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DOCTORAL THESIS

Title	**The Dynamic Process of Coordinating Innovation Networks: Mechanisms to Overcome Diversity and Conflicts**
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To Dr. Max Boisot

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Chapter 1

INTRODUCTION

This PhD Thesis study – ***The Dynamic Process of Coordinating Innovation Networks: Mechanisms to Overcome Diversity and Conflicts*** – is dedicated, in particular, to the analysis of coordination in innovation networks. Coordinating innovation networks is of considerable importance as many of these interorganisational collaboration fail due to poor coordination. Nevertheless, few empirical studies have been able to explain how these networks are coordinated. This lack of research may be explained by the managerial complexity of innovation networks, little understanding of their internal operations and in which situations different forms of coordination would function best, or even the dynamic and ambiguous nature of collaboration.

To shed light on these research gaps, the main research objective of this study is to investigate the role of coordination mechanisms in innovation networks, so as to overcome diversity and conflict within them and facilitate innovation. It aims to contribute to the fields of network coordination, strategic management and interorganisational relations by offering new insights and empirical evidence on network coordination and practice.

In the following chapter the research is thoroughly introduced. First, the general background of the study is explained, then, the study structure is presented.

1. Background of the Study

In the currently highly competitive and largely globalised business environment, organisation needs to constantly innovate in order to remain successful (Castells, 2010; Teece, 1996). While invention can emerge at any place, innovation requires combining a number of different aspects, such as different knowledge bases and specific resources and capabilities (Parjanen et al., 2011). Nevertheless, single organisations are often unable to provide alone these prerequisites (Heidenreich et al., 2014). Thus, in the pursuit of innovation, organisations are progressively engaging in interorganisational networks to gain access to other entities' resources and capabilities in order to succeed with their innovation tasks (Dooley & O'Sullivan, 2007; Hohberger, 2010). This is not only a business phenomenon as many governments have recognised the importance of these networks for boosting a country's innovation capacity, international competitiveness, and wealth creation (OECD, 2001; Provan & Kenis, 2008; Rampersad et al., 2010).

A network-generated innovation should be seen as the results of interplay between several actors (Ojasalo, 2008). Nonetheless, bringing together different, including competing, actors creates its own challenges, as collaborating for innovation is full of paradoxes and contradictions. For example, the seminal research by Lawrence and Lorsch (1967) and more recent works from Castells (2010), Parjanen et al. (2011), and Corsaro et al. (2012) argued that the diversity between innovation partners may be quite beneficial for innovation purposes but, at the same time, may be the reason why innovation networks fail. Scholars of business alliances estimate that around sixty percent of inter-firm collaborations are unsuccessful (Faems et al, 2006; Park & Ungson, 2001). Similar failure rates can be found in non-profit and public contexts (Huxham & Vangen, 2000).

Just like any organisation, innovation networks need to be coordinated thoroughly (Landsperger et al., 2012). The high failure rate of this type of collaboration indicates that, although coordinating innovation networks are not straightforward tasks, it is of utterly importance for guiding the networked innovation activities and accomplishing positive outcomes (Howells, 2006; Ritala et al., 2012). Coordinating innovation networks is inherently characterised by the search for balance and the need for compromise in an environment where activities simultaneously incorporate stability and dynamism (Sutton-Brady, 2008); autonomy and interdependence (Ospina & Saz-Carranza, 2010); additional resources but also barriers to performance (Geersbro & Ritter, 2010); a tendency to influence and to be influenced, and the protection and sharing of knowledge (Ritala et al., 2012).

Moreover, even the form that coordination takes is seen as paradoxical in the literature. Some authors (e.g. Martinez & Jarillo, 1989; Gulati et al., 2000) have suggested that management-like control is indeed possible, while others (e.g. Ford et al., 2002; Ritter et al., 2004) have taken networks as adaptive systems that cannot be centrally directed. According to Hurmelinna-Laukkanen et al. (2014), this debate steams at least partly from the fact that there are a wide variety of different kinds of innovation networks. Differences emerge in terms of how many actors are involved, how structured and organised knowledge exchange is, what are the aims of the network, and so forth. The different characteristics associated to different networks surely have an effect on the need of coordination and in its implementation (Hurmelinna-Laukkanen et al., 2012;

Möller & Rajala, 2007).

