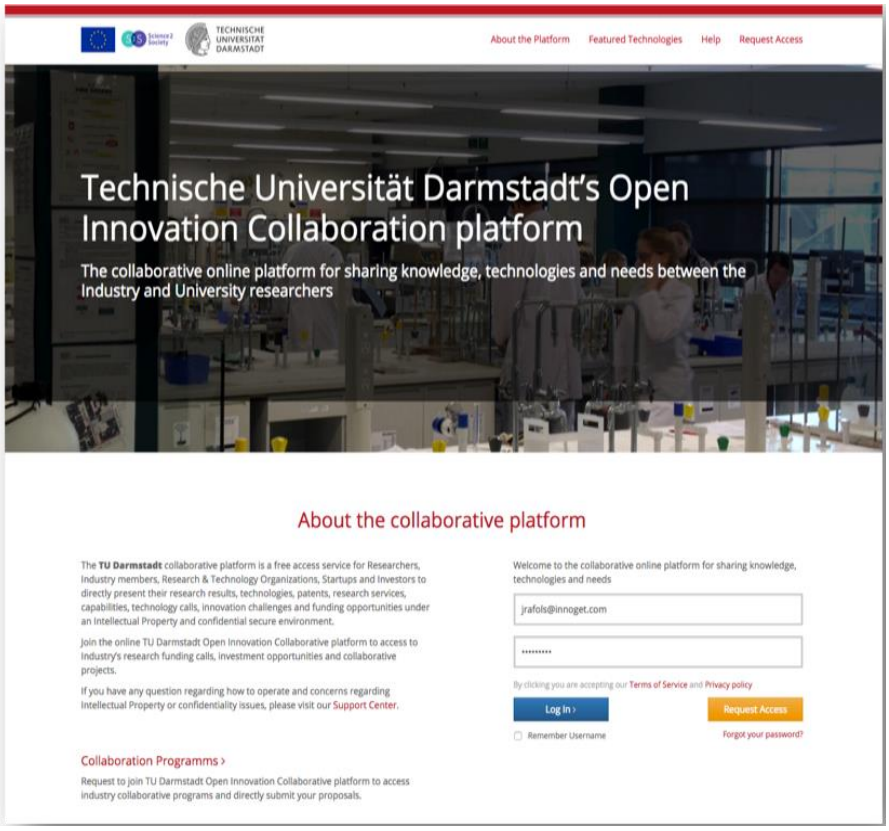

Figure 44: Screenshot of the TU Darmstadt Open Innovation Marketplace

3. Dos and don’ts in order to overcome the critical success factors.
4. A set of KPIs in order to measure and monitor the Open Innovation Marketplace performance.
5. Insights on new functionalities and IT technology to be developed and implemented into the next generation of Open Innovation Marketplaces.

The results of Pilot #7 were already presented during a professional workshop held in Barcelona (Spain) “Science2Society Workshop: Improving Technology Transfer in Europe”, a session performed in June 2018, and lead by the CIT UPC.

9.2 Description of the Open Innovation Scheme

The research community at universities constantly produces new knowledge in the form of innovative technology, expertise and processes that usually generate new patents and potentially great innovations for the society.

There is a long debate going on about what Technology Transfer scheme would work better in order to canalize the commercialization efforts for this new generated knowledge to reach out the market efficiently and on a timely basis. This is a task that is entrusted to the Technology Transfer Offices at the University. However, they do not have an easy time getting maximum performance out of the volume of solutions, products and technologies generated by their research groups because they often lack of effective tools to channel to the researchers the needs that come from businesses or to bring innovative technologies to the business sector. Thus, the "technology-push" versus "market-pull" debate is still open and advocates of the two approaches keep searching for new formulas and processes to better enhance technology transfer and commercialization while both the scientific community and the business sector are kept largely unconnected.

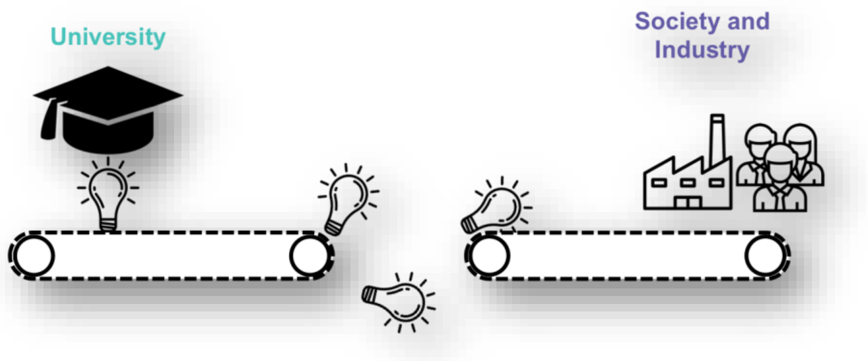

Figure 45: Gap in the classical technology transfer process

In the era of digitalization, this Open Innovation Marketplace scheme introduces a new approach to cover the gap between market-pull and technology-push approaches by implementing a new online environment for Technology Transfer Offices to facilitate direct connections between their research groups and the business sector under a secure Open Innovation platform that guaranties Confidentiality and Intellectual Property Rights of all participants. The TU Darmstadt Open Innovation Marketplace is truly peer-to-peer network where the research community can directly interact and connect with the businesses in order to explore opportunities for collaboration in R&D and Innovation by promoting their expertise and research output as well as responding to market needs published by the industry.

