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THE EMERGENCE OF “EXPERTS OF THE UNKNOWN” – LEARNINGS FROM RENAULT AND SNCF

Abstract

The paper studies the institutionalization of a new domain of expertise dedicated to the exploration of the unknown in two established French technological firms with strong organizations of experts. The research is built in a comparative qualitative longitudinal research partnership with Renault (global car manufacturer) and SNCF (national railway company). This research highlights 4 main results: firstly, experts of radical innovation management are experts at managing the unknown in industrial contexts and breakthrough innovation strategic issues, wielding tools, and methods for breakthrough exploration. Secondly, experts of the exploration of the unknown support the other experts to explore the unknown. In this way (third result) this domain emergence highlights a new kind of interaction between innovation and expertise that (last result) cements breakthrough exploration capability as a strategic field.

Keywords: Radical Innovation - Expert - Unknown - Design Management

Introduction

The role of an expert is well established in the literature: it is either to make a decision or to define a strategy (Trépos, 2016). In the context of hyper competitiveness (Ilinitich et al., 1996), experts also contribute to the dynamic and strategic renewal of industrial expertise within their firm (Cabanès et al., 2016). This dynamic only intensified to face the modern challenges (energetic transition, pandemic, etc.), which require more breakthrough R&D for radical innovation, and thus more industrial explorations in the unknown (Le Masson and Weil, 2020). So far, the literature that has linked innovation and experts (Cabanès et al., 2016; Lelebina, 2013) has never considered any expert of radical innovation management, specialized in breakthrough exploration methods and, thus in the management of the unknown. However, a new phenomenon in industrial expertise management has occurred these last years: domains of expertise dedicated to radical innovation management were officially created within expertise organizations. “Experts of the unknown” emerged whereas the associated skills seem not well-defined and established communities of practice are not largely recognized as legitimated scientific group within the firm. Moreover, the aim of such a domain of expertise is officially to foster the innovation capability of the firm while it is also the role of the other experts specialized in sciences or technology (Cabanès *et al.*, 2020; Lelebina, 2013; Trépos, 2016). To

our knowledge, when Renault (French car manufacturer) and SNCF (French national railway company), two large and established industrial firms, decided to create an official domain of expertise totally dedicated to radical innovation management, it was the first time that such domain appeared since the apparition of experts' organizations. It is also worth noting that these events occurred at quite the same time in two independent firms. Thus, our study proposes a longitudinal qualitative comparison between the apparition of both domains of expertise in radical innovation management at Renault and SNCF from January 2009 to today, in order to analyze this new phenomenon in industrial management of innovation capability. With the input of stakeholder, this paper aims to retrace the emergence of such a domain in each firm, and observe the organization, the definition of the strategy and the missions in each case.

Thus, our research addresses the following question “*Why established industrial firms need to institutionalize an expertise of the unknown?*”. This question involves interest from different points of view. For practitioners, the challenge is first to know how the new domain of expertise dedicated to the management of the unknown efficiently structures its activities in collaboration with the others actors of radical innovation within the firm (R&D project leaders, portfolio managers, product owners, experts leaders of other strategic domains, etc.), and second to know how leverage the impacts of the new domain of expertise on the both firm's innovation capability and industrial strategy. For researchers, the point is to observe why firms' managers needed to create a specific expertise area, while experts of both firms are already officially in charge of radical innovation in their field. They are also interested in how does the current relation between strategic explorations of the unknown and the experts of different domains justify the creation of a domain of expertise in radical innovation management.

This paper starts with a literature review of the managerial expectations of an expert's capacity to foster innovation in industrial firms. The second section presents the settings of the collaborative research and our data collection methods. In section 3, we present our comparative

case study. Section 4 discusses these results and presents the main conclusions for research on expertise management for innovation.

1. Expert in industrial firms: from technological competition to breakthrough R&D strategist

1.1. Technical experts: a source of knowledge for industrial innovation

In the 50's, to be competitive, science based firms were dependent on technological innovations as instrument of competition (Shepard 1958). Shepard (1958, p. 177) highlights that

“Within the individual firm, power tends to shift to those who possess the skills most needed for survival and growth. Over the past half-century, this distinction has passed from manufacturing to sales and thence to research and development.” Nonetheless, the R&D presented a weakness in its skills organization: with its growth, the R&D department presented problems of *“coordination, control, evaluation, program formulation, personnel maintenance, decision-making”* (Shepard, 1958, p. 178). Thus, a new managerial class emerged to exercise control over the scientific and engineering activities. By this way, all the technical men entering the managerial class were no more devoted to technical topics. *“When a good scientist is made a manager, a good scientist is lost”* (Shepard, 1958, p. 179). In the same time, having a high degree of technical competence in the laboratory is recognized as assuring better results. Hence, to offer an alternative to the managerial career, and to recognize the expertise of some scientists and engineers, a dual ladder was developed and offered a technical career path (Shepard, 1958). Thus, the technical and scientific experts appeared, and they aimed to secure a pool of technical and scientific talent for science-based organizations. This reinforced the loyalty of these experts, and it strengthened the development of the expertise on which the firm built its innovation strategy (Gilbert *et al.*, 2018, p. 128).

If the dual ladder was highly criticized from the moment of its creation (Allen and Katz, 1992; Bobadilla and Gilbert, 2017; Gastaldi and Gilbert, 2016; Lelebina, 2014; Shepard, 1958), it still mainly remains firmly established in many firms (Gilbert *et al.*, 2018). Indeed, since the dual

ladder does not really specify the role of technical and scientific experts, they are generally seen as an advisory service rather than an innovative force. However, since this model appeared, there has been a lot of research focusing on the role of an expert. After 1950, an area of expertise was based on an identified and established technology (Gilbert *et al.*, 2018). The expert (or scientist) needed to generate knowledge in his area of expertise and not intervene in innovation strategies. In innovation processes, the expert (or the scientist) was considered as a resource for the decision-maker: the expert's intervention is limited to providing information to the manager, considered as the decision-makers who made the request (Cabanes *et al.*, 2016, 2020). In 1980, a concurrent engineering model appeared, one based on a business / project matrix organizational structure (Wheelwright and Clark, 1992). The experts are divided into the different projects which had the effect of boosting the combination of knowledge but reduced the exploration and the creation of new knowledge. In such an organization, the experts of one domain can no longer share their experiences anymore. In the project management model, the experts must produce knowledge in their area of expertise in accordance with the combinability requirements imposed by the project manager in charge of piloting and organizing the design (Cabanes *et al.*, 2020). In the 1990's, Cohen and Levinthal (1990, p. 1) argue that, “ *while R&D obviously generates innovations, it also develops the firm's ability to identify, assimilate, and exploit knowledge from the environment*”. The experts thus become integrators of new knowledge according to the knowledge the firm already has (Bigliardi *et al.*, 2011). As knowledge keepers, the experts have to develop the future knowledge and thus they indirectly contribute to the development strategy of the firm (Barley and Tolbert, 1991) ; and they must also act as information and advice providers for decision makers, that is to say the top managers (Haas, 1992).

In summary, the role of experts is to be a resource by offering technical and scientific advice,

providing expertise for decision-making and building up technical arguments. Their roles don't change according to the innovation potential (incremental or radical) (Cabanes *et al.*, 2016).