However, despite the rising popularity of innovation networks and their inherent challenges, network coordination is an understudied field where empirical studies are still relatively rare (Gardet & Mothe, 2011; Hurmelinna-Laukkanen et al., 2014; Rampersad et al., 2010). Most researches have focused on innovation networks from the point of their creation, structure or the factors leading to their collapse (Goerzen, 2007). This lack of research is even more surprising when considering that interorganisational networks fail due to poor management (Rodríguez et al., 2007). Besides, the existing literature does not explicitly state in which different situations different forms of coordination would function best (Ritala et al., 2012). Not to mention, research on coordination mechanisms has essentially addressed these mechanisms individually (Gardet & Mothe, 2011).

This research aims to address the gap in the extant literature and to respond to calls for research on the coordination process in innovation networks, an area that would be highly relevant to managers by investigating *how does diversity and conflicts in innovation networks affect the coordination mechanisms employed.* Thus, it first needs to recognise which type of innovation network is being dealt with, and then to acknowledge to what extent an individual actor (or group of actors) can affect the direction that the network moves to. Regarding the latter part, this affecting possibility is categorised into two types of coordination: *management* (coordination by commanding) and *orchestration* (coordination by enabling). *Management* refers to formal coordination mechanisms such as having explicit rules, goals and timetables, as well as systems facilitating coordinated collaboration (Möller & Rajala, 2007; Ritala et al., 2012). On the other hand, *orchestration* refers to informal coordination done through orchestration activities that enable and facilitate (but not dictate) the coordination of the network and the realisation of the innovation outputs (Hurmelinna-Laukkanen et al., 2014). These two concepts may be seen as complementary or supplementary coordination mechanisms (Olander et al., 2010), but the emphases on each may vary. In this study, it will be investigated if these two types of coordination may co-exist in practice, thereby creating a hybrid form of coordination that use both.

Two innovation networks will be investigated, KIC InnoEnergy and ATLAS Experiment at CERN. KIC InnoEnergy is an interorganisational network formed with the purpose of providing innovative products and services in the field of sustainable energy in Europe. ATLAS Experiment at CERN is an interorganisational network that has developed innovative technologies and architecture for conducting basic research on high-energy physics. Furthermore, these two cases are also considered as innovation networks as in fulfilling their goals, they are bringing organisational innovation. Notwithstanding, they are settled in different environments, and have different network purposes, characteristics and stage of development. Therefore, it is believed that in comparing these two cases one may make interesting contributions into the debate on coordination mechanisms in innovation networks.

2. Structure of the Thesis

This doctoral dissertation is organised as follows. Chapter 2 is a theoretical chapter. First, it is conceptualised interorganisational networks and, in particular, one type of interorganisational networks which is the object of this study: innovation networks. The definition of innovation networks is clarified and it is investigated one of its most striking characteristics – the diversity of network members – as it can be perceived as a double-edged sword: at the same time that it is seen as beneficial for achieving desired innovations, it poses a real challenge for the network on how to coordinate such heterogeneity. Based on a review of the literature, two complementary mechanisms of coordination are suggested: coordination by enabling and coordination by commanding. It is suggested that these mechanisms might not be mutually exclusive, and that they vary in relative importance depending on some network attributes and the phase of development of the innovation network.

The following chapters are descriptive. In Chapter 3, it is described the research's design, including research problem, main research question, secondary questions, rationale and significance, unit and level of analysis, the research approach, and study sites and units (including the pilot study). In Chapter 4, it is described in detail the two cases that are under investigation: KIC InnoEnergy and ATLAS Experiment, followed by a brief comparison between the two cases.

In Chapter 5, the results of data analysis are presented. The focus of analysis in on the network as a whole rather than on one firm's viewpoint, thereby further contributing to the discussion on network-coordination processes. What follows in Chapter 6 is a discussion of the findings in relation to what has been discussed in the theoretical chapter and answering the general research question. And finally, in Chapter 7 the conclusions are presented, as well as the limitations of the study that are drawn together with suggestions for future research.