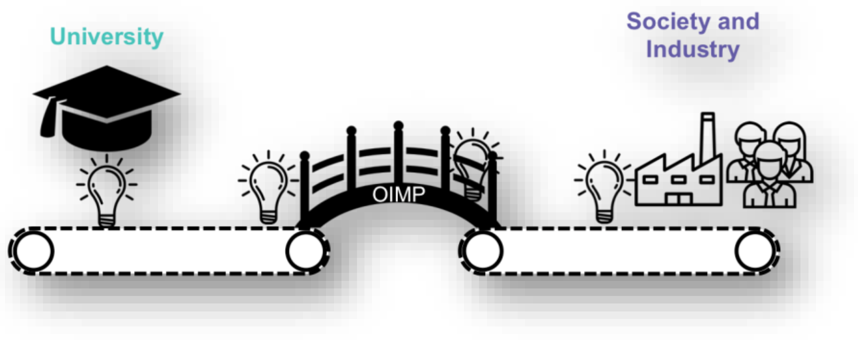

Figure 46: The Open Innovation Marketplace (OIMP) as a bridge over the gap of technology transfer

The implementation of a customized Open Innovation Marketplace owned and managed by the University is intended to complement all online and offline commercialization, business development and marketing efforts conducted by Technology Transfer Offices while at the same time allow them to grow their external network of innovation partners by using the Internet channel.

Pilot #7 follows the trend initiated by the public and business sector where similar initiatives have been launched during the last decade. Thus, many large companies in all business sectors such as P&G, Unilever, or Beiersdorf[56] to mention a few have successfully developed and implemented online-supported Open Innovation initiatives aimed at connecting external crowds with their internal R&D, Innovation and business development teams to co-develop and launch new technology and products into the market. Also within the public sector, some organizations are running online technology transfer platforms such Enterprise Europe Network (EEN), IPI in Singapore or the AUTM in the EUA[57] as well as privately held companies acting as "intermediaries" and offering access to online open innovation networks such as Innoget.com, NineSigma or Innocentive[58].

Launching an Open Innovation Marketplace for technology transfer demands a high degree of combined expertise in the fields of Digital Platforms and Technology Transfer. In terms of the software, Pilot #7 uses the InnogetCloud that is a SaaS tool specifically developed by Innoget to manage technology and knowledge transfer within any organization. The software has different modules:

- **Community management**: The administrator of the tool can invite new members as well as approve any request to become a member so they get full control about their community.
- **Content creation**: There are three main categories of content to post, Technology Calls, Technology Offers and Organization Profiles. The tool offers access to online templates that helps users to write self-comprehensive content while keeping their Confidentiality and Intellectual Property Rights well protected.
- **Matchmaking**: The connections between content generated by members and the rest of the community are created automatically according to the selected keywords and navigation patterns of the InnogetCloud users.
- **Connections**: Connections occur directly between members of the community. Users have access to online templates that will assist them regarding how to write a good proposal or request for information and hence improving the connection efficiency. Users learn how to fill in the connection template properly while protecting their Intellectual Property Rights.
- **Information and content Management**: The administrator of the tool can control the entire flow of information among all the users so as to approve, reject, send back to modify any content that any of their users is willing to post. Moreover, it can act as a contact point / broker between any user of the Platform and the rest of the community.
- **Online Support**: All users get access to a support center that can assist on any request.

Although selecting the appropriate software is very important, the Pilot focuses on all the aspects to consider for a good implementation, development and maintenance of an Open Innovation Marketplace at the University.

9.2.1 International experiences & Pilot uniqueness approach

There is a growing number of international experiences both from the private and public sector similar to this pilot, so we conducted a benchmark study to reinforce the uniqueness of the Pilot's Open Innovation scheme (Table 16).

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[56] Unilever (Open Innovation program): https://oiportal.yet2.com/
Beiersdorf (PearlFinders): https://trusted-pearlfinders.beiersdorf.com/Group/Welcome/TrustedNetwork
P&G (Connect+Develop): www.pgconnectdevelop.com/

[57] Enterprise Europe Network (EEN): https://een.ec.europa.eu/
IPI – Singapore International Chamber of Commerce: www.ipi-singapore.org/online-marketplace
Association of University Technology Managers (AUTM): www.gtp.autm.net

[58] Innoget: www.innoget.com, Innocentive: www.innocentive.com, NineSigma: www.ninesigma.com

Despite this growing number of organizations running online Open Innovation programs, we selected only some of the pioneers and most successful in launching their Open Innovation initiatives in order to evaluate how they operate their platforms compared to our Pilot.

Table 15: Open Innovation Platforms – Benchmark

	Pilot #7 scheme	Private Innovation Intermediaries			Public Organziations *			Industry *	
Market initiatives studied	TU Darmstadt OI Marketplace	Innoget	NineSigma *	Innocentive *	EEN	IPI	AUTM	P&G	Unilever
Open access platform	✔	✔	✔	✔	✔	✔	✔	✔	✔
Free access platform	✔	✔	✗	✗	✔	✔	✔	✔	✔
Proprietary Platform	✗	✔	✔	✔	✔	✔	✗	✔	✗
Licensed Platform	✔	✗	✗	✗	✗	✗	✔	✗	✔
Proprietary Data Base	✔	✔	✔	✔	✔	✔	✔	✔	✔
Directly Managed & controlled by the organization offering the platform	✔	✔	✔	✔	✔	✔	✔	✔	✗
Market pull approach - Technology Calls content based	✔	✔	✔	✔	✔	✔	✔	✔	✔
Technology push approach - Technology Offer content based	✔	✔	✗	✗	✔	✔	✔	✗	✗
Allow participants to directly post Technology needs and Technology Offers	✔	✔	✔	✔	✗	✗	✔	✗	✗
Peer-to-peer network (allow direct communication between Innovation seekers and Innovation providers)	✔	✔	✗	✗	✗	✗	✗	✗	✗
Offers protection of IP and Confidenciality	✔	✔	✔	✔	✔	✔	✔	✔	✔
Automicatically connected to other Innovation Networks	✔	✔	✗	✗	✗	✗	✗	✗	✗
Automicatically connected to Social Media	✔	✔	✔	✔	✔	✔	✔	✔	✔

** Information source: Internet*

Even though the nature of each of these programs might vary a little bit according to each organization's specific scouting and technology transfer strategy and goals, we found that none of them is operating under a peer-to-peer scheme allowing for direct connections among platform participants and none of them supports automatic connections to other external Innovation Networks. The unique level of connectivity developed and implemented in this Pilot is the key enabler for replication, scalability and user's engagement of our OI scheme. It is also the most important factor to generate positive networking effects offered by digitalization and the Internet.