1.2. From incremental to breakthrough and explorative R&D

Until 2000, the rule-based regime and systematic design theories prevailed. This regime is characterized by the generation of incremental innovation, whose main criteria are the improvement of cost, quality and delay (Redtenbacher, 1852; Abernathy and Utterback, 1975; Suh, 1990; Pahl *et al.*, 2007; Le Masson *et al.*, 2017). In spite of its preminent presence, this design regime was challenged by many modern evolutions since the 80's. First, firms were facing a hypercompetitive environment (Ilinitich *et al.*, 1996), and since 1990, new radical innovation challenges such as energy transition (Elmqvist and Segrestin, 2012) or pandemic (Guderian *et al.*, 2020; Sachs *et al.*, 2019). Thus, the role of R&D stakeholder is more crucial for science-based firms since they need to find more creative solutions and innovations to address these issues and to distinguish themselves from the competition. However, it has been shown that the systematic design theories were not able to provide breakthrough solutions (Le Masson *et al.*, 2017) which led to the search and the emergence of new design theories.

To begin with, the principle of organizational ambidexterity, which appeared in 1976 (Ducan, 1976) and was generalized in the 90's (March, 1991), implied a first change in the R&D organization : the necessity to distinguish activities which were aimed either at the exploration of new opportunities or at the exploitation of existing capabilities. This distinction was reinforced by the emergence and dissemination of innovative design theories during the 21st century, followed by the radical innovation regime. They introduced new innovation tools and methods to achieve radical innovation by exploration: the axiomatic design (Suh, 1990), the general design theory (Tomiya and Yoshikawa, 1986; Yoshikawa, 1981), the coupled design process (Braha and Reich, 2003), or the infused design (Shai and Reich, 2004a, 2004b), and the C-K theory (Hatchuel and Weil, 1999; Le Masson *et al.*, 2009, 2017). These suggest the R&D

process to get a new organization (Birkinshaw and Gibson, 2004; O'Reilly and Tushman, 2004; Hatchuel *et al.*, 2001).

These two design regimes do not aim at the same kind of innovation: the rule-based design regime aims at incremental innovation, while the innovative design regime targets radical innovation. Indeed, while engineering sciences model known objects, design theories support reasoning on unknown objects (Le Masson and Weil, 2013). According to the kind of innovation targeted, there are several types of R&D projects organization with many levels of change involved: *“exploratory projects are aiming at radical innovation while projects based on the improvement of one or more product and technology characteristics that enhance incremental innovation”* (Gilbert *et al.*, 2018, p. 146). The way to manage both projects differs (Lenfle, 2008). On one hand, *“in a rule-based design regime: objectives are known; the interactions between functions are not defined; the knowledge needed is known at the beginning of the process; and evaluation and validation methods are known.”* (Elmqvist and Segrestin, 2012, p. 73; Le Masson *et al.*, 2009). The aim of an exploitation R&D project is to minimize the risk to converge to predefined objectives (quality, cost and time), by exploiting existing competences (Elmqvist and Le Masson, 2009). This R&D organization fosters incremental innovation but limits the exploration beyond the expertise areas (Elmqvist and Segrestin, 2012). On the other hand, *“in an innovative design regime, the objectives are developed or revisited; the interactions between functions are unstable or revisited; the knowledge needed is not identified beforehand; and evaluation and validation methods need to be developed”* (Elmqvist and Segrestin, 2012, p. 73; Le Masson *et al.*, 2009). Exploratory projects ‘goal is to make innovation fields emerge. The main difference is that: *“it is no more possible to define ex-ante the goal and the means to reach it. Projects thus became highly uncertain and reflexive probe and learn processes. In this perspective projects are first and foremost a way to explore and learn. They became a fundamental component of search processes”* (Lenfle, 2008, p. 21).

Thus, the apparition of exploratory projects for radical innovation required the development of new tools and methods: breakthrough R&D tools. Even if the literature on the topic is still emerging, some research has already presented tools and process for designing radical innovation, which have already been adopted by industrial firm. A few examples are C-K mapping , KCP (Le Masson *et al.*, 2009), Design Thinking (Carlgren, 2016; Rauth *et al.*, 2014), Fuzzy Front End (Velamuri and al. 2017), the creation of different spaces for exploratory projects such as FabLab (Leveque *et al.*, 2020; Lô and Fatien Diochon, 2019; Mahmoud-Jouini and Charue-Duboc, 2008) or ideation capabilities (Björk *et al.*, 2010; Mahmoud-Jouini *et al.*, 2007). Thus, the generation, the exploration and the development of radical new ideas and concepts are now considered as activities that form the innovative capability for a firm (Assink, 2006; Elmquist and Le Masson, 2009). This supposes an adaptation of the R&D stakeholders and, therefore an adaptation of the experts.

1.3. Technical and scientist experts facing radical innovation management for an explorative R&D

To manage radical innovation and exploration activities, experts in established industrial firms must work on the integration and the development of dedicated tools, methods, or processes. In this way, some solutions were already considered by established firms, and were recently studied, as literature on the topic has only emerged since the 2010's. We identified three solutions. The first solution consists in separating the experts' activities according to the kind of innovation targeted. The second solution consists in organizing exploration and radical design workshops with experts used to rule-based regime. The last solution considers training experts already accustomed to rule-based regime to adopt innovative design tools.

1.3.1. The Technical Staff College: incremental and breakthrough R&D project management

In his study, Cabanes (2016) observed at STMicroelectronics that the technical staff of the R&D department (i.e. researcher, scientists and engineers) were not really engaged in their

communities. As a remedy, they replaced the dual ladder by a new organization: *The Technical Staff College*, in charge of coordinating activities and missions. The main objective was to enhance the impact of experts in the development of innovation strategy. In this way, experts were tasked with managing “*the exploration of new concepts for radical innovation, in organizing knowledge sharing, in providing technological information, in managing the renewal of expertise and in motivating members of technical staff.*”(Cabanès *et al.*, 2016, p. 10). Based on its description in the literature, the Technical Staff College is composed of seven Technical Staff Offices, three of them are dedicated to support functions. Two offices are attached to the thematic development of incremental innovation. Likewise, the radical innovation development theme is made up of two offices. It is important to understand that these last offices oversee the emergence of new domain of expertise, which then may contribute to the design of new products and services, as they identify pain points or potentials, then new fields of innovation to explore; a collective of different experts then explores the new fields in order to develop new domains of expertise for the firm, and not to develop product or service. Thus, the impact of these experts on innovation is still indirect but considers the both design regimes. Thereby, a new expert role appeared in addition to the resource expert (see part 1.1): the strategist expert, who can go beyond the known to explore the unknown systematically and collectively.

1.3.2. Reorganizing the R&D process with a radical innovation tool

In practice, several R&D department of science-based firms already used the KCP methods to organize collective action in innovation activities (Agogué *et al.*, 2013; Berthet *et al.*, 2016; Elmquist and Segrestin, 2012; Hooge *et al.*, 2016). We will consider here only two studies. At AutoX, some members of the team in charge of the strategy product planning department, initiated the KCP, and actors of the R&D department participated (Elmquist et Segrestin 2012). The KCP method helped the R&D stakeholders to identity missing knowledge, design relevant

criteria, and develop innovation strategies. In “aerofirm”, the R&D managers initiated the use of the KCP method, by which innovation capabilities were improved through the exploration process (Hooge *et al.*, 2016). In both cases, experts took part into the KCP workshops. Nevertheless, no R&D department had definitively established the KCP method as radical innovation process.