Chapter 2

THEORETICAL BACKGROUND

1. Networks: Defining the Object of Study

1.1. Origins of the Concept

The interest on the linkages between a defined set of actors - also known as networks - started to catch attention of mathematicians in the beginning of the 18th century. The first study on networks can be traced back to the work of the Swiss mathematician Leonard Euler in solving the "*Königsberg bridge problem*"[1] in 1735, which subsequent led to the development of graph theory. However, the role of these linkages was overlooked after these initial concerns. It was just in the 1930's that networks started to be study in other fields like social sciences (Newman, 2003; Prell, 2012; Scott, 2000). Since then Sociology, Communication and Social Psychology have been conducting a considerable amount of researches on the importance of networks and the patterns of connection between people to understand the organisation of society

[1] The *Konigsberg bridge problem* was an old puzzle concerning the possibility of finding a path over every one of the seven bridges that spanned a forked river flowing past the island of *Konigsberg* in Prussia, but without crossing any bridge twice. Euler argued that such path did not exist. To prove his argument, Euler formulated the problem in terms of graph by abstracting the case of Konigsberg — first, by eliminating all features except the landmasses and the bridges connecting them; and second, by replacing each landmass with a dot (called a vertex or node) and each bridge with a line (called an edge or link) (Carlson, n.d.).

and the diffusion of information (Grabher & Powell, 2004; Kilduff & Tsai, 2003).

The seminal paper of sociologist Mark Granovetter (1973) can be said as the trigger for the managerial attention to networks as a mean of describing a form of organisation, which became popular during the 1970's. His study raised a hypothesis about the usefulness of a certain type of ties (e.g. weak ties) between acquaintances in a situation of job search to show the value of these ties in comparison to others. Management writers and practitioners have been approaching network from the perspective of how people interact in the pursuit of a given task. They have looked at network as teams between parts of an organisation, or in between organisations.

The network literature is extensive and fragmented as it can be found in many fields, in particular in social sciences (Kadushin, 2012). Although there is much overlap in these respective theories, a cohesive view of the phenomenon is yet being created[2], and hence, the theories should not be interpreted as either equivalents or alternatives, but as providing different perspectives (Rampersad, 2008). As so, it is necessary to define what is a network before carrying on.

1.2. Framing the Term *Network*

In broad terms, a network can be defined as a set of actors (often called as "nodes" or "vertices") connected by a set of relationships (called as "ties"). Differently from a cluster where actors interrelate with each other because of their geographical proximity and interdependence, networks get rid of this "tyranny of proximity" since the focus of attention lies on the associations and connections among the different nodes

[2] In the last years, the network research field has been converging into a unison voice, in relation to the quantitative aspects of networks, what could turn into a theory of network in the near future.

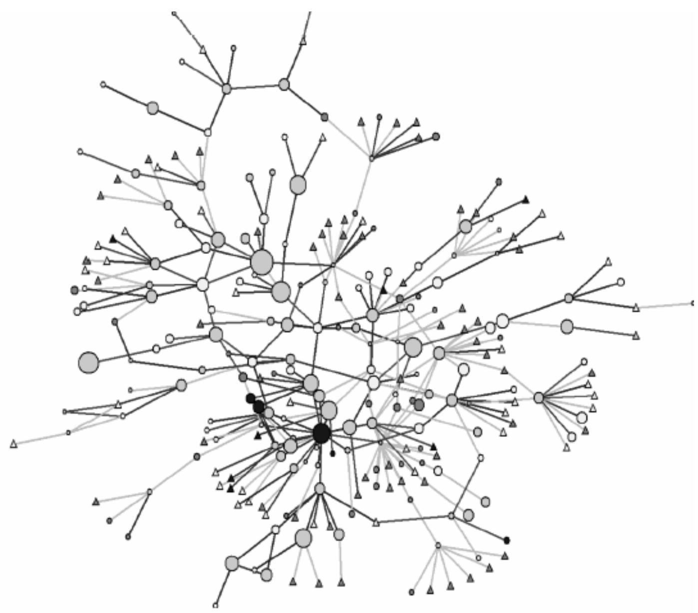
(Latour, 2005). Two nodes and the relationship that links them, as represented in the figure bellow (fig. 1), form the simplest network:

Fig.1: The Simplest Network Form

Source: own author

As the number of nodes increases, the connections between network members take a more complex form as represented in figure 2:

Fig. 2: Representation of a Network with Multiple Connections



Source: Powell et al. (2005)