Since the access to accurate data from these Open Innovation platforms is very limited, the pilot's KPIs and results are benchmarked against historical data provided by Innoget regarding their open innovation network on www.innoget.com.

All in all the results show that the performance of the TU Darmstadt OI Marketplace has the most useful features compared to the other platforms. Therefore, it is very interesting how the concept of the OIMP will work out at university level.

9.3 Implementation of the pilot

The pilot implementation consists of two main open innovation components, which are highly inter-connected:

1. The first one responds to the creation of a Trusted Network, through which the TU Darmstadt will be able to implement a tool that will allow their Technology Transfer Office to “know what they know”. By bringing their research community into the platform, they are offering their researchers a simple way to update their scientific profile as well as present their research output and initiate contacts with the industry.
2. The second component is the called “Extended Trusted Network access”. Innoget developed an API to connect the TU Darmstadt Open Innovation Marketplace automatically to its global open innovation network www.innoget.com.

The sequence of steps for this pilot implementation is shown below:

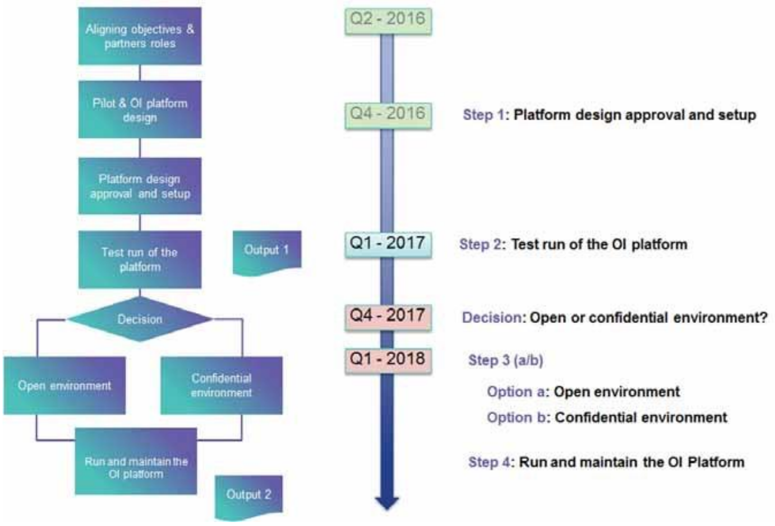

Figure 47: Implementation process of Pilot #7

9.3.1 Pre-pilot implementation phase

At this point all pilot members got involved into the pilot. All pilot actors believed that collaboration in R&D and technology transfer mostly happen between trusted partners, so we wanted to create a process backed by an existing cloud-based open innovation platform to facilitate research groups and academics to get feedback about their research output from the industry and easily make trustworthy contacts and initiate join projects.

At the same time, TU Darmstadt wanted to enhance technology transfer between their research groups and external partners from the industry and R&D organizations.

Innoget wanted to provide its InnogetCloud platform as the tool to bring all the actors under a secure environment and measure its overall performance according to KPIs set by the group. Furthermore, Innoget wanted to open up the process to allow platform actors to exchange confidential information as well as link the TU Darmstadt Open innovation Marketplace (OIMP) to Innoget.com.

CRF’s and LBF’s aim were to enhance the technology transfer to industry partners on the one hand side and to intensify the research collaboration with academia on the other hand. Moreover, CRF wanted to support the development of new processes for University-Industry collaboration under confidential information sharing environment.

Bax&Co assisted the main Pilot actors to identify opportunities for further developing the next generation OIMP at Universities by running a Design Thinking session with external stakeholders to gather feedback and ideas on new features and functionalities. Also TU Darmstadt organized an internal workshop to gather inputs from their research groups in order to improve their research community engagement with the OIMP and proposed improvements for the OIMP concept.

9.3.2 Step 1. Platform design approval and setup

9.3.2.1 Pilot Starting Point

The first draft design of the TU Darmstadt Open Innovation Marketplace (OIMP) was shared among all pilot partners. We decided that there would be only non-confidential information exchange among OI platform members and that the TU Darmstadt OIMP won't be initially connected to www.innoget.com.

All pilot members agreed on the framework and the process of the OIMP and each partner's role:

- **Centro Ricierche Fiat**'s (CRF) role is to provide innovation and knowledge transfer, cooperation with other industrial companies as well as universities and research institutes. CRF represents a research and technology organization center of a large industrial enterprise. Its specific activity is set at posting technology calls and technology offers on the platform, as well as to assess technology offers posted on the platform by other users. The main objectives were to increase the experience in getting new contacts in universities and research institutes.
- **Fraunhofer LBF** performs as content provider representing a research and technology organization. Main activities are posting attractive technology offers on the platform and, if available, attractive technology calls as well. Main objectives are getting science-industry contacts, promote research results, increase experience in getting new industry contacts, and actively using the platform as a tool for technology transfer and science-to-business collaboration enabler.
- **TU Darmstadt**'s (TUDA) roles are to setup the OIMP together with Innoget, to adapt the OIMP to TU Darmstadt's needs, to run the open innovation platform, to check posted technology calls and technology offers for quality before they go online, to maintain the OIMP, and to invite researchers and companies to join the platform. They represent the academic side and their main objectives are increasing the experience in getting new industry contacts, developing new processes for collaborations between scientists and the industry, and to successfully run and maintain the OIMP.
- **TU Darmstadt's research groups** are also one of the key actors of the pilot and are expected to actively use the platform, to increase the experience in getting new industry contacts, to post technology offers on the OIMP in order to promote own research results, and to get science-industry-contacts. A direct communication with possible research partners is desired.
- **Innoget's** objective is to act as the platform, technical and software support provider for the correct implementation of the tool. Innoget grants access management to Innoget.com and will supply an Open Innovation platform to TU Darmstadt. Innoget develops guidelines and recommendations on how to set up and manage an online open innovation platform for universities. Innoget wants to develop new processes for University-Industry collaboration under confidential information sharing environment. Moreover, Innoget supported TU Darmstadt's team to set up and manage the OI platform, coordinated content creation with CRF, TU Darmstadt and LBF, and monitored the matchmaking process among OIMP participants.

