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Visual Mapping for the management of an innovation field: An application to Electric Vehicle Charging in Renault

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Radical innovation is becoming essential to insure firms stay competitive. Nevertheless, R&D departments struggle to achieve systematic innovation processes. The management of an innovation field requires adapted tools to the diversity, broadness and flexibility of the generation of innovative ideas. To face this challenge, we propose the use of a set of visual tools. These allow the abstraction of three fundamental innovation field dimensions: 1) the nonlinearity of the ideation process; 2) the degree of maturity of a technology and 3) the stakeholder diversity of an ecosystem. We propose an Innovation Map, a synthetic tool grouping several visual representations that allow describing these three dimensions of an innovation field. Having all aspects simultaneously described by a tool is enriching since it makes it possible for the visual representations to complement each other.
This managerial tool was applied inside Renault, in the automobile sector, for the mapping of the electric vehicle charging, a strategic field in electric mobility. We tested the tool with several internal R&D stakeholders of the innovation field having different profiles and responsibilities. They perceived the Innovation Map as a useful tool to point out and share various strategic aspects of an innovation field, as well as establishing potential partnerships. This collaborative research is a first step towards the establishment of a visual language framework that managers can apply to communicate, organize and understand an innovation field.

1. Introduction

Successful radical innovations give a substantial advantage to firms; consequently innovation projects play a strategic role for any department of Research, Development or Innovation in a world where large firms are shaped to do incremental innovation (Leifer, 2000). Although systematic innovation strategy based on radical innovations might be the key to success (Midler et al., 2012), breakthrough R&D projects are particularly difficult to implement because the emergence or design of ideas is a stage that is proven to be difficult to manage (Backman and Bo, 2007; Koen et al., 2002, 2001). Therefore, the innovation strategy starts with management of an *innovation field* i.e. the exploration area for innovative design (Hatchuel et al., 2001) where innovation projects share a common theme defined by various aspects and they are interrelated (Salomo et al.,

2008). This specific activity requires adapted management tools to the diversity, broadness and flexibility of the generation of innovative ideas and the coordination of simultaneous explorations. Numerous tools have been developed alongside with innovative projects to communicate, evaluate and make decisions (e.g. the well-known stage-gate process (Cooper and Kleinschmidt, 2001)). Describing R&D activities at the project level, every single tool tackles one or several aspects of an innovation field and translates them to a methodic procedure in the form of a strategic plan, a control structure or a visual tool. These procedures are focused on a practical approach that helps managers deploying innovation management strategies. To explain the complexity of R&D activities at the innovation field, visual representations have been proven to best articulate the management of the field because visual metaphors have a rich vocabulary in terms of format and content, therefore such a tool enhances the communication efficiency of a firm (Andriessen et al., 2009). But how do visual management tools help managers to design their innovation strategies? What is the best way to visually translate strategic dimensions of an innovation field? Does an integrated tool that sums up the majority of the dimensions of an innovation field – as the multiplicity of stakeholders of the innovative ecosystem, the dynamics and interactions of the ideation process and the maturity of technology and manufacturing techniques – into a comprehensive yet simple tool for managers exist? This paper tackles precisely these issues of collaborative tools for the strategic management at the level of an innovation field.

2. Literature review

To improve our understanding of the nature of the impact of visual tools on strategic innovation management, we start with a review of existing visual tools. Scholars previously highlighted the fact that the use of visual tools has a positive effect on a firm's organization (Bresciani and Eppler, 2010). There are many different visual tools adapted for a specific issue of an innovation field and they are diverse in format and methodology. Thus, we can organize them in two categories: qualitative tools that are conceptual in matter (Bresciani and Eppler, 2010) and quantitative tools that gather big source of data and transform it to visuals (Huiying and Hui, 2011). An alternative way of organizing visual tools places each tool in an innovation project frame, where the innovation project is divided into few stages and the tools are placed in the project frame according to their purpose. Our review allows us to further aggregate the tools into three families of visual strategic tools, according to their focus in R&D project management. They focus on: 1) decision-making, the "Stage Gate" family; 2) technological evolutions, the "Roadmap" family and; 3) stakeholders' interactions, the "Network Mapping" family. These families were placed in the innovation project frame in Fig.1.

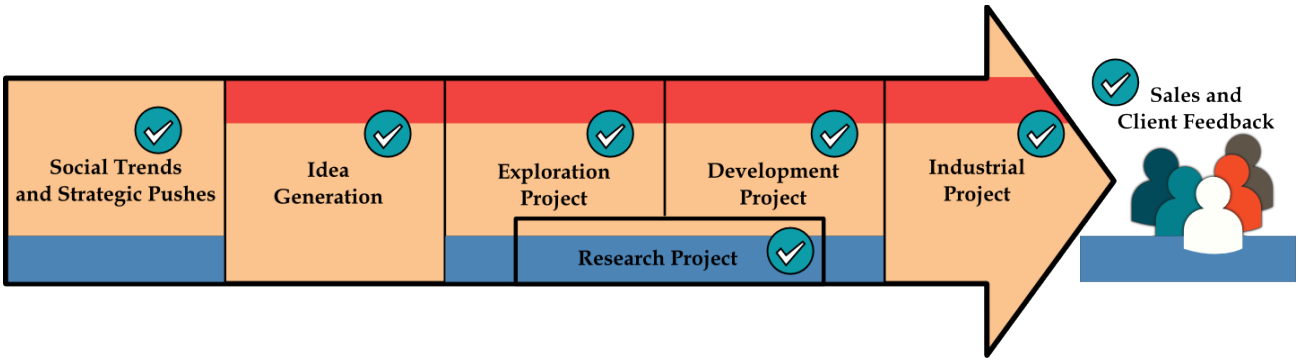

Figure 1. Innovation project frame: in red, the Stage Gate family; in blue, the Roadmap family and in cyan with a check circle, the Network Mapping family.