1.3.3. Massively training experts in innovative design

Rampa, Abrassart, et Agogu   (2017) studied how the Research Center of Hydro-Qu  bec (IREQ) went out of their R&D project development limits to be more innovative by integrating innovation design methods. IREQ decided to train 20 researchers to the reasoning specific to innovative design. The training lasts 8 days. After the training, participants developed new capacities for innovation design reasoning and collaborative creativity increased in the firm. IREQ could stimulate its creation of new ideas, new ways to explore new fields for research, and boost its ability to organize collectively creation activities. In this way, technical and scientific experts were able to explore the unknown of their field by learning innovative design tools. However, IREQ trained only 20 of its 500 researchers. Further research would help to study the impact that training all of the experts in innovation design reasoning would have on the firm’s innovation capability.

However, until today, no study has demonstrated the existence of any expertise of radical innovation management, specialized in breakthrough exploration or in another word, the management of unknown.

2. RESEARCH METHODS

2.1. Collaborative management research with two firms

This study is based on a collaborative management research (Shani *et al.*, 2008), conducted by academics and practitioners. It aims to give actionable knowledge for the organization and new theoretical models in management research (David and Hatchuel, 2008). The partnership has

been led since 2019 by the first author, a PhD candidate who is both a researcher in design and innovation capability and an employee of the main industrial partner, and it has been supported by senior researchers in innovation management, as well as members of industrial expert organizations specialized in radical innovation management. Moreover, the research relies on a longitudinal partnership on innovation capability (Pettigrew, 1990; Menard, 2002) that the research team leads with two established French technological firms with strong expertise organizations, firms that have both nominated experts dedicated to radical innovation management since 2014.

The core of the research is leaded with Renault (global car manufacturer) which re-structured its expertise organization in 2009, and now has 51 domains of expertise, embodied by approximately 779 experts, labelled as “Expert Leader”, “Experts” or “Specialists” of the domain they are charged with. In June 2018, Renault created a new domain called Innovation Patterns and nominated its first Expert Leader of such a domain. At the end of 2020, the Innovation Patterns Domain (IPD) was composed of 1 Expert Leader, 3 experts, and 12 Specialists, and new nominations of experts and Specialists are expected for 2021. The current dozen of experts in engineering design was trained for years in both systematic and innovative design, through a large diversity of engineering methods of optimization as well as breakthrough R&D and exploratory methods, such as for example C-K theory tools, Design thinking workshops, TRIZ, etc. All of them were involved in several innovative projects since the beginning of their careers at Renault. In particular, the study was carried out with 3 practitioners: the “Expert Leader” of the new expertise area, who oversees the domain of expertise, an expert in innovative design methods with skills in radical innovation marketing, and finally a Specialist in creativity methods and forecasting.

Concurrently, a second set of data was collected with SNCF (French national railway company), which also had structured an expertise organization in 2009 named Synapse. In 2011

an expert in radical innovation management was nominated “Synapse 2” (intermediate level of expertise), and then “Synapse 4” in 2014, which was the highest level of expertise charge within the firm. This expert was trained for years to innovative design through the C-K theory and was involved in many foresight and innovation industrial projects in his previous job from 2000 to 2011, in a public French transport firm and then at SNCF. This second collaborative research was carried out by the first author and this Synapse 4 expert, with the support of the research team for theory building.

2.2. Data collection process and research material

This article is based on two qualitative (Evrard *et al.*, 2009; Grawitz, 1996), longitudinal (Menard, 2002; Pettigrew, 1990) case studies (Yin, 2011). The collection of data uses multiple methods ranging from documents and participant observation (Mucchielli, 2021), to semi directive interviews (Merton *et al.*, 1990) and intervention research (David and Hatchuel, 2008), to triangulate the data collected (Flick, 2004).

Data on Renault case

As an employee of Renault, the first author has a direct access to Renault’s personnel, and was officially in charge of leading a study on the structuration of the IPD. In this context, the research team first gathered internal documents (Mucchielli, 2021) on the expertise organization to identify the people to interview and to understand the history (Webb and Weick, 1979). The authors realized 36 semi-directive interviews in three waves (Table 1). First, in 2019, the researchers met the main designers of the expertise organization: one semi-directive interview with the founder of the expertise system at Renault to get the history, one with the Expert Fellow in charge of all the expertise management to understand the current organization of the experts, and four with the IPD Expert Leader to understand how she became the Expert Leader of the IPD. The second wave occurred during the summer 2020. The authors led 10 semi-directive interviews with 5 Expert Leaders of scientist/technical domain, and 5 Expert

Leaders of management domain, to get their point of view on their roles as Expert Leaders, their impact on the innovation in their domain and on the strategy of the company. This second wave also served to examine their understandings of the IP domain's mission, and if they were differences between the two kinds of expertise (scientist vs management). For the last wave in September 2020, the authors interviewed 15 IPD Experts and Specialists in radical innovation management to understand what their capacities were, how they became Experts or Specialists and how they expected the domain to impact the firm's innovation capabilities.

In 2020 from January to December, the researcher organized a series of workshops with the IPD Expert Leader and one IPD Specialist, to take place every two weeks, with the goal of defining the purposes and the missions of the IPD (20 workshops in total). These workshops use the action research methodology (Coughlan and Coughlan, 2002).

Continuing to apply the action research methodology in order to develop practical solutions for the IPD (Mckay and Marshall, 2001), the researchers organized with one IPD Expert and one Specialist an innovation workshop called Dat@CK, based on the KCP workshop method (Hooge *et al.*, 2016). These three actors met every week since January 2020, to organize the workshop, they also had regular progress points with the IPD Expert Leader and the Expert Fellow. This workshop aimed to test a new breakthrough R&D exploration tool by mobilizing a few Expert Leaders on a strategic issue for the firm.

Table 1- Data Collection on Renault Case

Data on SNCF case

Between 2019 and 2020, the authors conducted 8 semi directive interviews with the “Synapse 4” Expert in mobility and innovation, who is the equivalent of the IPD Expert Leader at Renault (Table 2). A large base of secondary data (Webb and Weick, 1979) on the innovation capability implementation within the firm was also shared by the expert with the researchers, in accordance with the longitudinal partnership (Menard, 2002; Pettigrew, 1990) between the lab

and the firm and was sporadically completed on element gathered during interviews (Merton *et al.*, 1990). The purpose was to understand the apparition of a radical innovation expertise at SNCF and compare it with Renault's case. If the researchers team didn't get enough data to triangulate (Flick, 2004), the current data allow first conclusions.

Table 2 - Data Collection on SNCF Case

2.3. Data analysis

The authors used different methods of analysis, which often gathered many different data collected previously. The researchers used a part of all the data collected previously to produce a comparative longitudinal qualitative analysis (Eisenhardt and Graebner, 2007) in order to reconstitutes the history and the context of creation of the experts organization, as well as those of the domains dedicated to radical innovation management at Renault and at SNCF. This analysis is presented in a monography, which has been constructed by following the methodology developed by Van de Ven and Poole (1990). Indeed, the research team first chronological organized list of events that occurred before and until the creation of the domains of expertise, at Renault and for SNCF. They rearranged these lists in conceptual categories, to explain and describe the creation of those domains of expertise. These conceptual categories akin to stage, as described by Thiétart (2001, p. 348), since Renault and SNCF present similarities which did not occur in the same order. In this monography, the searchers also followed the principles of inductive social network analysis (Lazega, 1992) to first understand the current organization of the experts' system and, then the organization of the domains dedicated to radical innovation management at Renault and at SNCF.