9.3.2.2 Platform design approval and setup

Innoget and TU Darmstadt set up the platform and provided a descriptive domain name that is available at: www.tuda-openinnovation.innogetcloud.com.

Pilot partners agreed on how to invite new users to the platform. An invitation text was formulated by TU Darmstadt. The text was initially written in English language and TU Darmstadt, acting as the OIMP administrator, sent out the invites. Innoget harmonized the platform design according to TU Darmstadt requirements, taking into account corporate colors, typography and logos, among other graphic elements.

9.3.3 Step 2. Test run of the TU Darmstadt OIMP

The test run of the Open Innovation Marketplace was carried out by the following steps:

1. Pilot partners were invited to join the Open Innovation Marketplace and the first Technology Calls and Technology Offers were posted on TU Darmstadt OIMP by the hand of TU Darmstadt (technology offers), CRF and LBF (technology offers and technology calls).
2. Organization profiles from TU Darmstadt research groups, CRF and LBF were created and publicly listed.
3. TU Darmstadt researchers were invited by the administrator (TUDA) to join the OIMP. The invite, written in English, was sent to more than 600 researchers.
4. Email alerts to disseminate new postings were regularly sent to OIMP members.
5. The matchmaking process is monitored as well as the matchmaking results and connections are analyzed.

Innoget and TU Darmstadt gathered information for preliminary KPIs analysis. Based on KPIs information the pilot partners reviewed the following processes and platform functionalities in order to identify areas of improvement as well as to take a decision about the possibility to explore the option to share confidential information online among OIMP participants:

1. The technology offer and technology call templates:
   Some minor modifications were introduced to provide better guidance for users to create and publish better quality content.

2. The user's registration process:
   We moved from a by-invitation only registration process to a free-open access registration process.

3. The new users' invite template and process:
   We decided to use local German language to send out invites to new internal users. We agreed that the official language of the OIMP would be English for content creation but some components of the OIMP would be nice to have an option for users to select their preferred language for communication purposes (Invites and Email alerts).

4. Connection of the TU Darmstadt OIMP to www.innoget.com:
   Innoget developed and implemented an API to automatically connect the TU Darmstadt Open Innovation Platform to www.innoget.com so that selected content from Innoget was transferred to the TU Darmstadt OIMP.

5. TU Darmstadt platform and email alerts design
   We introduced some design modifications on the front-end page of the TU Darmstadt OIMP and launched a completely renewed email alert design, where the content is more clearly presented.

Final KPIs were defined and a users' questionnaire was set up in order to gather feedback about the OIMP for further development and maintenance.

Moreover, we run a Design Thinking session conducted by Bax&Co and Innoget in Barcelona to gather inputs and ideas from external stakeholders in order to depict future lines of research. We wanted to incorporate their feedback before starting the promotion activities and the scaling up process of the OIMP.

9.3.4 Step 3. Decision: Open or Confidential environment?

Since we realized that keeping the registration process under the administrator's control was a barrier for new users to sign up, we skipped the idea to explore the option to allow participants to share confidential information online.

We concluded that exploring such a possibility for sharing confidential information online through an Open Innovation scheme would require a completely different approach. It required the introduction of new security approaches, such as the Blockchain, which is still at its very early stage of research. Thus, it's not possible to implement these approaches during this Pilot is carried out.

9.3.5 Step 4. Run and maintain the OI Platform

The OIMP was re-launched and re-released to the public once the above-mentioned actions and activities were implemented.

In order to improve the platform results on a continuous basis, a workshop was conducted at TU Darmstadt. The main goal was to identify enablers to enhance engagement and connections between users and content published on the platform. The workshop is support by TU Darmstadt Technology transfer Office. The main research groups' representatives are invited to participate in a session, where design thinking methodologies are used to gather as much information as possible regarding user's experience, functionalities, engagement and dissemination processes.

It is planned to measure and evaluate the Users' satisfaction by using the Users' Questionnaire developed in this pilot and regularly evaluate KPIs.

Innoget will provide updates of its InnogetCloud software not only based on TUDA insights but also from their existing customer's base and their main Open Innovation Platform Innoget.com .

LBF and CRF run the process for continuously providing technology offers and technology calls to the platform as well as promoting its utilization through their innovation partners.

9.4 Conclusions & Recommendations

9.4.1 Conclusions

Open Innovation schemes based on the use of digital capabilities is a widely spread practice that is being used by a growing number of companies, RTOs and Universities all over the World. Launching an Open Innovation Marketplace for technology transfer demands a high degree of combined expertise in the fields of Digital Platforms and Technology Transfer in order to be successfully and sustainably implemented and developed.

Although selecting the appropriate software is very important, other aspects were considered as key elements for a good implementation, development and maintenance of an Open Innovation Marketplace at the TU Darmstadt.

Thus, if we evaluate the initial results obtained after launching the TU Darmstadt Open Innovation Marketplace just by focusing on the number of collaboration projects generated among OIMP participants we would conclude that the overall pilot results are negative since no cooperative project between researchers and the industry has been initiated so far.