In the first family, focused on decision-making, the Stage-Gate is the most representative tool. It was created to respond to an innovation management need of structuring the decision-making process in an innovation project (Cooper, 1990). This tool describes the life scope of a project included in an innovation field. It is used by many firms on their own adapted version of a Stage Gate process (Chao et al., 2013; Cooper and Kleinschmidt, 2001; Cooper, 2008). The basic principle of this tool is that each gate represents a decision point in the life of a project and each stage increases the degree of maturity of a project. The first stage "Discovery" which refers to the generation of ideas is a crucial step in innovation projects because it determines the research guidelines of the R&D department. This stage is analyzed in Fuzzy Front End literature (Koen et al., 2001). Nevertheless, since the Stage Gate tool has generated many guidelines, it is largely considered as too rigid for an innovation process that is supposed to be fluid and dynamic (Akroyd et al., 2009; Ettlie and Elsenbach, 2007; Högman and Johannesson, 2013). Hence the Stage Gate tool has been modified to include a more open and dynamic interaction of an innovation environment. Thus the Innovation Funnel could represent an innovation field from a decisional perspective and its interactions with other portfolios or external stakeholders (Grönlund et al., 2010). Despite its weaknesses, and because of its diffusion among managers and the straightforward lecture, this tool is an anchored

reference of visual representations for innovation strategic management.

In the second identified family, the technological capacity of turning an innovation into a product or service is a dimension to be analyzed. A well-known tool that treats technological development is a Technology Roadmap (Kostoff and Schaller, 2001). A roadmap's goal is to give an idea of the technological development planning. In a R&D management project, it can be considered insufficient, because it does not give any indication on the degree of maturity of an innovation. In contrast, a Technology Readiness Level (TRL) and a Manufacturing Readiness Level (MRL) are two tools that better measure the state of a technology or process (Mankins, 1995; Sauser et al., 2006). Used in complementary terms, these tools are insightful to understand what key elements need to be explicated in roadmaps, even if their implementation deeply impacts an organization. Therefore, roadmaps are more suitable for placing an innovation field inside an innovation environment and for proposing a forecast of what the innovation field will look like in the future. However, even though this is valid for roadmaps in general, these take several different formats, which are illustrated in an extensive review by Phaal, Farrukh, and Probert (2004) . One particular format, a "Multilayered Roadmap", is interesting for visual mapping because it envelops many aspects of an innovation field into different categories: market, business, product, service, system, technology, science and resources (Kerr et al., 2012; Phaal and Muller, 2009). By doing so, it is possible to place a given development within a firm's organization and within the technological trends of the corresponding sector.

Finally, the third tool family, the network mapping, has the ability to make the design phase of an innovation clearer from an R&D stakeholders' point of view (Mitchell et al., 1997). Innovation activity is characterized by its many iterations and interactions between inventors, designers and prescribers of innovation. Therefore, the two methods of identifying this intricate network are: a quantitative method that is based on a large amount of data using an algorithm to find the significance of a given relationship within the ecosystem of innovation (Barabasi et al., 2002; Huiying and Hui, 2011; Wang et al., 2012) and a qualitative method that studies a project contribution in a R&D department by a peer-to-peer evaluation conducted by interviews (Marra et al., 2011; Salter and Gann, 2003). Project interaction within a R&D portfolio was studied in a Visual Project Mapping with a contributor and beneficiary logic (Killen and Kjaer, 2012).

Each of these major visual tools depicts some paths of an innovation field. Nevertheless, these tools are not enough to describe an innovation field in extent. Moreover, these tools do not cover the entire length of an innovation project. Based on previous literature and a case study analysis, we propose in this research to discuss, learning from experimenting, a tool which presents a good overview of an innovation field and describes an innovation project in extent.

3. Methods and research material

Based on an intervention research (Radaelli et al., 2014) led inside Renault in 2014, we conducted the construction of a visual map that managers could integrate into their common practice based on the experimentation of the tool on a specific innovation field: the electric vehicle charging. This field is of utmost importance for the development of the electric vehicle mobility, especially in Renault that is involved in an ambitious strategy on electric vehicles. To be successful, this innovation field needs also the involvement of numerous actors outside the firm: carmakers, software engineers, electricity producers and retailers, and public policy interact on this field to define standards and charging options.

First of all, the literature review of visual tools adapted to represent a dimension of an innovation field led us to a baseline of the requirements to construct a suitable tool for an innovation field. We discovered the current limitations of visual representations and how to evaluate the performance of a visual tool (Andriessen et al., 2009). This academic preparation concluded that visual tools do not englobe everything that a manager looks for in a visual tool. Therefore, we discovered that some tools could be complementary in nature that is the disadvantage of a given tool could mean an advantage for another one and vice versa. Finally, we addressed three major challenges in order to create a comprehensive tool of an innovation field: 1) an interphase and fusion challenge arose when an innovation project stage is either described by two or more tools or when it is not described at all; 2) due to the dynamic nature of an innovation field, the visual tool must also capture these changes in time, this is the evolution challenge and 3) a common visual language is a requirement in order to make a complementary tool useful.

The next step of the collaborative research, inspired by field work in New Product Development (Grönlund et al., 2010; Högman and Johannesson, 2013), was to conduct 16 semi-directed interviews addressed to managers from many different positions involved in the development of the innovation field. These interviews lead to a synthesis of the innovation field challenges and the limits of the innovation process of the firm to solve such an issue. In addition, the content and format of the visual tools from literature was discussed with internal R&D stakeholders and compared with existing tools in the firm's innovation process. Once that a tool format was defined and the knowledge on the activities within the innovation field of electric vehicle charging innovation field was sufficient, a proposition of the *Innovation Map* was tested with the same participants of the interviews. In order to evaluate and validate the new tool by managers, we conducted a workshop which objectives were to present the visual tools, to explore the uses of the tool through a serious game where managerial roles were given to participants and then, to test the tool in real case scenarios. The workshop enabled managers to interact and share their opinions about visual representations of an innovation field and put them in situation to use the Innovation Map.

In the next section, we are going to present the Innovation Map and each of its visual components.