Thus, the authors were first able to explain the creation of the experts' organization at Renault and then at SNCF. Then, they presented three internal difficulties related to managing radical innovation, at Renault and then at SNCF. They finally observed the simultaneous development of radical management tools and methods, which then became a dedicated domain of expertise at both Renault and SNCF.

3. Data findings

3.1. The expertise organization: a response to foster the innovation capability of the firm

At Renault as at SNCF, both firms had old expertise organizations that they decided to rebuild in order to increase their innovation capability, starting in 2009.

3.1.1. Renault strategy of expertise organization: one specialization per expert managed by a generalist Expert Leader

Since 1999, Renault, Nissan and Mitsubishi (both Japanese car manufacturers) have founded strategic relationships called the Alliance. In 2009, Nissan had 91 domains of expertise. At that time, Renault totally rebuild its expertise system by looking at Nissan's model for inspiration, to improve its innovation capability. Among the 91 domains of expertise of Nissan, the executive committee of Renault selected 57 domains they considered strategic for the firm and decided to create them progressively. In December 2009, the first 15 domains of expertise were set up in the following categories: engineering, vehicle engineering, powertrain engineering, logistics engineering, and only one was focused on management and not technology: human resources. During the next 12 years, the number of domains of expertise increased to 54. Nowadays, the experts are still hierarchically organized with an Expert Fellow who monitors the Expert Leaders, Expert Leaders, who in turn oversee their own domain as well as the nomination of Experts, who are themselves charged with nominating Specialists. In each domain, the capacities of the Expert Leader, their Experts, and their Specialists are not the same: Experts and Specialists are highly specialized in one sub-topic whereas the Expert Leader is more a generalist of the area who also possesses strong networks and facilitation skills. In 2009, the official presentation written by the founder to the executive committee to set up the new expertise organization contained this definition of the role of the first Expert Leaders: “ To manage a medium and long term vision of the field; To innovate by proposing and promoting disruptive solutions; To lead a network of internal and external Specialists; To ensure the

human development of his field; To represent the company”*. Radical innovation management was clearly one of the main goals of the newly rebuilt expertise organization and it was the second priority expected of each nominated Expert Leader, just after the foresight role which is also a well-known part of innovation capability. Today, when an Expert Leader is nominated, they receive a letter of commitment from the Human Resource department. In this letter, it is written that the Expert Leader must: *“Contribute to maintaining and developing the innovation capacity of the company, its global functions and to leverage its employee’s potential for innovation, for robust and sustainable profitability”**. The expectations on innovation management exceed the expertise area, and now concern all the firm. Thus, since its foundation in 2009, the main objective of the system of experts at Renault is to create sustainable innovation capability for all the company essentially carried out by all the Expert Leaders.

3.1.2. SNCF strategy of expert organization: a panel of scientific and technologic “synapses” in interaction

Starting in 1850, the European railway companies were created by financial companies who employed many engineers. Coming up from the ranks of this technical history, the first directors of each engineering department and their successors were experienced in-house engineers and constituted a “college of experts”. Considering that there were between 15 and 20 engineering departments in the 20th century, there were as many experts. These managers demonstrated their expertise capacities through their huge professional experiences in their respective domains. However, it was simply a hierarchical recognition of their technical expertise, since they never received any official title, but had an internal, external, and international recognition. In France, SNCF was created in 1937 following this layout and maintained the college of experts until 2009. Then, an institutionalized network of experts was developed within the group and its coordination was delegated to the executives of the Innovation & Research department. The

* each * means it was translated from French by the authors

“new” experts received the official title of “Synapse”, as well as a financial bonus for their contributions. Today, this “Synapse Network” is now composed of technical and scientific experts from the various entities of SNCF, whether they are managers of engineering teams or not. Currently, 450 experts are members of the Synapses Network, and they are divided into four levels of expert mastery (Synapse 1, synapse 2, synapse 3 and Synapse 4 which respectively indicate that the person is regarded as a junior, intermediate, major expert in their domain). Each Synapse is attached to a scientific or technical domain and the network contains around 20 domains. All the Synapses of one domain develop the expertise of the same capacity and knowledge but at different levels of mastering. Each person’s ranking is based on their recognized ability to efficiently apply their expertise for the firm’s benefit, establishing a spectrum of Synapses that range “*from an expert in the making to a true bandmaster who transmits and shines in and outside the company*”, according to the official communication of the network for their annual meeting on January 7th, 2009. They ensure the development of key areas to support collective innovation and research and can rely on their internal and external network to support R&D and industrial projects, partnerships, or new expertise domains. Indeed, in the same document, it is underlined that their *raison d’être* is to “*boost innovation and research through collective and cross-functional actions, but also ensure the sustainability and development of key expertise for the future of the Group. Thus, the latest experts welcomed into the Network complete skills such as artificial intelligence, data, system engineering, operation, etc.*”.

Despite the difference between Renault’s engineering approach to innovation, or SNCF’s scientific approach, what is noteworthy is that 10 years later, the top managers of the Expertise system in both firms decided to label a new domain of expertise dedicated to radical innovation management methods, in order to improve the effectiveness of such an expertise or synapse system. According to our data, this decision was motivated by experts themselves once they

perceived the need to leverage the managerial skills of breakthrough R&D exploration at the expertise level. We will now describe why.

3.2. A mixed report by the experts: the company does not know how to manage radical innovation with the same rigor as incremental innovation

3.2.1. Managing radical innovation requires different skills than usual industrial project management

At Renault, all the Expert Leaders that were interviewed had a mixed opinion regarding the firm's innovation performances, but they considered that a distinction between incremental and radical innovation had to be stressed. Thus, one of them told us that *"the company is well equipped to make incremental innovations, but not for radical innovations, and what's more: we don't realize it"* *. For incremental innovation, they master the use of traditional metrics of the cost, the delay, and the quality. During the last century, Renault optimized the cost of production of a car to the nearest penny, time of design was reduced from 5 to 3 years and the quality was improved through product lines (Midler, 1995). But, the mastering of incremental innovation engineering may act as a brake for radical innovation. Indeed, one expert declared that *"it's no longer innovation, we integrate things that already exist, and we make them coincide with architectural problems in the car. We leave it to our suppliers to figure out, with whom we make partnerships, but they bear the costs and the benefits"* *. Another expert underlined that *"at Renault, we make innovations only if clients are ready to pay for them"* *. These two declarations can be considered as a wish to reduce the risk related to the design process of a new service or product and its introduction on the market. These suggest that some Renault's experts think the firm is not able to manage radical innovation and to face the risk it includes. And they designate two main reasons for it: first Renault does *"not have the maturity or the mindset to manage [radical] innovation"* *; then, even if the firm already succeeds to industrialize major innovation, Renault does not have any rigorous method or process to manage radical innovation, to understand how it appeared, and how to replicate it. Indeed,

“From time to time there is a lot of innovation of concepts at Renault, but without knowing the origin”^{*}, *“We are able to put out incredible things, but the company does not always have the maturity to take on topics at the right time. In innovation, there is an element of luck. We don't know if we will succeed or not”*^{*}. Consequently, experts share the explicit perception that Renault's organizational capability lacks specific radical innovation management skills in order to rigorously manage industrial innovation.