Even though the term network is widely used in the scientific literature, the usage of this concept includes some incoherency as it has served multifaceted interests and objectives (DeBresson & Amesse, 1991). For instance, in sociology attention has been drawn to the social structure made up by a set of social actors (individuals or organisations) and their interaction patterns. In biology, a network is any system with sub-units that are linked into a whole, such as species units linked into a whole food web. In computer science, networks refer to systems that allow computers to exchange data. In management, different concepts and terminologies – such as strategic alliances, partnerships, coalitions, and collaborative agreements – have been used to refer to network. In spite of differences, the term has been subjected to two broad sets of approaches: one which emphasises the relational aspects of actors and uses the term network to conceptualise and understand a social reality, and other which considers network from a governance perspective, contrasting network as an hybrid or intermediate organisational form to the traditional forms of markets and hierarchies (Powell, 1990; Saz-Carranza et al., 2007; Thorelli, 1986). These can be noticed in the different definitions of "network" exemplified in the following table (table 1).

Table 1: Some Definitions of Network

<u>*Network as a social reality:*</u>
"Network can be seen as a specific set of linkages among a defined set of actors, with the additional property that the characteristics of these linkages as a whole may be used to interpret the social behaviour of the actors involved. Consequently, the term network designates a social relationship between actors. The relationships evolving between actors can be categorised according to contents, form and intensity. The form and intensity of the relationships establishes the network structure" (Seufert et al., 1999: 182).
"A network can be approached in terms of its activities, resources and actors. The activities and resources in two different relationships can complement each other or they may be in competition. Similarly, actors can use the existence of complementarity or competitiveness in their relationships in different ways when interacting with each other. Networks are evolving organism and their dynamic is caused by the fact that actors, relationships, needs, problems, capabilities and resource change over time" (Ojasalo, 2008: 54).
"The network concept is a useful framework for evaluating the configuration and operation of existing network, and for highlighting factors that might improve networking performance. Networks are more than portfolios of links between a group of people or organisations: they imply structure and synergy" (Steward & Conway, 2000, p. 282).
<u>*Network as a governance perspective:*</u>
"Networks are modes of organising economic activities through inter-firm coordination and cooperation. In this way, networks lie at the heart of organisation theory. They are nexuses of integration mechanisms encompassing all the range of organisational coordination devices, in addition to or in substitution for market mechanisms" (Grandori & Soda, 1995: 184).
"Networks are intermediate or hybrid form of organisation of economic activity with respect to markets and firms (Grandori & Soda, 1995, p.184). Rather than a simple mechanist connection between elements, they represent coherence without contract or command and, as such, signal a new stage in organisational forms" (OECD, 1999: 8).
"Networks are a third-type organisational arrangement, with its own characteristics and properties" (Powell, 1990: 296).
"A network is a relational form of management in which authority is broadly dispersed, such arrangements are more commonly associated with setting where both markets and environments change frequently and there is a premium on adaptability" (Smith-Doerr & Powell, 2005: 381).
"Network thus combines some of the incentives structures of markets with monitoring capabilities and administrative oversight associated with hierarchies" (Powell & Grodal, 2005: 60).

The examples above show only a small sample of the various definitions found in the management literature. Although stressing in the surface different characteristics and properties of networks in expense of others, nearly all definitions sustain certain common themes, including the importance of networks as a source of value, contributing to economic growth and sustainable competitive advantage (Grandori & Soda, 1995; Provan el al., 2007). Thus, based on knowledge production and other missing resources, organisations engage in networks as a manner to minimise costs, risks and uncertainties (Pyka, 2002); to increase efficiency and effectiveness (DeBresson & Amesse, 1991; Graf, 2006); to acquire needed resources (Gray & Woord, 1991); to reach problem-solving (Wissema & Euser, 1991) or to achieve some end that they could not have achieved independently (Provan & Kenis, 2008).

Aside from differences in definitions, when reviewing [management] network research, one can notice studies conducted at different levels and with different methodological approaches. In terms of level of analysis, studies have oscillated between a micro-level of analysis (with individualist, essentialist and atomist explanations) and a macro-level (with more relational, contextual and systemic understandings) (Borgatti & Foster, 2003). Regarding this last level of analysis, the term "whole network" has been introduced to refer to a group of three or more organisations connected in ways that facilitate the achievement of a common goal (Provan et al., 2007). In terms of methodological approach, in general, there has been a recent shift from structuralist to process-oriented analysis, which favours the recognition of the need of understanding network management processes and their social aspects (Galaskiewicz, 1996).