4. Proposing a tool for innovation field management: the Innovation Map

The Innovation Map is composed of several visual tools built to be compatible with any innovation field and tested on the case of electric vehicle charging inside Renault. Here we will discuss how each of the tools describes an important dimension of the innovation field. Since the main goal is to present the Innovation Map as a whole we will introduce briefly each tool with a first-hand approach describing the visual aspects, the main outputs, user feedback and current limitations. We will then give the global Innovation Map and why the different visual tools should be assembled in one map.

4.1. The Integral Roadmap: representing a firm´s strategy

Roadmaps were highlighted by managers as a key tool to represent the strategy of a R&D department during the interviews we conducted. These tools allow a global view of the innovation field that is not limited to the description of the various technological development of the innovation field. Starting with a theoretical draft based on a multi-layered Roadmap (Phaal and Muller, 2009), we adapted the tool to answer the main requests that were encountered in practice by managers. In essence, this tool: englobes 6 categories of the electrical vehicle charging field displayed on a time frame. These categories, presented in the rows of the tool, were chosen as the key strategic aspects that needed to be explicated in a Roadmap by managers. This enhanced Roadmap presents the interactions between each of the categories and it states the key aspects of the innovation field. The organization of this representation follows an indoors to outdoors logic starting with the very outer interface that is the external stakeholders all the way down to the main product specifications that are dictated by customer needs and client services as seen in Fig. 2.

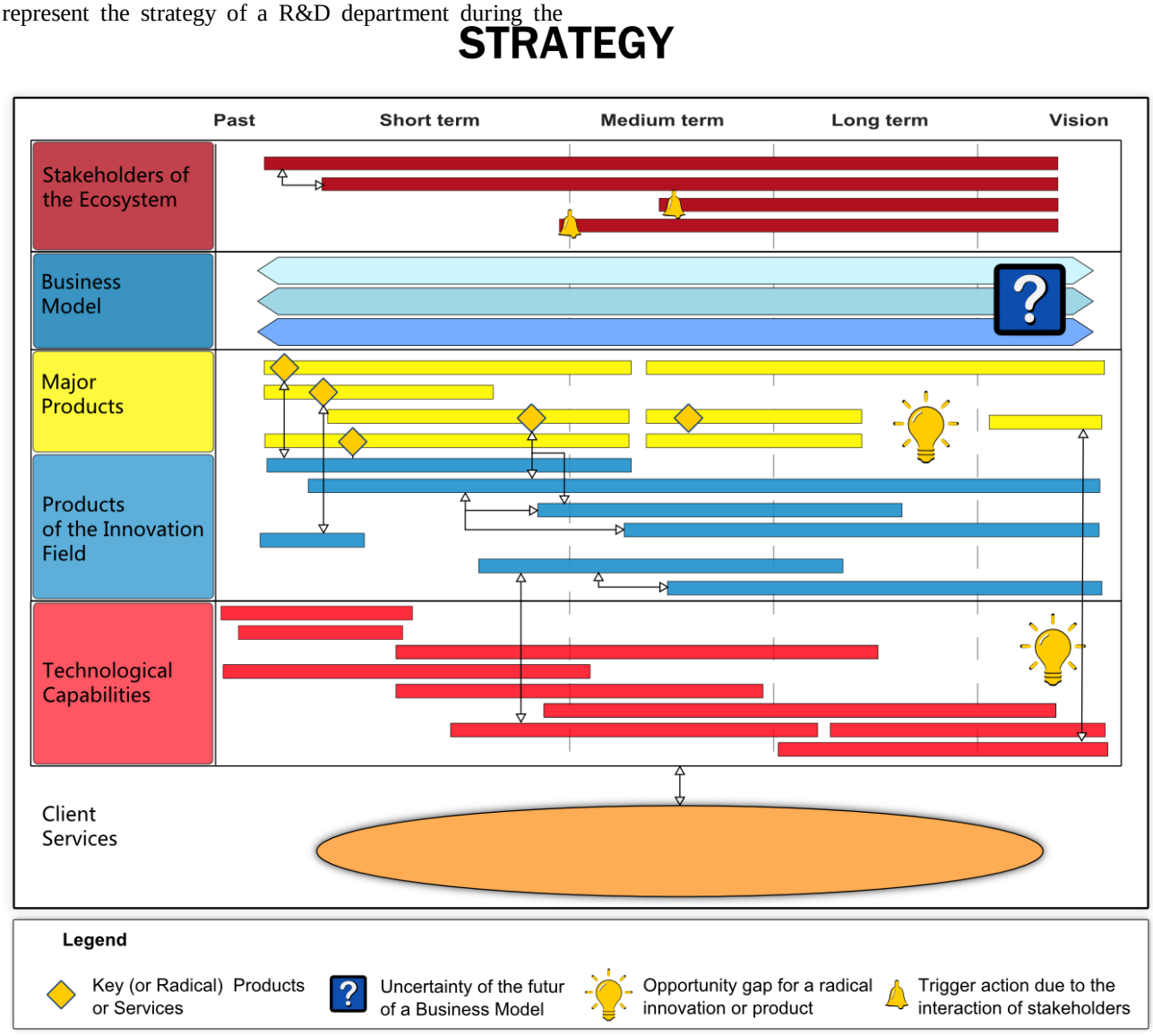

Figure 2. Schematics of the Integral Roadmap.

Concerning the visual aspects of this tool, we kept some of the characteristics of the Roadmap family. But, as some of the categories are not usual, i.e. business model and client services, we represent them in a more

flexible way that disconnects these two categories from the time axis. Furthermore, the fundamental interactions between each category are useful to take into account various point of views when analyzing an innovation field. Finally, 4 special icons are dedicated to address some key aspects of the innovation field such as: key products or services, the uncertainties of the future of a Business Model, the opportunity gaps for a radical innovation and the triggers action due to the interaction of stakeholders.

4.2. The Business Models Roadmap

In the Integral Roadmap, the representation of a business model was limited to a single row. However given its importance in any innovation field, we created a visual tool designed to describe the main business models within an innovation field. Starting from the outline of an enhanced Roadmap, the logic of this tool is to zoom into one of the categories of the Integral Roadmap. The main goal of this Roadmap is to briefly describe the state of each of the business models existing in an innovation field. As seen in Fig. 3, the aesthetics of the two Roadmaps are very similar with the main difference that the Business Models Roadmap includes more detail.