At SNCF, we have less feedback of the various synapse mindsets. However, the declarations of the Synapse 4 we interviewed, and the secondary data also underline a mixed feedback regarding the firm's innovation performances, which is also linked to the firm's capacity to differentiate incremental and radical innovations. That being said, SNCF had this intuition earlier than Renault. Indeed, since the end of the 90s, the various presidents of the SNCF wanted the strategy to be more in touch with the realities of innovation. The creation of the TGV (high speed train) in 1981, was the last major innovation: since then, few innovative projects have emerged, and when they did, they were not as ambitious. Moreover, the TGV is especially a very high-level improved known object. It can be explained by the fact that *“the railway workers' problem is that they were trained to improve upon an existing system considered to be the top, so any questioning would have been seen as a reduction in quality”*^{*}. It means two things: first, SNCF is excellent in incremental innovation but does not manage radical innovation; and second, SNCF needs to develop a radical innovation capability. Therefore, in 2005, the president changed the Research and Technology Department (DRT) by renaming it the Innovation & Research Department (I&R), to push this organizational change. But an internal audit realized in 2008 highlighted that few changes happened.

Thus, experts' interviews show that Renault and SNCF both set up systems of experts to foster their innovation capability, while they should have specified the nature of innovation capability

they were expecting. Indeed, both firms performed in the incremental innovation management and now experts contribute to increase it.

3.2.2. A lack of legitimacy perceived by the experts which limits their ability to support breakthrough R&D

Beyond the perception of these firms' inability to manage radical innovation, our data underlined that experts themselves lack confidence in their ability to contribute to such an innovation capability improvement.

At Renault, some experts don't have the feeling they are carrying out innovations in their domain of expertise, and consequently, that they are effectively contributing to the firm's innovation capability: *"There are not a lot of innovations in my area of strategic expertise."*^{*}; *"I do not participate in the [name of the new product and advanced engineering processes of Renault] etc."*^{*}. Other experts who find innovations in their domains, submit them into these strategic roadmaps (designated by the name Square), but they are not convinced that their submissions have an impact: *"I contribute to innovation through Squares: we don't get much."*^{*}; *"I am wary of all [Renault's processes], it is not concrete enough and it does not work."*^{*}. Some experts do not even feel legitimate as experts in their field: *"For me, an Expert Leader is a leader of experts. Each of my experts is better than me in their fields. And I make them work together. I have to know how to ask the right questions to bring out the best for them."*^{*}; *"I am not the super sharp expert but I have a global visibility on what it is, I have the positioning and the internal and external networks of the company."*^{*}; *"As an Expert Leader does not mean knowing everything but mobilizing an internal and external network capable of providing answers to complex questions that must be addressed. An expert cannot know everything (in the 80s: the expert knew everything), today an Expert Leader is able to run a network to answer the most complex questions."*^{*} *"There is a constant questioning of my job: I'm not sure I feel like Expert Leader, but what is certain is that I am one of those best able to pilot this expertise."*^{*}. From the researchers' perspective, these verbatims are surprising and seem to

contradict the facts: they don't feel to be very specialized in scientific fields, while they all have been experts for 2 to 11 years, and they all have at least 10 years of experience in their fields. So, they "are" experts for the firm, but they do not consider themselves legitimate to build on it to defend innovative paths in the new product development processes. Instead, the Expert Leaders consider that their main force is to mobilize and animate their internal and external networks, in order to constitute a short-lived community to answer a specific question, yet they also do not consider themselves legitimate to use these networks to organize the management of a rigorous process of ambitious innovation.

In SNCF, our research setting does not allow us to understand how incumbent synapse 4 were perceiving their role on innovation management (more data is needed to triangulate) but our interviews with their "expert of the unknown" underlined also that the incumbent experts were uncomfortable to support innovative paths. Indeed, between the 90's and 2005, few radical innovations were realized at SNCF and as indicated previously, the internal audit of 2008 called into question the performance of the Innovation & Research department. This audit concluded that it was appropriate to consider the dissolution of the I&R department to distribute it among the SNCF operational functions, therefore returning to a decentralized organizational model before the research service created in 1966. Thus, the researchers of the I&R were officially recognized by the firm to be useless, lastingly breaking their confidence in their ability to efficiently innovate. Yet the Synapses named since 2009 are mainly coming from I&R and our data underlined that this had a big impact in synapses involvement in exploratory processes a few years after. Moreover, the SNCF expert of the unknown, who was hired in 2011 for his experience of radical innovation methods, testifies that "*it took 4 years for people to believe in the method*"* which is a demonstration of the expected level of robustness of a radical innovation process from internal stakeholders.

This feeling of “illegitimacy” is a first explanation of why expert leaders or synapses are not comfortable with supporting a breakthrough project in the firm, and from our data, in both firms, the source of this perceived illegitimacy was twofold: 1) they considered that they did not master strategic issues around innovation decision-making, and; 2) they all regretted the lack of scientific methods and robust collaborative tools to manage radical innovation concepts at the level of rigor expected by experts used to research and engineering tools.

3.2.3. The experts also need very specific tools for breakthrough R&D

As it is mentioned in their mission, the Renault’s Expert Leaders have to contribute to the innovation of the firm by identifying in their field the strategic innovation to be developed. Even if they mostly claimed to be under-efficient in innovation, the expert leaders told us they used many tools with various actors to do so, as presented in Table 3. First, an Expert Leader still relies on their **feelings** based on its professional experience. Then, with the Experts and Specialists of their field, they use **forecasting, trends watch, the absorptivity** of external knowledge **and brainstorming methods / tools** to engage in quick creative problem-solving. All of them can also rely on their internal and external networks, which gives them ideas like **external think tank**, and **academic partnerships**. Cross-domains activities are also led between experts of different domains. The Expert Leader works on specific and strategic topics with experts of other domains through **expertise projects**. Once a month, all Expert Leaders and the Expert Fellow meet during a strategic session called **Expert Leaders Seminar**. Thanks to all these tools, expert leaders with the Experts and Specialists of their field can work on a **road map** to give an explicit orientation to their domain. They also all meet once a year during a **design review**, in order to define a strategic innovation plan that the Expert Fellow will present to the executive management. As identified before, the Expert Leaders are not particularly trained to the radical innovation management tools, or if there are, they don’t use them: *“Design thinking, etc. no, [I don’t use them]: I have them in mind, and I think design*

*thinking or whatever should have a more important place, but I have not seen any change from the outside. We are talking about agile, which is great for development, but not for innovation”**.