Therefore, for the purposes of this study, the term network is used to refer to collaborative interorganisational arrangement where three or more organisations are working together towards a common purpose (Popp et al., 2014). That is, the network here discussed are often formally established and governed, and goal directed rather than occurring serendipitously (Kilduff & Tsai, 2003). Thus, the focus is on analysing interorganisational collaboration at a macro-level, considering the social interaction between actors rather than on their individual attributes. Analysing the management of innovation networks at the network level of analysis appears timely and relevant for innovation management practitioners and academics alike to understand the extent to which organisations are working together to achieve a common goal (Müller-Seitz & Sydow, 2012). Besides, it has the potential to increase our understanding of how do interorganisational networks evolve, how are they coordinated, and ultimately how do network level outcomes might be generated (Provan et al., 2007).

Given this focus, a number of topics – e.g. social networks and social network analysis, social capital, intraorganisational networks, and communities of practice – were not investigated in-depth in this study, although they are related and could contain knowledge that might be potentially useful for studying collaborative interorganisational networks.

2. Interorganisational Networks – Types and Functions

As previously mentioned, the overarching purpose of interorganisational network is collaboration with a goal of addressing a complex problem that no single organisation can address on its own. Under the umbrella of collaborative networks, there are a variety of interorganisational network types and functions[3] identified in the management literature and described in table 2 bellow. A review of the literature on

[3] This literature review has not taken into consideration illegal or dark networks as recently distinguished within the network literature [for further references see Popp et al. (2014), Milward & Raab (2006), Hejnova (2010)].

interorganisational networks shows that the descriptions of network type and function are delineated by the scopes of activities (processes) and outcomes (goals) undertaken within the network. It is acknowledged that many networks have multiple functions and do not fall neatly into one type. These functions are often connected and they may evolve over time to meet the changing needs of the network. Many of these functions can also be described as desired outcomes for networks. Additionally, what is viewed as a type of network in one context may be seen as network function in another. However, while this may seem overly academic, the purpose of classification is to clarify what functions a given type of network performs (Popp et al., 2014).

Table 2: Interorganisational Network Types and Function

Network Type	Function	Authors
Collaborative Governance	Primary focus is on direction, control and coordination of collective actions	Ansell & Gash (2008) Emerson et al. (2012) Provan et al. (2003)
Information Sharing	Primary function is on sharing information across organisational boundaries	McGuire (2006) Milward & Provan (2006) Samaddard et al. (2006)
Innovation	Primary focus is on creating an environment where diversity, collaboration and openness are promoted with the goal of enabling and diffusing innovation	Borgatti & Foster (2003) Dhanaraj & Parkhe (2006) Hoberecht et al (2011)
Knowledge Management	Primary focus is on the management of knowledge (e.g. generation, exchange, integration and use), as well as spread of new ideas and practices between organisations	Carlsson (2003) Swan et al. (1999) Thorelli (1986)
Learning	Primary focus is on learning	Borgatti & Foster (2003) Powell et al. (1996) Noteboom (2000)
Policy	Primary focus is on public decisions, in particular on decision making about public resource allocation	Börzel (1998) Isett et al (2011) Ospina & Saz-Carranza (2010)
Social Capital	Primary focus is on building social capital in community settings	Burt (2000) Inkpen & Tsang (2005) Walker et al. (1997)

Source: Adapted from Popp et al. (2014)

From the functions identified above, empirical research on the role of interorganisational networks in the innovation process has been increasing in importance during the last decades. The consideration of the innovative capacity of a firm as one of the critical factors for enhancing its performance, competitiveness and efficiency (Grant, 1996; Pyka, 2002; Taatila et al., 2006) together with the growing number of research and development (R&D) projects involving multiple organisations, all contributed to an increased interest on innovation networks (Freeman, 1991; Ojasalo, 2008; Powell & Grodal, 2005). However, there is still a gap in the management literature in relation to the effectiveness of networks for innovation (Oliver & Ebers, 1998).

The following section explores more in detail innovation networks, which is the object of analysis of this study.