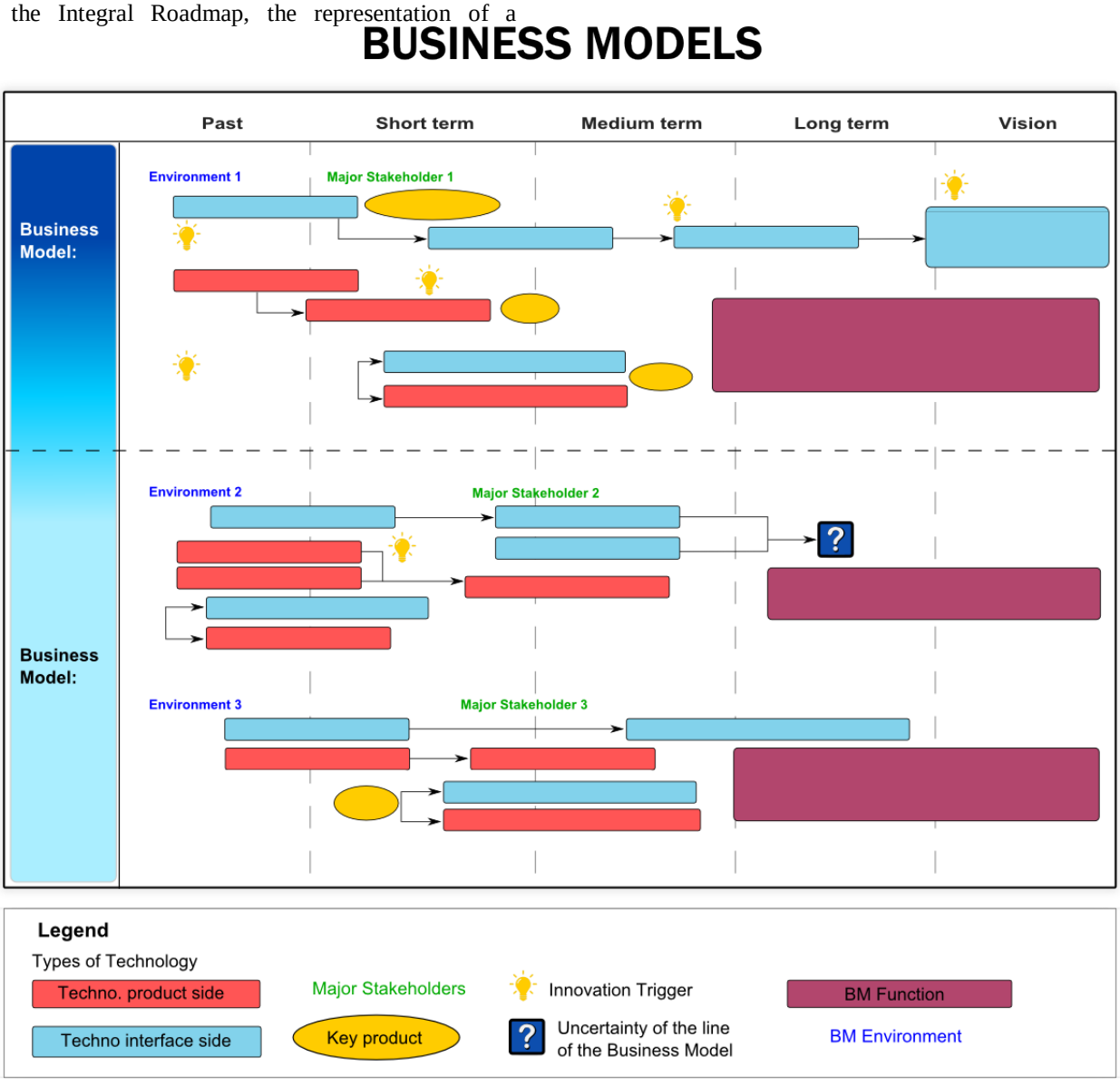

Figure 3. Schematics of the Business Models Roadmap.

Since some business models can overlap, it is possible to find the same product or service in two different business models. Therefore, this tool indicates the various meanings for a firm to place their products into a given market. This tool is useful to explore new ideas for taking a product from the prototype phase to the marketing and sales phase.

4.3. The Technological Evolution

We pointed out that history of an innovation field is crucial to understand its evolution. In order to display this dynamic in time, a visual tool was developed inspired by the Idea's Channel or Funnel (Cooper,

2008). This tool focuses on the broadness and variety of an innovation field. The technological developments were depicted in a time axis that englobes the various solutions that were developed through history. In terms of format, the shape and color of the technology evolution indicates how the innovation field changes in time. In other words, if an innovation field has many technology options then the size of the innovation field at a given point in time will be bigger. Likewise, color changes whenever the innovation field becomes more active that is the technological developments are no longer prototypes but become products, this also means bigger funding for the innovation field projects. The changes in the life of an innovation field are marked as key facts that changed the dynamism of the field. Likewise, the separated stages of the innovation field, marked in yellow, define the stage of development of the field. Having the history of the innovation field in hand is a first step to understand the technological solutions used today. Moreover, this tool represents the history of a product line or service, like a family tree, from the first innovation to its current state. From managerial perspective this tool gives some clues to explain why some paths were a success and some others were a dead-end (See Fig.4).