Table 3 - Tools used by Expert Leader for the innovation strategy definition

In SNCF, the change of name of the Research and Technology Department (DRT) to the Innovation & Research Department (I&R) in 2005 did not immediately drive the creation of innovation tools, methods, or processes. The 2008 audit highlighted that, by suggesting the I&R department could embody innovation by recreating more links with the various business lines of the company. Nevertheless, the current I&R director was aware that new tools, methods, and processes were essential to avoid the dissolution of the department and she organized an innovation tools and methods watch. Moreover, as she participated in 2010 to an innovative design approach that brought together various French firms and institutions, she discovered the KCP method and met the RATP practitioners in KCP, including the future I&P director. She chose to implement the KCP method at SNCF, because it is an industrial innovation method which combines research and operational staff. The theme of this first KCP was “Maintenance of infrastructure in a dense zone”*. In 2011, when she hired the expert in KCP to implement these new tools in the I&R department, she also asked him to prepare a 30-minute presentation for Synapse Summer University, on a KCP presentation but also, more broadly, on the organizational shift “from R&D to R-I-D” based on French scholars’ works (Hatchuel *et al.*, 2001) and his experience. Indeed, the founder of the synapse network also played an essential role in the introduction of this tool to the SNCF. From 2012 to 2016, all subsequent summer universities had been organized according to innovative design principles from C-K theory and KCP workshops good practices, with a first day of intense knowledge acquisition and sharing, and a second day of collaborative design. Some Synapses asked to participate in innovation workshops following the presentations of the KCP method at all the annual universities of the Synapses network. The notoriety of KCP workshops, internally renamed Lab, was then

amplified by the results of the first thematic workshops, but also by the many articles and snippets in the various internal media of the company.

In the SNCF case, it is obvious that synapses relied on an external skilled actor to be trained to a specific method and to make them more aware of the diversity of breakthrough R&D exploration methods. Regarding the Expert Leaders at Renault, despite the creation of many tools in R&D exploration methods within the Research & Advanced Engineering department, most of them still don't know the methods or don't use them with their Experts and Specialists of in their fields.

3.3. Officialization of the strategic importance of breakthrough R&D exploration methods

3.3.1. Creation of internal processes and organizations with breakthrough R&D exploration methods

Building on this general agreement, top R&D managers from both Renault and SNCF deployed new breakthrough R&D exploration methods and tools, of which the restructuring of expertise organizations in 2009 was only a first step.

In Renault, top managers used to invest themselves in many partnerships with scholars in management science since the end of the 1980's, to develop a reflexive and science-based ability to describe the organizational experimentations, either successful or not. This habit makes the firm a very well-documented case in management research. Thus, the period that interested us (2005-2020) is largely studied by researchers in innovation management. Although the majority of the publications we consulted are in French, the reader could easily find many case-study that were published in English on their efforts to improve their New Product Design (NPD) process (Aggeri and Hatchuel, 2003; Elmquist and Segrestin, 2012; Hatchuel and Weil, 1999; Hooge and Hatchuel, 2008; Le Masson *et al.*, 2009; Midler, 1995; Midler *et al.*, 2017; Segrestin, 2005), the organizational capability for innovation (Börjesson *et al.*, 2014; Hooge and Dalmasso, 2015; von Pechmann *et al.*, 2015), and some specific

organizations dedicated to radical innovation as their idea campaign system (Elerud-Tryde and Hooge, 2014) the Innovation Community (Hooge and Le Du, 2014), the Renault Fab Lab (Fuller, 2017; Lô and Fatien Diochon, 2019).

From our understanding of this work, the main organizational deployment steps were as follows. In 2006, Renault's research board restructured the upstream phases of the firm's new product development process and organization in a new department: The Research and Advanced Engineering (R&AE). First years were mainly used to rebuild the fuzzy front-end process of NPD project in a new stage-gate system that the new department managed for all the firm. In 2008, one of the research managers with a large experience of innovation management within the firm took the lead of the sub-department of technological watching with the purpose to transform it in a tool to develop the innovation capability of the firm. With her colleagues, she was mainly motivated by the aim to build an effective structure of innovative design-oriented organization (Hatchuel *et al.*, 2002, p. 20) through the organization of an "innovation factory" consciously using the concept of Hargadon and Sutton (2000). This division is recalled "Creativity and Vision", to implement and diffuse the use of creativity methods in the firm, as well as a long-term vision innovation. That made the technological watchers evolve progressively into new roles: technological intelligence and foresight but also in creativity and innovation activities facilitation. Thus, since 2008, this Creativity Department has grown up, step by step as new needs of innovation issues have been identified and considered. This department hence developed many tools or projects to better the current R&D activities that failed to develop breakthrough R&D explorations. In 2007, the manager of the creativity department organized the first **Learning expedition** (LX) in California where she discovered a new way to innovate, with the valorization of failure, a better collaboration between different services and outside the firm. This LX contributed to the creation of the **Innovation Community**, which gathered 25 members from Renault, 6 partner companies, and some

scholars to share knowledge on strategic topics in March 2008. A few months later, the **Innovation Room** was built as a space that received 3 annual internal thematic exhibitions. Its objective was to display innovation trends in order to generate ideas in operation engineering teams. In 2009, another tool to internally incubate disruptive ideas of automotive architecture and launched demonstrator projects was set up: the **Collaborative Laboratory for Innovation** (CLI). The CLI encouraged teams to explore these concepts with external partners. In 2010, an internal platform called **Renault Creative People** was developed to foster the innovation capability through virtual thematic campaigns on strategic themes. The purpose was to publish a thematic call for submissions, to generate internal cross-source ideas. In 2012, Renault set up the first Corporate FabLab called **Creative Lab**. In 2013, a **Coworking Library** was developed. **Le Square** was created in 2016 as a place to experiment with new forms of collaboration. This same year, **coaching** services for innovative activities were organized, as well as an intrapreneurship competition called **Pitch & POC**. From 2008 to 2021, only a few of these tools disappeared (the virtual platform for idea campaign, Renault Creative People, stopped at the end of 2015 and, more recently, the Innovation Community stopped on June 10th, 2020).

At SNCF, after the usefulness of the Innovation & Research Department (I&R) was put in question by the audit of 2008, the I&R decided to get more internal clients to better embody innovation. The current director decided to experiment with a new innovation design method which brings together research and operational staff — the KCP method — that some managers discovered during a collaborative workshop managed by RATP, the Parisian subway operator. In 2010, the I&R director and the scientific director organized a first KCP on the “Maintenance of infrastructure in a dense zone” at SNCF, which was facilitated by consultants and scholars, with two objectives: to test the KCP method adequacy for SNCF strategic innovation issues on a specific industrial area, and to assess its acceptability by collaborators who are often reluctant

to import external methods. This experimentation resulted in 150 projects and was considered as a huge success. It was immediately followed by a second application of the method on energy management issues. Moreover this method was developed by academic researchers (Le Masson *et al.*, 2009) who are professors in a French renowned engineering school, which facilitated its adoption by the engineers. After this first success, the question of a sustainable organization for radical innovation arose, and this is how in 2011, a RATP expert in KCP was hired in the I&R department to deploy the method as a routine. Beyond the KCP workshops, he was in charge of creating an entity dedicated to innovative design and technological intelligence called Innovation & Prospective (I&P) department. This new I&P department was designed to have two purposes: to build up internal expertise in innovation management to make the I&R department a benchmark in disruptive innovation, and to transversally disseminate a new culture of innovation that brought together R&D, operational staff and external players. In this way, the I&P manager created an innovation design methods toolkit by adapting the KCP in 4 models of workshops called LAB, MiniLAB, SpotLAB, InterLAB. He also contributed to the creation and animation of a training in design theories for the Synapse experts, since the synapse network has been created at the same time by the scientific director who was already convinced by the efficiency of the method. The scientific director also pushed his I&P Manager to formalize his experience into a validated science protocol by pursuing and obtaining a PhD degree, under the academic supervision of the scholars that created KCP workshops.