3. Innovation Networks: A Multifaceted Phenomenon

Studies on the role of networks in the innovation[4] process have a fairly recent history. Until the 1960s, very few empirical studies were done about networked innovative activities or the diffusion of innovations. In the 1970s, economists started, alongside geographers and sociologists, to investigate individual innovations in order to

[4] This study relies on Schumpeter (1934) to consider innovation as a collaborative phenomenon emerging from the active combination of people, knowledge, and resources. Thus, it is a process of creating new social connections between people, their ideas and resources they carry, so as to produce novel combinations (Pyka & Küppers, 2002).

identify the specific characteristics, which led them to commercial and/or technical success (Cowan et al., 2007). Although these studies barely used the expression "network", yet they were the earliest contributions to the identification of the important role of both formal and informal networks to innovative outcomes (Freeman, 1991). From the 1980s onwards, this importance became more evident as the idea of the "sole firm as innovator" was no longer applicable due the unprecedented pressures and opportunities posed by business globalisation, widely distributed sources of knowledge and rapid technological advancements (Fowles & Clark, 2005; Küppers & Pyka, 2002; Powell et al., 1996). DeBresson and Amesse first coined the term 'network of innovators'[5] in 1991 in a special issue of the journal Research Policy entirely devoted to this topic.

Despite the increased interest on studying innovation networks, the term has remained vague, and few attempts have been made to properly define it (Heidenreich et al., 2014). Following the definitions of Dhanaraj and Parkhe (2006), Freeman (1991), and Grandori and Soda (1995) this study defines innovation network as a formal or semi-formal institutional arrangement of inter-firm[6] coordination and cooperation to cope with innovation. It can be viewed as a loosely coupled system[7] of autonomous, diverse and geographically distributed partners that have entered into collaborative relationships to create and/or to adopt innovations (Pyka & Saviotti, 2002; Ratcheva, 2005). These networks are, typically, strongly based on research of science and technology (Hurmelinna-Laukkanen et al., 2009). As these collaborative initiatives are

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[5] Network of innovators and innovation networks are used interchangeably in the literature with no difference in meaning.
[6] Actors of an innovation system are not confined to firms, but also include universities, research institutes, government agencies, and others.
[7] Loosely coupled system is constituted by elements that are responsive, but retain evidence of separateness and identity (Weick, 1976). They are linked but retain some degree of independence (Freeman, 1991).

usually complex and difficult to manage and organise, they rarely occur spontaneously. Rather, they tend to result from long-term strategic perspectives and are likely to encourage radical attitudes and solutions (Marques et al., 2005).

The collaborative agreement between firms can be formal and ridged, usually encompassing a collaborative agreement or strategic alliance with long-term objectives, or they can be informal, flexible and trust-based relations. These networks are planned on a large scale with partners located throughout the world, but with certain activities are coordinated from one central location (Knell, 2011). Partners work together to reach not only their own goals but also a collective goal (Provan & Kenis, 2008), what often entails the development and acquisition of new capabilities (Knell, 2011). Knowledge in innovation networks is often highly tacit, individual and widely dispersed (Doz et al., 2000). The relationship between existing and emergent knowledge is typically vague, what makes quite impossible to see what kind of knowledge different actors possess, what kind of knowledge is needed in the innovation process, and what kind of value may be generated as a result (Hurmelinna-Laukkanen et al., 2009).