However, we believe that getting things running is a chicken and egg situation that we did already expected at the beginning of the pilot. This is why we also wanted to identify the main hampering factors that we have to overcome such as the low dissemination efforts of the OIMP, the lack of sufficient initial content, and an unclear message about the OIMP's benefits. All that led to a lack of motivation for TU Darmstadt's researchers to sign up to the OIMP.

A set of solutions were identified in order to better engage research groups and industry members to the Open Innovation Marketplace and thus create more contact and generate cooperation projects between them (see also Annex 9.6 to this chapter, where a detailed guideline can be found):

- Invest more efforts in marketing,
- Define both an online and offline communication strategy to invite the target audience to join the OIMP,
- Clearly communicate the benefits of being part of the OIMP,
- Conduct seminars and workshops showing how to join and how to publish high quality technology offers and technology calls,
- Write case studies to build trust,
- Connect the OIMP to an existing larger Open Innovation Network, and
- Make use of guidelines and the training materials based on the pilot implementation to facilitate the correct management of the platform.

Key Findings

The identified critical success factors of the pilot are:

1. The volume, accuracy and quality of content created (Technology Calls and Technology Offers).
2. Handling of confidentiality and intellectual property issues.
3. The size and engagement of the Open Innovation Marketplace community.
4. The selection of a Technology Transfer specific Open Innovation software provider that can provide both the Open Innovation tool and implementation support.

Moreover, besides the previously mentioned hampering factors 6 key findings have been identified out of the implementation of the OIMP scheme:

- The opening of the platform for external partners strongly correlated with the degree of confidentiality of the information to be shared within the platform.
- The first impression of a new online platform is a key decision factor for new users to sign up. A well-designed and intuitive user interface needs to be provided.
- The platform is seen as the good place to identify the centers-of-excellence, start-ups, etc. From an industry perspective, the tool could develop into being the best place to identify the centers-of-excellence, start-ups, etc. which are currently performing state-of-the-art research in certain technology fields.
- Freely distributed postings of technology calls and technology offers didn't work out. There has to be one person in charge to coordinate the platform activities within the whole organization in order to control and assess the content that is going to be published.
- The participation of both technology providers and seekers needs to be as wide as possible. As is the case with any internet-based search and comparison tool, the wider the forum, the more effective the tool. Conversely, restricting participation either side leads directly to limitations in the usefulness of the tool. Thus, linking the OIMP to an existing innovation network to automatically exchange content is very important.
    - Controlling access of users to the OIMP under the principle of a "managed community" hampered the motivation of new users to join the OIMP due to delay on getting access approval from the platform administrator.

9.4.2 Recommendations

Key takeaways

For the steps of the implementation process, key takeaways and general recommendations are identified as follows:

- Step 2 – Platform setup
    - Make sure that the OIMP is running smoothly in order to avoid dissatisfaction of new users (check different browsers, OS, etc.).
    - Give new users an idea of what is waiting for them inside the OIMP by showing some interesting technology calls and technology offers at the start page.
    - Make it easy for the users to sign up.
- Step 3 – Platform release
    - Write the text of the invitation messages in the language spoken at your university in order to avoid that people mistake it for a spam mail.
    - Keep the invitation message short and simple – many people will most likely not read a full page of text.
    - Adopt an existing community in order to have the critical mass of content and users right from the very beginning.
- General recommendations
    - Motivate university researchers to join the platform through seminars, workshops or events.
    - Educate and motivate registered users on how to setup their accounts.
    - Educate and motivate registered users on how and why to post technology offers and calls for innovation.
    - Educate and motivate registered users on how and why to reply to technology offers and technology calls.
    - Evaluated the user satisfaction and adapt the platform accordingly.
    - Define a continuous online communication strategy in order to disseminate platform results. Communication plan should consider conducting seminars and workshops to increase content and growth rate, as well as share case studies to entrust confidence in the platform.

We strongly recommend making sure that besides selecting an appropriate Open Innovation tool, you have the expertise in-house and/ or sufficient external support to Manage, Create, Operate and Generate:

- **Manage** an online Open Innovation platform for technology and knowledge transfer.
- **Create** high-quality level content.
- **Operate** under a peer-to-peer platform in order to become a partner of choice for innovation and R&D projects.
- **Generate** more and better contacts and collaboration projects while protecting Intellectual Property rights and confidentiality of participants.

Impact on the pilot

This pilot could be applicable to any University, RTO and even large Company in the EU and abroad that is interested in expanding their network of innovation partners by implementing a strong a long-term digital technology transfer strategy backed by an online Open Innovation Marketplace that based on peer-to-peer connections and automatic links to existing global innovation networks.

The impact on the stakeholders could be summarized as follows:

- An easy and cost-effective way to launch, manage and maintain an Open Innovation Marketplace.
- An innovative scheme to enhance technology transfer and technology scouting among platform participants under a secure environment where Intellectual Property Rights and Confidentiality are guaranteed.

- An Open Innovation Marketplace that can be automatically connected to existing larger external Innovation networks so that OIMP participants can have access to a significant amount of open collaboration opportunities from day one.
  - Get access to a set of KPIs to help manage and monitor an Open Innovation Marketplace.

Furthermore, Pilot #7 key findings, workshop results and the resulting guidelines are already being presented to other Universities for implementation. To mention a few, the University of Burgos (Spain) or the photonics cluster PhotonDelta (Netherlands), are current examples of platforms on which new features have been implemented and resulting guidelines are followed to enhance collaboration and technology transfer between members of the platform.