So, Renault and SNCF created new disruptive R&D exploration methods and tools, which do not seem to address the same kind of collectives. After some years, these methods and tools appeared to be strategic, since Renault and SNCF nominated one Expert Leader and one Synapse 4 in charge of breakthrough innovation based on disruptive R&D.

3.3.2. Creation of a domain of expertise dedicated to disruptive R&D exploration methods

At Renault, in November 2018, the director of the “Creativity and Vision” department was nominated Expert Leader Innovation Patterns. These Innovation Patterns domain (IPD) relies on the tools, methods, process, and members of the “Creativity and Vision” department. Indeed, all the members of the Creativity and Vision department were trained in the different breakthrough R&D explorative tools, as they created or implemented them. They have thus the capacities required to be part of the Innovation Patterns domain of expertise. As a consequence, many of them were nominated as Experts or Specialists of the IPD.

The IPD’s main purpose is to “*Contribute to maintaining and developing the innovation capacity of the company, its global functions and to leverage its employees’ potential for innovation, for robust and sustainable profitability*”*. To do so, the IPD identified 3 purposes: learning exploration and dynamic continuous skill renewal; collective intelligence; tools and methods. These 3 missions integrate the missions and then the tools of the Creativity and Vision department, but not only. These missions have the willingness to dig deeper in the implementation of the breakthrough R&D exploration. Therefore, the scope of the “Creativity and vision” capacities was widened (Table 4), and the IPD also plans to create new tools (Table 5). As example, the IPD Expert Leader wanted to test a new tool inspired by the SNCF practices: KCP. A team project composed by a PhD candidate, an Expert, and a Specialist was organized. They presented the project, called Dat@ck to the Expert Fellow who immediately agreed to sponsor the project, as he understood the interest of this tool. The next steps are to mobilize experts of other domains during the year 2021.

Table 4 - The evolution of the capacities between “Creativity and Vision” department and the Innovation Patterns domain

Table 5 - Future Tools of the Innovation Patterns domain

As an excellent KCP practitioner, the I&P director at SNCF implemented the KCP methods and its tools between 2011 and 2013. During these three years, the I&P director had to

demonstrate the efficiency of the KCP method, and thus he had to build up his legitimacy in the eyes of the other Synapses and engineers : “ *I had two / three years or I was playing survival with all the projects I couldn't afford to plant one.*”*. In 2014, he succeeded and was nominated to the Synapse 2 level. “ *It was ambiguous because on the one hand I was recognized as an expert and on the other I had to redo my proofs so in 2014 I was appointed synapse 2 in innovation. At the same time, they recognized innovation expertise but at the same time they did not know what to do with it, because usually these are technical expertise.*”*. Between 2010 and 2018, 98 labs were led by the Synapse 2 and his teams. Indeed, he hired 3 engineers and 2 PhD researchers. He trained two of them to animate KCP lab, the first became Synapse 2 in 2015 and the other was named Synapse 1 in 2018. In 2016, the I&P director was finally nominated to the Synapse 4 level, which suggests a total recognition by the main engineers that innovation is a major value they want to display in the synapse network.

4. Discussion and Results

4.1. Radical innovation management experts: experts of the exploration of the unknown

Since 2009, the Creative and Vision director at Renault and the KCP expert at SNCF have developed their expertise on the development of radical innovation management. While the experts dedicated to the exploration of the unknown in the Technical Staff (Cabanès *et al.*, 2016) oversee the emergence of new expertise, the expert at SNCF and Renault must develop tools and processes for radical innovation design and exploratory project, by mobilizing the collective organization to explore an innovation field. Thus, being expert in radical innovation management at Renault or at SNCF means being able to explore the unknown: more precisely, to be an expert of the exploration of the unknown. Moreover, these experts no longer base their expertise on an identified and established technology (Gilbert *et al.*, 2018), as they now base it on a management field.

4.2. Experts of the exploration of the unknown to guide other experts in the unknown

The other experts and Synapses of the firm need tools to improve their capacities in radical innovation management. Both domains of expertise in the “unknown” offer solutions to the other experts and Synapses. Thus experts of the “unknown” are still information and advice provider, but the nature of the decision makers they advise has changed, since it is no longer the top manager of the firm, but the experts of other domains (Cabanès *et al.*, 2020; Haas, 1992). The other experts are now in capacity to use this expertise of the exploration of the unknown to facilitate their exploration and find innovation in their fields. In other word, experts in exploring the unknown lead the other experts in their exploration of the unknown.

4.3. Two new ways for experts to manage radical innovation

Until the creation of expertise of radical innovation management, all experts had to contribute to the innovation solutions and strategic plan. By establishing experts of the exploration of the unknown to help other experts to explore the unknown, all innovation or R&D stakeholders are in capacity to lead a radical innovation exploration by using the available tools and methods developed by the experts of the unknown. Indeed, for Renault, many options as TRIZ, Design Thinking, different spaces for exploratory projects, etc. were developed. By creating many tools, Renault try to reach different designer of the innovation from engineering, design, and marketing departments. In other words, the Creative and Vision Department aims at entraining in the innovation design as much different profile as possible. Therefore, these tools adapt to an ephemeral and very diverse collective. On the other hand, SNCF concentrated its innovation effort in one scientific method declined in 4 tools, dedicated to the Synapses, who are all scientists. These tools therefore adapt to a specific and stable collective of scientists. In other words, expert of the exploration of the unknown are able to manage radical innovation by developing tools and methods who intended for either an ephemeral and diverse collective, or a specific and stable collective of scientists.

4.4. Breakthrough exploration is strategic for industrial firms

As century-old firms, both Renault and SNCF are master in systematic design, and therefore, in incremental innovation. They developed many robust and powerful processes, methods, and tools, that even their Expert Leaders and Synapse 4 expert's master. However, it is not the same to foster incremental versus radical innovation capability (Gilbert *et al.*, 2018; Lenfle, 2008). Thus, the recent creation of expert or synapses system in the 20 past years could not foster the innovation capability of the firms if they were not familiarized with the innovation design management.

However, innovation design theories appeared in the 90's (Braha and Reich, 2003; Hatchuel and Weil, 1999; Suh, 1990; Tomiyama and Yoshikawa, 1986), and the first methods and tools in the 2000's. Their introductions to firms are recent and required an effort to train some Expert Leaders or Synapses, as we can see in the organization of KCP workshops in R&D department (Agogu  and Kazak ı, 2014; Elmquist and Segrestin, 2012; Hooge *et al.*, 2016) or with the training of only 20 researchers among the 500 employees at IREQ (Rampa *et al.*, 2017). By focusing mainly on the C-K theory with the KCP, SNCF succeeded in establishing the KCP method as radical innovation process. In the same way, by developing many tools to foster the exploration of the unknown, Renault succeeded in establishing several processes, such as TRIZ, Design Thinking, and creating different spaces for exploratory projects, etc. to structure a radical innovation process. Thus Renault and SNCF established the radical innovation management and the exploration of the unknown as being officially strategic for both firms.