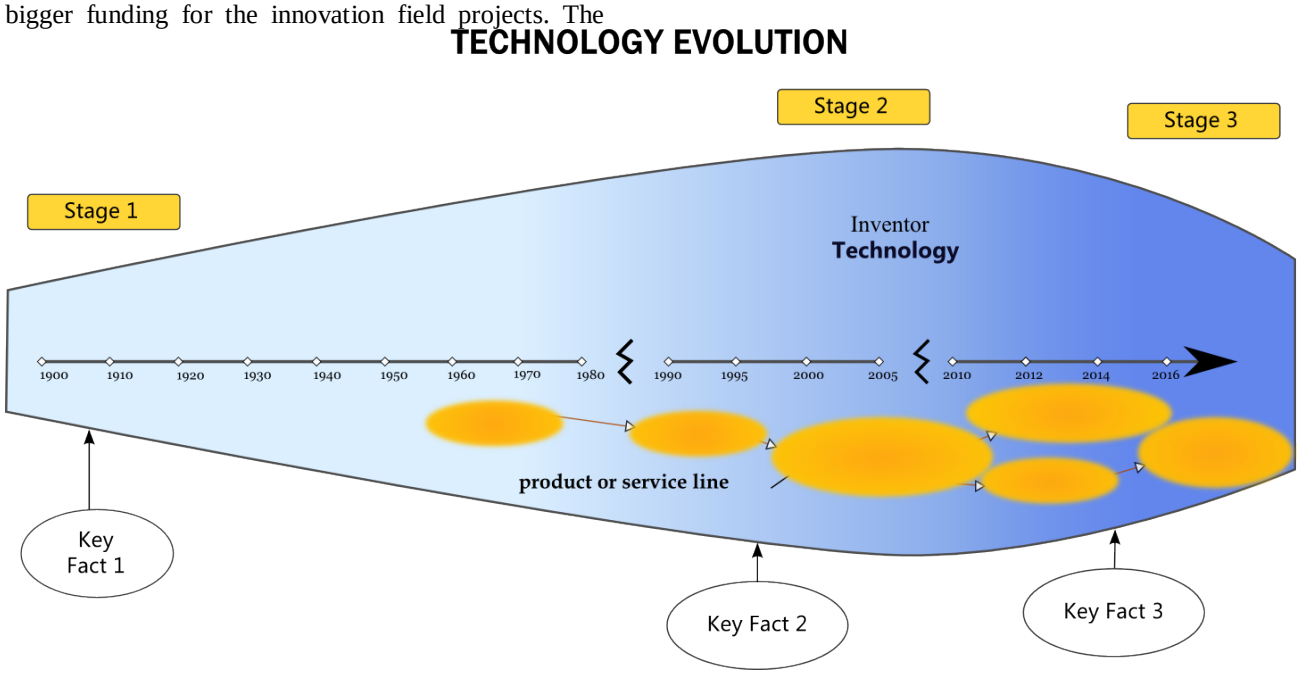

Figure 4. Schematics of the Technological Evolution.

4.4. The Ecosystem of Interactions

First network representation included in the Innovation Map, the Ecosystem of Interactions, gives a macroscopic lecture of how the industry interacts in an innovation field. On one hand, this network highlights the weight of the interaction between the main industrial sectors involved in the innovation field. Thus, the arrows linking each of these categories are not equal in terms of investments, lobbying and partnerships. On the other hand, to make the difference between sectors clearer, we classified each industry into a category that has a different color according to the importance of this category in the innovation field. Finally, we included a critical category in the ecosystem that is the client, placed in the center of the tool, because it has major influence in all industries sectors, as seen in Fig.5.