Key Performance Indicators (KPIs)

Table 16: KPIs of Pilot#7

KPI	Output	Type	What measures	OIMP members	How to measure	Target value	Test Phase	Release Phase
Active TC and TO	Total #	Engament	Total # of active (and accepted) tech-calls and tech-offers	All	InnogetCloud	> 100	23	23 + 25
# contacts/ active TC and TO	Ratio	Engagement	Average # contacts per tech-call and tech-offer	All	InnogetCloud	> 5	0	0
# successful cooperations/ #TC and TO	Ratio	Engagement	How many % of the TC/ TOs lead to a successful cooperation	All	@Questionnaire	> 10%	na	na
Time to first response	Time	Time	Average time it takes to receive a first contact for a posted TC/ TO	All	InnogetCloud	< 60 days	na	na
# Platform members	Total #	Engagement	Total # of platform members	All	InnogetCloud	> 500	10	61
# accepted invites/ # sent invites	Ratio	Community	% of invites to join the platform that are accepted	All	InnogetCloud	> 20%	2 %	6 %

The replication of the pilot can be considered successful if its guidance and best practices lead to an improvement of both the qualitative and quantitative KPIs, which at the end of the day should be reflected in more connections between platform members. The university should consider the implementation of the Open Innovation Marketplace successful if it results in more collaboration opportunities and higher commercial benefits compared to the results previously achieved.

Key Performance Indicators defined for the Pilot #7 are as follows:

- Active Technology Calls (TC) and Technology Offers (TO), a quantitative KPI aimed a measuring the total number of active and accepted technology calls and technology offers posted. Target value is set at > 100.

- Number of Connections / Active TC and TO, a quantitative KPI aimed at measuring the average number of contacts per technology call and technology offer posted. Target value is set at > 5.
- Number of Successful Cooperation / Number of TC and TO, a qualitative KPI aimed at measuring the % of technology calls or technology offers that lead to a successful cooperation, based on the questionnaire defined. Target value is set at > 10%.
- Time to First Response, a quantitative KPI aimed at measuring the average time it takes to receive a first contact for a posted technology call or technology offer. Target value is set at < 30 days.
- Number of Platform Members, a quantitative KPI aimed at measuring the total number of platform members. Target value is set at > 500.
- Number of Accepted Invites / Number of Sent Invites, a qualitative KPI aimed at measuring the % of invites to join the platform that are accepted. Target value is set at > 20%.

In terms of the critical factors for the pilot as a whole, 6 main categories are analyzed for each implementation step:

1. **Enabling factors**. Main factors identified are:
    - Actors goals and objectives alignment for the Pilot Starting Point phase as well as for Step 3,
    - InnogetCloud OI platform for Step 1,
    - Active invitation of TU Darmstadt researchers,
    - Quality and quantity of technology calls and technology offers and active support of the platform by the operator (e.g. invitations, new technology offers, etc.) for Step 2,
    - Active invitation of external members,
    - Active invitation of TU Darmstadt,
    - Critical mass of technology offers and calls,
    - Good user experience/satisfaction (e.g. reaction time, established cooperation, etc.), and
    - Active support of the platform by the operator (e.g. invitations, new technology offers, etc.) for Step 4.
2. **Hampering factors**. Main factors identified are:
    - Competing goals between the actors for the Pilot Starting Point phase as well as for Step 1 and 3,
    - Wrong OI platform setup,
    - Bad OI platform design and unclear message to TUDA researchers' community about the OI platform benefits for Step 2,
    - Handling of confidentiality and IP issues,
    - Low number of new members (External and internal),
    - No critical mass on good quality technology offers and calls, and
    - Missing growth of the platform for Step 4.
3. **Technical success factors**. Main factors identified are:
    - Adaption possibility of the backend and functions of the existing Innoget-Cloud OI platform for the Pilot Starting Point phase and Step 3,
    - Reliable server to host the OI platform for Step 1, Step 2 and Step 4, and
    - OI Platform framework for Step 2 and Step 4.
4. **Organizational success factors.** Main factors identified are:
    - Communication between pilot partners and milestones responsibilities for the Pre-Pilot Phase, Pilot Starting Point phase and Step 1 and
    - Sharing information and milestones responsibilities for Step 2 and Step 4.
5. **Contextual success factors.** Main factors identified are:
    - Active communication and compromises for the Pre-Pilot Phase, Pilot Starting Point phase and Step 1,
    - Active communication,
    - Mutual assistances between the pilot partners and activating partners within the pilot actors to provide technology offers and technology calls for Step 2,

- Implementation of a process for continuous provision of attractive technology offers on the research side and business world sides,
- TU Darmstadt OIMP connection to www.innoget.com,
- Develop new process to share confidential information among OIMP members, and
- Mutual assistances between the pilot partners for Step 4.

6. **Process to overcome critical points:**
    - Actors goals and objectives alignment for the Pre-Pilot Phase and Pilot Starting Point phase,
    - Innoget OIMP for Step 1,
    - Active invitation of TU Darmstadt researchers,
    - Quality and quantity of technology calls and technology offers and active support of the platform by the operator (e.g. invitations, new technology offers, etc.) for Step 2,
    - Actors goals and objectives alignment for Step 3,
    - Active invitation of external members,
    - Active invitation of TU Darmstadt,
    - Quality and quantity of technology calls and offers,
    - Critical mass on technology offers and technology calls,
    - Good user experience and user satisfaction (reaction time, established cooperation, etc.), and
    - Active support of the platform by the operator (e.g. invitations, new, technology offers) for Step 4.

Take home messages

The 3 main take home messages we learned from the Pilot’s conduction are:

1. An Open Innovation Marketplace in fact is a valuable tool to boost the technology transfer capabilities of universities.
2. The attractiveness of the OIMP is highly related to the amount of initially available content. Try to enrich the Marketplace’s content by connecting to existing platforms.
3. Facilitate the sign-up-process as much as possible or even skip it. Users decide if they like the platform in a blink of an eye. Use this short time to show them the best you can offer.