Conclusion

Our study originated from the recent emergence of new domains of expertise dedicated to radical innovation management, and more specifically to the exploration of the unknown. Recent researches point out that R&D departments have to take into account radical innovation management (Gilbert *et al.*, 2018; Lenfle, 2008) to face the hyper competitiveness, the radical innovation challenges, and the rise of the radical innovation design regime (Elmquist and

Segrestin, 2012; Ilinitch *et al.*, 1996; Le Masson *et al.*, 2009). Recent research studies how experts of these R&D department integrated radical innovation management: The Technical Staff College is a reorganization of the experts in offices dedicated either to incremental or radical innovation, KCP process in a new R&D process for radical innovation where experts took part, and the training of some experts to KCP process. But none of them had pointed out the emergence of expertise of the exploration of the unknown. Our research goal was therefore to characterize how a radical innovation expertise appeared in two well-established industrial firms with well-organized systems of expertise explicitly dedicated to fostering their firms' innovation capability. As a result, our research concluded that experts of breakthrough innovation management are experts of the unknown, who lead other experts in the exploration of the unknown, through tools and methods for breakthrough exploration; second, this expertise is a new kind of interaction between innovation and expertise which, in turn, offers new ways of managing innovation in an established technological firm, by facilitating the exploration in the unknown for all experts, while they remain in charge of innovation within their own fields. Finally, the domain of expertise in the exploration of the unknown formalize breakthrough explorations as strategic activities for established firms. However, our study presents a limit in the data collection at SNCF, where more triangulations would be needed. To pursue the research on the expertise of the exploration of the unknown, further research is still needed to (i) identify the different strategies that radical innovation management expertise could adopt, (ii) and asses how they could possibly be articulated with the other domains of expertise or innovation stakeholders.

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Table 1 - Data Collection on Renault Case

Data sources		Number and length of research activities	Type of data collection
IPD	Interviews of the founder of the expertise system at Renault	1x 2h	Written interviews notes Records Old presentations of the expert system
IPD	Expert Fellow meeting	1x2h	Written interviews notes
IPD	Interviews of the main expert in breakthrough innovation management at Renault	4 x 1h	Written interviews notes Records
IPD	Workshops on the mission of the domain of expertise in breakthrough innovation management at Renault	20 x 1h	Sharing and discussing field notes Sheet with the missions of the domain of expertise
IPD	Interviews of the 15 experts in breakthrough innovation management at Renault	15 x 1h	Written interviews notes Sheet summarizing all the interviews
IPD	Regular progress points	10 x 1h	Written field notes Sharing and discussing field notes Analysis
IPD	Interview of expert-leaders: - 5 of science domains - 5 of management domains	10 x 1h	Written interviews notes
Dat@ck	Organizing project team members	36 x 1h	Sharing and discussing field notes Presentation of the
Dat@ck	Regular progress points with the Expert Fellow	2x1h	Written field notes Sharing and discussing field notes
Dat@ck	Workshop points	10 x 1h	Written field notes Sharing and discussing field notes Analysis

Table 2 - Data Collection on SNCF Case

Data sources		Number and length of research activities	Type of data collection
SNCF	Interview of the Expert Leader at SNCF	9 x 1h30	Written interviews notes Records
SNCF	Organizing project team members	10 x 1h	Sharing and discussing field notes Analysis

Table 3 - Tools used by Expert Leader for the innovation strategy definition

Innovation Process	Tools Area	Tool or Method	Pilot // User (if different)
Innovation identification Strategic innovation definition for the firm	No Tool	Feeling based on the years of experience	
Innovation identification	Transversal Tool	Forecasting	Experts + Innovation Teams
Innovation identification	Transversal Tool	Trends and new Tool watch	Experts + Engineering Departments
Innovation identification	Transversal Tool	Absorptivity: integration of new knowledge according the knowledge already existing (copy what the competition is doing)	Experts + Engineering Departments + Innovation Teams
Innovation identification	Transversal Tool	Brain storming	Experts + Innovation Teams + Engineering Departments
Innovation identification	Networking Tool	Business push: the different business entities make suggestions for breakthrough projects	Business Entities // Expert Leaders
Innovation identification	Networking Tool	Small Circle: working meeting with the top management which requires specific work on a subject	Executive Management // Experts+ Executive Manager
Innovation identification	Networking Tool	External community: community creation with other companies, which are strong in my field, to discuss innovations	Experts + External Actors
Innovation identification	Networking Tool	Partnership with academic research institutions	Expertise + Academic Actors
Innovation identification	Tool common to all the domains of expertise	Expertise Project: update on the situation of the new techno in order to enlighten the decision-makers to equip the company with good capacities	Experts
Strategic innovation definition for the firm	Tool common to all the domains of expertise	Expert Leaders Seminar: the Expert Leaders meet in a think tank on an innovation topic	Experts
Strategic innovation definition for the firm	Tool common to all the domains of expertise	Design review: define and validate innovation plans and innovation processes by addressing risks related to new products	Experts // Executive Management
Strategic innovation definition for the firm	Tool common to all the domains of expertise	Road map: each Expert Leader defines the road map of its domain of expertise	Experts // Executive Management

Table 4 - The evolution of the capacities between “Creativity and Vision” department and the Innovation Patterns domain

Status	Nomination	Capacities of Creativity and Vision	New capacities of IPD
Expert	Future nomination	Automotive product and service design regimes: - Use of CK theory in an industrial environment - Knowledge of other design tools (TRIZ, Design thinking) - Use of a number of innovative design approaches - Knowledge of the limits of classical design	
Specialist	Nominated	Coaching and animation method of a collective Innovative design method (CK, TRIZ, Design Thinking)	
Specialist	Future nomination	Method of design and creativity (CK, TRIZ, Design Thinking) Coaching and animation method of a collective	Customer behavioral study Identification of their needs Adaptation of the formulation of digital customer journeys
Specialist	Nominated	Method of design and creativity (CK, TRIZ, Design Thinking) Coaching Technology (new technology referent)	
Specialist	Future nomination	Method of design and creativity (CK, TRIZ, Design Thinking) Coaching and animation method of a collective	
Expert	Nominated	Entrepreneurial approach: - Methods of conducting an intrapreneurship project - Organize intrapreneurship in a structure - Ecosystem of intrapreneurship - Ecosystem and open innovation internal or external to the company Method of design, pitch, application of digital creation methods,	
Specialist	Nominated	Watch on trends and objects Story telling Scriptwriting Communication tools (new networks)	
Specialist	Future nomination	Fab lab organization	
Expert	Nominated	Prospective	Anthropology applied to automotive
Specialist	Future nomination	Innovative spirit: Curiosity - daring - empathy - creativity Ecosystem creation and management Social business model Storytelling and Scriptwriting	Frugality Co-design Inheritance engineering: exploration project, the responsibility of the project leader is to ensure that you can tell a story: and therefore, pass it on.
Specialist	Nominated		Philosophy applied to automotive
Specialist	Nominated	Design Prospective	Anthropological Design
Specialist	Nominated	Prospective Modeling Socio-economy	Business Model Innovant Business Model Business Model of the ecosystem value

Table 5 - Future Tools of the Innovation Patterns domain

Origin	Name or purpose
Creativity and Vision Tool	Innovation Rooms
Creativity and Vision Tool	Innovation Community
Creativity and Vision Tool	Square
Creativity and Vision Tool	Fab Lab
Creativity and Vision Tool	Incubator
Future Tool	People finder
Future Tool	Coaching to creativity (CK, TRIZ, Design Thinking)
Future Tool	Design tools on the new methods to generate innovation
Future Tool	Design and organize places conducive to the emergence of innovation.
Future Tool	Design a tool to effectively structure learning ramps to make the right decisions
Future Tool	Design a tool analyzing the stabilization of the vocabulary describing the project, to identify its development phase (exploratory or predominantly design)