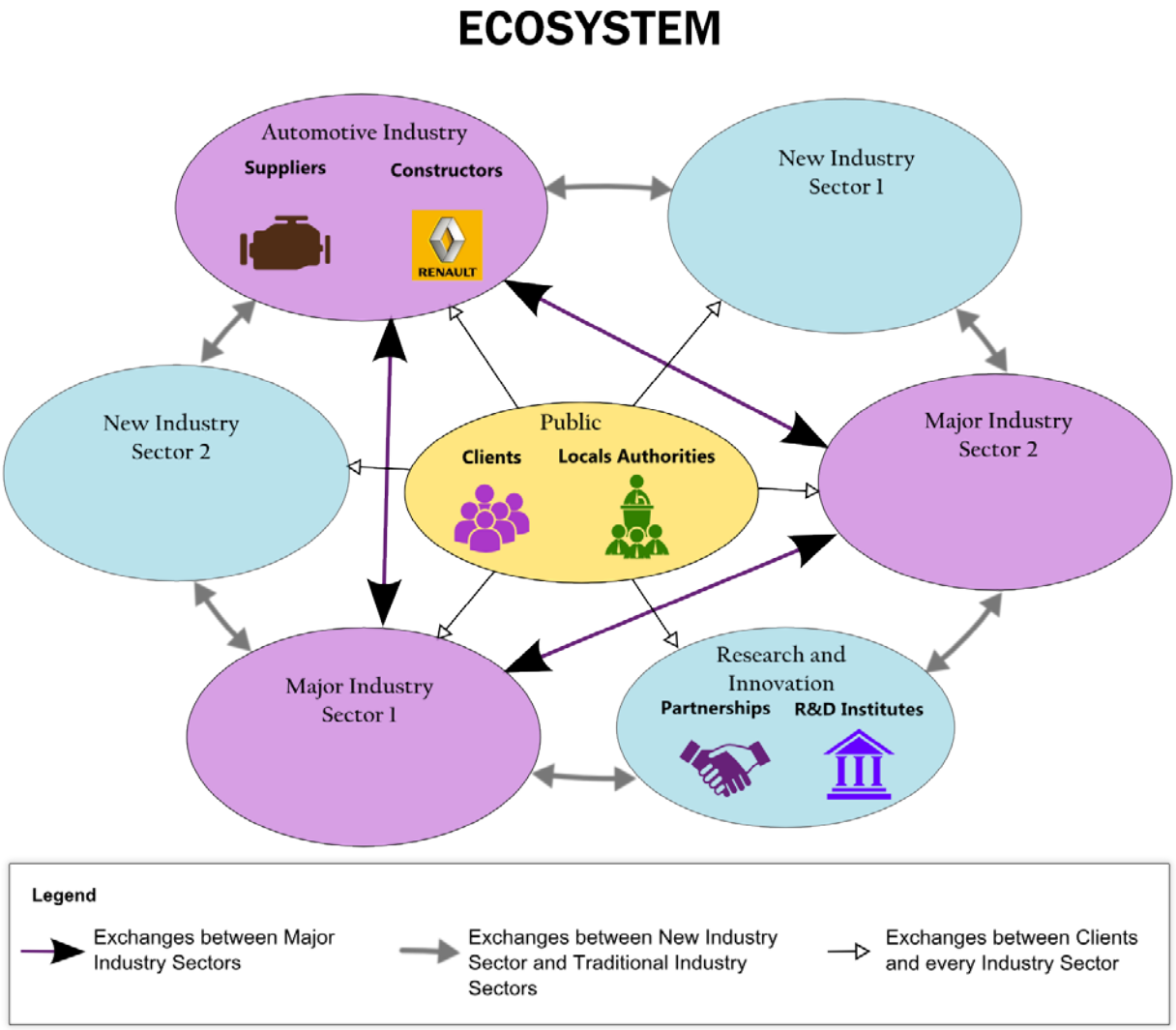

Figure 5. Schematics of the Ecosystem of Interactions.

4.5. The Projects Network

The Project Network is a second visual representation of the stakeholders of an innovation field. With the Ecosystem of Interactions, it is a toll that is used to represent the complexity of a diverse group of stakeholders in the field. They are similar in the sense that they both contain nodes and interaction links between the different types of stakeholders but they differ in the type of information they give to managers.

The main goal of this representation is to have a partnerships map where a manager is able to identify the firms working in an innovation field. Furthermore, the tool focuses on a specific project interaction within the ecosystem. As in the previous network tool, the main firms are grouped into industries sectors. Nevertheless, there are several differences between the two network representations of the Innovation Map. In the Project Network, we emphasized the role of a company in the ecosystem, in our case study this company is Renault and it is placed in the center of the visual tool while the other firms are placed around the main company as seen in Fig.6. In order to mark a given project in the ecosystem, we developed an accumulation approach of the Projects Network that make the main dynamics of stakeholders that worked throughout the years with Renault in the innovation field of electric vehicle charging visible. From this basis, the tool builds up in detail displaying some important information about the given project that is:

- In the center, the name of the project, the time lapse of the project and the research axis in red.
- The project coordinator in yellow from one of the industries´ sectors.
- The budget distribution: at the right bottom corner, the total budget of the project and the corresponding grant given by a public entity in the public sector category.

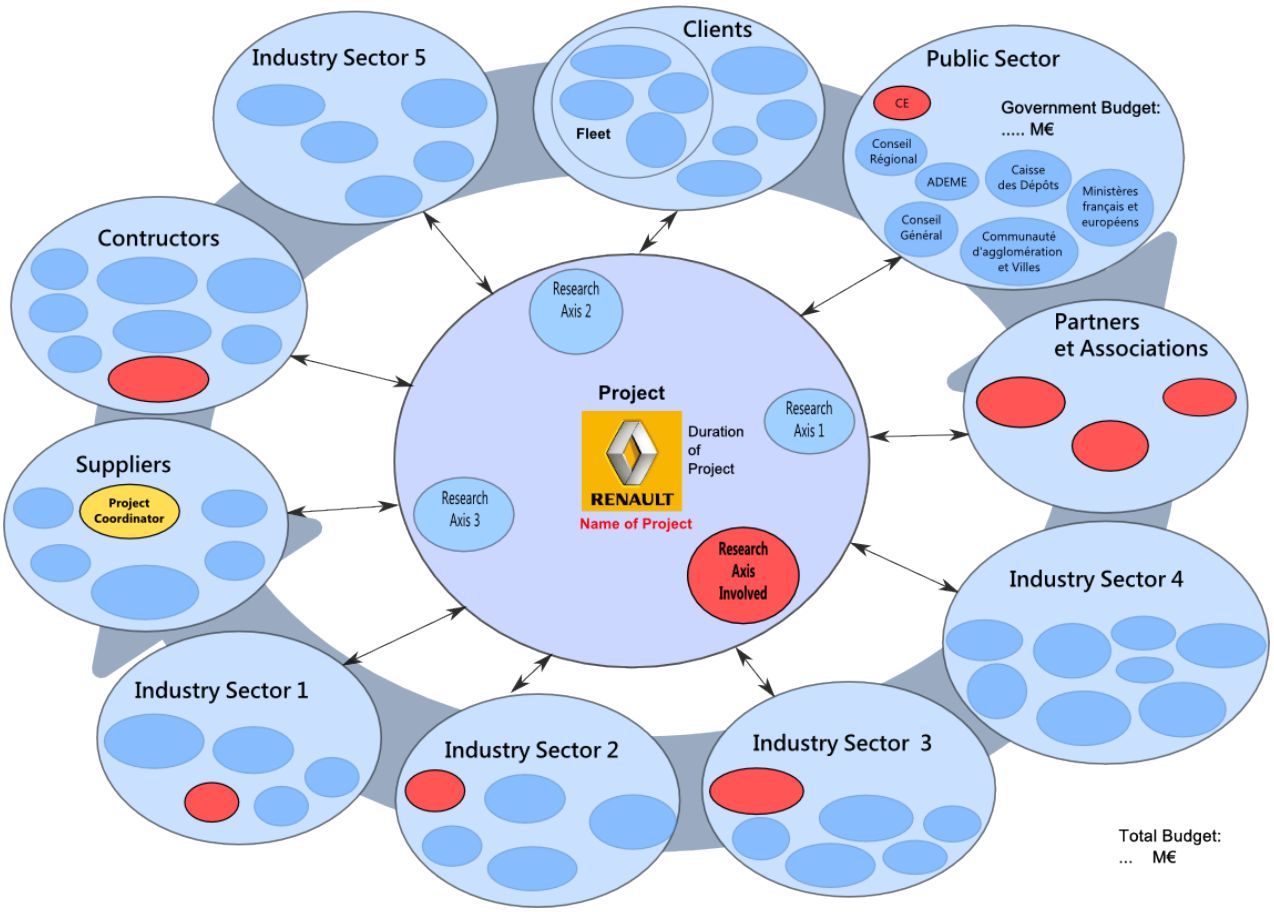

Figure 6. Schematics of the Project Network.