9.5 Future line of research

In terms of future lines of research, there are a number of key opportunities that we certainly encourage to investigate, as might have an impact on future replications. From the identified mega trends – open source knowledge, social connectivity and going mobile – to new disruptive technologies as the Blockchain or the Artificial Intelligence, all of them could help the matchmaking process, as well as facilitate how platform members engage with the content and the type of Confidentially constrains that would regulate the online information exchange among participants

On the other hand, it would be important to demonstrate successful cases of OIMP that have led to collaboration projects in order to motivate not only the researchers but also external stakeholders from the industry to join and engage with the content available in the OIMP platform.

Moreover, the Design Thinking workshop led by Bax & Company showcased some technical challenges and IT development proposals for the next generation of the InnogetCloud and OIMP tools in general as follows:

- Patent evaluator system to rate technologies,
- Instant video chat option to get into contact with other users,
- Go mobile with an APP,
- Integration of a Crowdfunding option for research,
- Call for urgent actions with instant notifications of relevant users,
- Hire a journalist to ask the right questions, for improving the descriptions, offer additional roles, for instance the facilitator, intended for retired people who can make an application to the platform and improve a project.
- A Google type “I’m feeling lucky” button, to boost serendipity,
- Free keywords (check if others use the same),
- Link funding sources info to different offers (like H2020),
- Fast pitches on video recordings,
- Online tech speed dating,
- Tick box NDAs on individual and corporate levels,
- Moveable 3D models, secret analysis (search for comparable solutions or interested companies when you start your research),
- Have a list of centers of excellence for research groups to find the best researches, and
- VR conference calls and platform suitable for sharing specs in a private room.

9.6 Appendix to Pilot 7

Guidelines for the implementation of an Open Innovation Marketplace (OIMP) at University-level

Introduction

As part of the results of the Pilot 7 execution, in the following pages are defined the set of guidelines to be followed for the successful implementation of an online Open Innovation Marketplace (OIMP) at university level, which is defined as a technology transfer-oriented platform to provide direct connections between university's researchers and external stakeholders, while improving the process of knowledge transfer into the market.

The guidelines are defined with the aim that any university willing to adopt such scheme, can easily implement it following the steps and recommendations obtained from the execution of the Pilot 3.7, one of the 7 pilots conducted within the EU-funded H2020 project Science2Society.

Pilot 3.7 is based on the premise that many companies and Research and Technology Organizations, are already making use of the Internet and digital platforms to develop new open innovation processes to find new technology, innovate faster and engage with new external technology organizations more efficiently, while building their global trusted network of innovation partners.

However, on the University side, such adoption of digital platforms for technology transfer and projects generation is not as widespread, which is constraining how Universities engage with potential partners and access available research and funding opportunities worldwide, at the same time many of the innovations and research outputs coming out from research organizations do not find their way to the society.

At this point, based on the analysis of the results of the Pilot 3.7, we can say that a successful implemented Open Innovation Marketplace will help universities:

1. Improve the process of knowledge transfer into the market in the form of products and services,
2. Make research output much more available to the market and,
3. Provide the research community with an easy access channel to research funding opportunities and collaborative projects from the global market.

Pilot 3.7 has been run for a period of 2 years and has involved the participation of the following stakeholders:

- CRF (Italy) – Industry
- LBF (Germany) - Academia
- TUDA (Germany) - Academia
- Innoget (Spain) – Platform Provider

Besides the written document, there is also available a graphic video to visually understand the implementation of the tool, as well as a live example of the implemented OIMP.

Open Innovation Marketplace Implementation

While implementing an OIMP, we/the University will come across 3 main steps to be followed in order to correctly implement the tool, starting with the selection of the platform provider, then setting up the tool, and finally releasing it to the public. Following are explained each of these steps along with recommendations learned from the execution of the pilot.

STEP 1. MARKET RESEARCH

TIMEFRAME: 1 – 2 MONTHS

To implement the tool, we will first have to conduct a market research to identify potential platform providers. Actors to conduct the research may be the technology transfer managers as they will be directly involved in the transfer process. However, if the University counts on a media lab or a marketing department, those can also take part in the benchmark process.

Market research can be conducted searching on web browsers, looking for suggestions on software recommenders, looking for business cases, best practices, etc. It is also useful to see whether other Universities in our region are using any tool, and ask for referrals.

As soon as we came up with potential providers, we should schedule a demo to figure out the functionalities offered and ask for a service proposal in order to compare and evaluate it afterwards.

Between 1 and 2 months after the market research starts, the university should have collected enough proposals to select the right platform provider to implement the marketplace, taking into account 4 key factors:

1. The user experience of the platform, or how our users will interact with the interface. We have to make sure they will be able to easily navigate through the OIMP. It is preferable that the platform provides a browser and categories for structured information.
2. The levels of customization, so the platform could be adapted to the corporate look and feel of the organization. The provider has to facilitate the customization of the colour palette and label. We also should be allowed to define a custom landing page to optimize conversion.
3. The technology availability, whether it’s cloud or desktop based. Based on the current megatrends, platform traffic from mobile devices is increasing year after year, so we have to make sure our users will be able to access the platform anywhere, at any time, through the easiest way possible.
4. The level of technology transfer orientation. We have to keep in mind the purpose of the tool; we are looking for an online platform to facilitate technology transfer and connections between researchers and University’s partners. Any platform moving away from this concept should be discarded.

As soon as the provider is selected, the University faces the setup stage.

STEP 2. PLATFORM SETUP

TIMEFRAME: 1 – 2 MONTHS

At this point, the University will start with the draft design of the Open Innovation Marketplace in order to adapt the look and feel of the tool to the corporate design, one of the key points to entrust confidence and make sure users recognize the platform as part of the University’s digital assets.

At the same time, with the support of the IT department and the platform provider, the University will have to setup the platform according to the defined needs, customize any preferences if necessary, and select a platform administrator and train them to manage the tool.