In order to have a horizontal perspective of the project portfolio of the innovation field, more than one project network should be analyzed in parallel. Therefore, the number of solicitations within this portfolio will show the importance of a specific stakeholder or industry sector. Moreover, this tool highlights the way a firm works with its ecosystem. For instance, it could show the heavy weight of a stakeholder or the lack of partnerships with an industry sector that might rethink the partnership strategy of a firm. Likewise, since the project network is dated it is possible to study the evolution of partnerships of the innovation field in a chronological order. In addition, the tool includes the budget of a given project to give an idea of the public and private investment in a given technology.

4.6. The convergence of visual tools: the Innovation Map

The visual map combines 6 main strategic elements of the innovation field: the current state of development, main stakeholders, history, major assets and challenges of the field and business models. These strategic elements were the basis to build five visual tools: Integral Roadmap, Business Models Roadmap, Technological Evolution, Ecosystem of Interactions and Projects Network. Each visual tool was associated with an innovation field dimension. The combination of various visual tools in a synthetic map enables an enlarged lecture of the field targeting critical points that were considered relevant by managers. Furthermore, each tool complements the others, making this visual map a strong synthetic tool. In the end, the visual tools were gathered to constitute the visual map of an innovation field. The Figure 7 presents the blueprint of the final map.

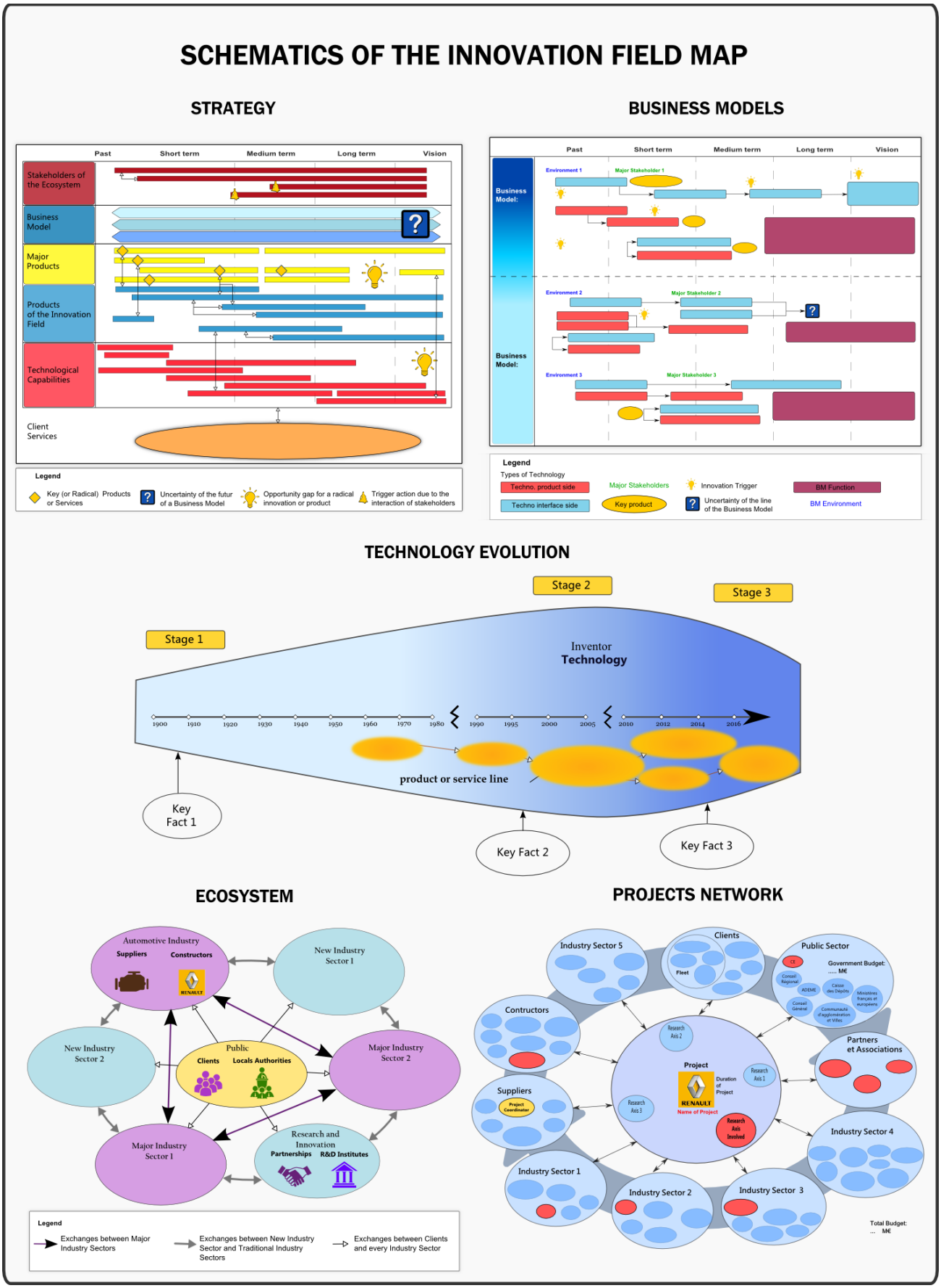

Figure 7. Schematics of the Innovation Map.

5. Main findings

The previous description of each tool introduces the basics uses that a manager can do with them independently. Although, not every tool is suitable for a given analysis, we recommend in the workshop that the user chooses the most adapted tool for his analysis. Therefore, we present, in more detail, the capabilities of each tool in Table 1. and their limitations in terms of interpretations.

Table 1. Capabilities and limitations of the Innovation Map tools.

Name	Tool Capabilities	Tool Limitations
Integral Roadmap	Macroscopic lecture of the innovation field Identifies the main innovation triggers in the field	Does not show the stakeholders´ ecosystem Is not adapted to represent the innovation project history
Business Model Roadmap	Detailed view of the Business Model of the innovation field Allows a deeper understanding of the market and clients in the business	Requires a more paused analysis of the visual tool Needs an expert or upper level management validation to be legitimated
Technology Evolution	Shows the field history Is suitable for studying the field changes throughout time	Does not include the innovation field ecosystem Is of little use if the innovation field is brand new
Interaction Network	Synthetic tool that locates the innovation in the industry ecosystem. Gives a qualitative value to the interaction between different activities sectors. Differentiates the stakeholders within the innovation field.	Does not include the representation of a given project It is less standard than the other tools since every field has its own particular place in the industry ecosystem
Project Network	Determines the most important stakeholders, the evolution of their implication and the current company´s dependency to a partner in the field. Gives the Accumulation Network of every partner that worked with a company in the innovation field.	Does not give any distinction to the way stakeholders interact Does not show the weight of stakeholder compared to others Does not show if some of the resources in a project are shared with other projects in terms of partnerships

The capacities of each tool are not perfect if treated separately. Nonetheless, the configuration of Innovation Map overcomes this inconvenience by building on the convergence of these handy but not comprehensive tools. Therefore, the visual map was created to give sense and correlate the tools into the innovation field dimensions.

Regarding the challenges that we cited of the ideal tool for the representation of an innovation field, the Innovation Map complies with the requirements set. First of all, the alliance between various families of tools enables the depiction of the entire project frame. Consequently, managers will be able to position the field into the firm´s project frame using one or more of the tools in the Innovation Map. For example, for the Social Trends and Strategic Pushes phase both the Integral Roadmap and the Business Models Roadmap describe this state. Some of the major concerns of this earlier stage are strategy, innovation triggers and market awareness that correspond to the main features of these tools (see Table 1).

Second, two of the tools from the map: the Technology Evolution and Projects Network are suitable for describing the dynamism of a field. From Table 1., the main capabilities of these tools: describing field history and determining the evolution of stakeholder´s implication, involve the representation of time evolution of the field.

Third, a common language for visual mapping is only possible if the tools conceived for this purpose are specially adapted to give a simple and standard guideline of reading and communication for managers. In the case of the Innovation Map, we treated this issue by two meanings: from an model based perspective, the map is constructed to put the more similar tools together, therefore the Roadmap family is located on top and The Network family in the bottom of the map and from an aesthetic perspective, colors, fonts, layouts are similar within a family tool and are also coherent with other families.

Furthermore, the practical uses of the map were studied in a workshop where we addressed the visual tool to a group of Innovation, R&D and Business Development managers that evaluated the tool with a hands-on situation. The first hypothesis we wanted to test with this real evaluation was that according to the reader's profile, i.e. how he was involved in the different steps of the decision

making process, the interpretation of the information given by the tool would be distinct. For example, a business developer unit manager will emphasize his attention on the business models roadmap and the integral roadmap. This hypothesis was confirmed by our workshop, we showed that our tool could be used by different profiles, who read the visual map according to their specific needs. Moreover, the workshop underlined that different profiles of managers are helped by the common tool to take strategic decisions together.

A second hypothesis tested the cross lecture of the visual map that assumes that given a concrete managerial problem there might be a more suitable reading sequence of the visual map that best responds to the problem. In order to challenge this assumption, we created three realistic scenarios where participants were asked to choose which visual will they use to resolve the problem. The results were as predicted, managers used the map in a sequential manner where they picked a visual tool to answer one aspect of the issue and then they moved to the next visual to attack another aspect of the problem. The performance of a map that combined different tools focused on specific strategic data was validated.

The majority of the managers felt comfortable using the more commonly known tools that are the Roadmap family tools and the Technology Evolution tool whereas, they felt less familiar with the Network family tools. Nevertheless, they all considered that seeing the ecosystem in a network fashion was something that they always considered in their planning and strategy but they did not put it into a visual tool. Overall, managers thought that the principles of the visual tools of the Innovation Map addressed the principal aspects of the innovation field. They also agreed on the importance of establishing a common language to use visual representations in a firm.

6. Discussion and further research

The Innovation Map presented here is an initial work on a practical use of visual abstraction to point out and share various strategic aspects that managers have to overcome at the innovation field level.

First, the innovation field map of the electric vehicle charging proved to be a basis for further applications in other areas because the dimensions represented on the map that are strategy, business model, technology evolution, ecosystem and project mapping are common foundations of every innovation field (Coombs, 1996; Le Masson et al., 2010; Wheelwright and Clark, 1992). The construction of each visual tool could be done in a workshop manner where each participant contributes to elaborate a common tool or by a tool designer that synthetizes the information gathered from experts into a visual tool. It is important to highlight that the process of building these tools is as significant from an innovation field management perspective as the tool itself, as the information building process increments knowledge (Phaal et al., 2004).

Nevertheless, some limitations and perspectives emerged. One of the modifications that came across as being interesting to the model is translating the on page version of the visual map into an interactive map with the help of virtual applications. If the aim of the company is to have a dynamic and interactive tool, then a digital version will allow getting more or less detail from the tools depending on the user's demand. In other words, a first modification targets an apparent rigidity of the first version and enables user personalization. From an innovation management point of view this further development would give an original and powerful tool to an innovation field.

However, as the aim is to have a common tool that is the same for every manager, beyond the language associated to the nature of the objects within the innovation field, a common language of visual abstraction has to be developed as a first step to make the innovation field map a managerial tool. Then, even if the innovation field map is not a decision making tool in itself, it efficiently supports managers in making decisions.

In conclusion, from the variety of tools proposed in the Innovation Map managers thought that there are two possible ways to enhance the current version. First, replace the Business Models Roadmap with an adaptation of the Business Model Canvas (Osterwalder and Pigneur, 2011) at the field level. Since this tool is specifically design to depict a business model, it is compatible with the Innovation Map. Second, managers thought that the Innovation Map lacks a quantitative approach of the innovation field. Hence, the map could be enlarged to a sixth dimension that includes a more classic visual tool as a 2D/ 3D Plot that addresses the key challenges of the innovation field from an economic performance perspective. These two modifications are suitable for further research.

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