There are 3 key points the University has to fulfil here:

1. Make sure that the OIMP is running smoothly in order to avoid bugs that may cause dissatisfaction of new users. It is highly recommended to conduct cross-browser tests, test the platform on different OS, and make sure the platform is responsive for mobile devices.
2. Give new users an idea of what is waiting for them inside the OIMP by showing some catching Technology Calls and Technology Offers at the start page, as well as a visible call to action to optimize click through rate.
3. Make it easy for the users to sign up. Avoid long forms and ask just the details required to the user signs up. We have to take into account that every additional field in the signup form adds friction to the signup process. Reducing this friction as much as possible will aid conversion rate.

STEP 3. PLATFORM LAUNCH

TIMEFRAME: 1 – 2 MONTHS

Once the platform is customized and set up, it's time to launch the tool and invite research groups, individual researchers and external industry partners to join the marketplace and interact online.

To do so, we will need to agree how to invite them and formulate an invitation text to be sent to their inbox. The invitation text is recommended to be in the same language spoken at the University in order to avoid that people mistake it for a spam email. We should also have to take the invitation message short and simple, so the user understands clearly our call to action.

In case the platform providers offers such possibility, we will always try to adopt an existing community in order to have the critical mass of users and content right from the very beginning.

It is highly recommended as well to organize a seminar, webinar or workshop to present the features and capabilities of the open innovation marketplace to our target users. This way we will make sure they know how to navigate and engage with the content published in our tool.

We will also have to provide continuous support to our members in order to help those who have difficulties using the platform. In order to provide them help, we can either use direct communication tools like Skype, WebEx or via e-mail, create an online Help Center if the platform providers allow so, or create a dedicated microsite with the frequently asked questions.

The release phase may take between 1 and 2 months, and it is expected to involve the marketplace administrator and managers, research groups, science managers and innovation managers as well as the IT team.

At this stage, the University will be running an Open Innovation Marketplace that will let them transfer both knowledge and technology in a more efficient and easier way, bridging the gap between the university and society, and connecting the organization with research, innovation and funding opportunities all around the globe.

Key aspects of the implementation process

As a general recommendation, we have to keep in mind that, as any other network, the number of members engaging with it bolsters our OIMP. Therefore, we are required to motivate both internal and externals users to join the platform, educated them on how to setup their accounts, how and why to post technology offers and technology calls, and how to reply to those publications in order to make the most of their time in the platform.

As soon as we achieve a certain level of activity within the marketplace, all we will have to do is to periodically evaluate user satisfaction and adapt the platform so it matches with user requirements.

It is also a good practice to design a dashboard of KPIs in order to track the performance of our tool so that we can detect deficiencies and correct them to optimize the flow within the platform.

10 HIGH LEVEL CONCLUSIONS AND RECOMMENDATIONS

The implemented pilots were quite different in their nature addressing different aspects of co-creation and open innovation. Consequently, the lessons learned and recommendations derived should only be understood as guiding boundaries for further uptake of these UIS interface scheme. The lessons learned and recommendations must be critically reflected by possible third parties while duplicating the pilots. Particular the specific culture and the given administrative structure of the duplicating parties must be taken into account and the pilots adapted accordingly. Consequently, no generalised recommendation can be given which pilot should be adapted by a third party and which not. This must be judged by the duplicating party by themselves whereby the presented results can be used as a valuable guide.

However, the following three fundamentals elements for implementing UIS interface schemes can be derived from the implemented pilots.

Trust Building

At the beginning of forming a new relationship within the knowledge triangle building of trust between the participating partners becomes essential. This trust building needs time and in many cases is related to personal relationships among the partners. The pilots “Co-Creation (pilot 1) and “Collaborative R&D&I” (pilot 3) can be used to build up such trust and to establish long-term relationships on a more personal basis. Also the online knowledge marketplace (pilot 7) supports the trust building phase by providing reliable information on know-how and competences and by bringing organisations throughout the knowledge triangle. Once a first trust has been established partners could go one step ahead exchanging staff between them (intersectoral staff mobility, pilot 4) building up a trust level also on a personal level. This is prerequisite to establish a long-term relationship between universities, RTOs and industry through co-located innovation labs, independent whether they will be established physical or virtual.

Creating Win-Win Situations

Lasting co-creation and open innovation schemes can only be established if all parties will gain a benefit from it. As such the outline of the UIS interface scheme must reflect win-win situations for all participating parties. Within Science2Society several pilots have been implemented creating such win-win situations. Most obvious is pilot 5 addressing business models for exploiting available big data. Successful business models per se creating win-win situations. But also the knowledge marketplace (pilot 7) to create win-win situation aims through advertising knowledge and innovations. Furthermore, the co-creation scheme (pilot 1) can only be conducted if particular the industrial partners can draw a benefit from it. Nevertheless, all three pilots clearly have shown that all partners within the knowledge triangle must be open-minded and willing to create win-win situation. However, particular SMEs are often not familiar with the co-creation and open innovation concepts hindering them to create new win-win situations. Here, the training and coaching of SMEs becomes a crucial element as shown in pilot 6 (direct university training and coaching).

Fair Access to IPR

Third element to be dealt with is the access to IPR. Every stakeholder within the knowledge triangle usually experiences the issue of IPRs as hindering factor in collaboration with third parties, independent whether bi-lateral or in a collaborative way. In order to overcome IPRs as hindering factor, the previous elements “Trust Building” and “Creating Win-Win Situations” play an important role. If a sound basis of trust is established and the win-win situation is clearly described, all involved stakeholders should have a natural interest negotiation a fair access to IPR for all parties. Particular the established personal relationship could be a lever to overcome classical regulation regarding IPR and to introduce new UIS interface schemes strengthening the innovation capacity of all. In this context, the presented UIS interface could serve as a blue print and best practice guide for interested stakeholders of the knowledge triangle.