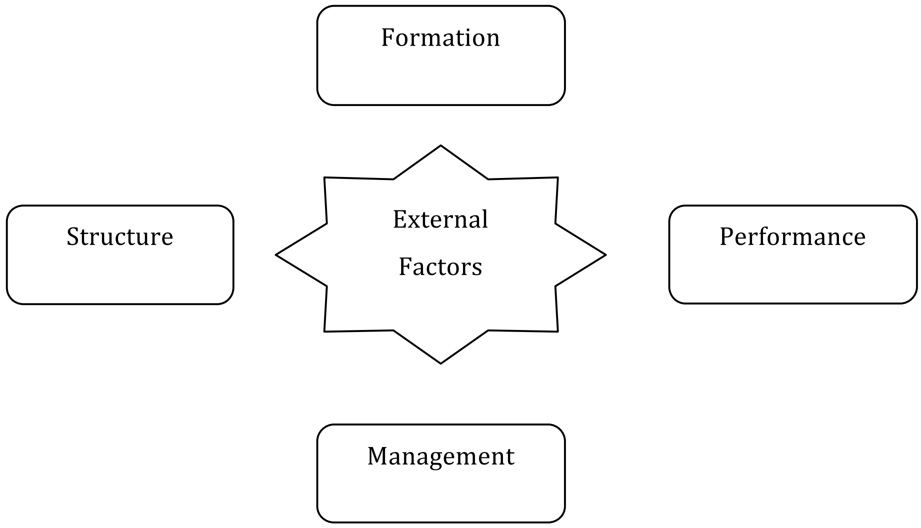
The concept of innovation networks has been used to examine many configurations in different disciplines including, but not limited to, interorganisational relations, strategic management, health care and services, public administration, sociology, communication; and computer science. Not surprisingly, such interdisciplinary focus has led into a great variety of theories, concepts and methodologies, making it difficult to arrive at unified, robust and general results (Boschma & Frenken, 2010; Najafian & Colabi, 2014). Moreover, despite the increasing number of research on innovation networks, there is still scarce empirical knowledge of them. For instance, according to Ojasalo (2012), there is clear a knowledge gap on the challenges of innovation networks, in particular in relation to its lack of coordination and leadership.

When reviewing the literature of innovation networks in the management field, the first thing to be noticed is that, in essence, the network view is a process view (Imai, 1989). The state of the innovation network in one period influences the state of the system in subsequent periods, as a result of a dynamic process of experience, accumulation and learning (Swan et al., 2003). The structure of networks are thus in a state of continuous change, where the behaviour of firms shape networks, and networks in return shape the performance and state of firms (Ozman, 2009). Thus, the literature review of innovation networks conducted in this study is inspired by this process view of networks.

Besides, the majority of studies on innovation network falls into four broad categories: formation, structure, management and performance of innovation networks. Since external conditions play an important role, it is represented in centre of the figure bellow (fig.3). External conditions are not direct results of networks but shape how innovation networks form as well as their innovativeness (see Annex 1 for a summary of selected researches on innovation networks).

The four broad categories that encompass this literature review on innovation network research are represented in figure 3.

Fig. 3: Literature Review on Innovation Network Research



Source: Based on Ozman (2009) and Popp et al. (2014)

Studies on the *formation of innovation networks* mainly deal with the motives for firms to participate in innovation networks, the selection of partners, and the effect of external conditions and firm-specific attributes on collaboration decision. One major focus in this research stream is the access to resources that a firm gain by incorporating itself in networks to enhance its innovative performance. The resource-base view explains collaborations among firms with respect to the complementarities in firm resources (Pfeffer & Salancik, 1978). Powell et al. (1996) examined the key factors that promote interorganisational networks in the biotechnology industry, a field where no single firm has all the necessary capabilities to innovate. They stated that firms network with each other not only because they lack resources and need to access others, but because they seek to explore and exploit knowledge bases. Baum et al. (2009) emphasised the role of complementary knowledge stocks in partner selection, arguing not only that knowledge complementarity should not be overlooked, but that it may be the true causal force behind network formation. In line with this consideration, Cowan et al. (2007) stated that firm look for partners whose knowledge complements their own. However, repeated interactions generate similarity between partner's knowledge, reducing complementarity. Jointly, these effects imply that firms will have distinct partners over time.

Studies on the *structure of innovation networks* are about the overall architecture of the network, focusing on the patterns of direct and indirect relationships between actors (Calia et al., 2007; Ozman, 2009). Since studies on this research stream borrow heavily from what has been learned about the structure of social networks, some of the measures used for the structural dimension often refer to the number of ties existing in a network. More specifically, scholars who have analysed benefits of single network members have looked at ego network size, while scholars who have analysed structures of whole networks have used measure of network cohesion or density (Dumbach, 2013). Ego network size or degree centrality is regularly measured as the number of network ties a network member has. For instance, Whittington et al. (2009) found that proximity and network centrality exert complementary, but contingent, influences on organisational innovation. Similarly, Wang et al. (2015) study showed that network centrality positively influences both organisational innovation and performance. In addition, findings indicated that the impact of network centrality on organisational innovation is stronger for small organisations while that on organisational performance is stronger for large organisations. The influence of network centrality on overall organisational innovation/performance is stronger for organisations in developed institutional environments as well as in knowledge-intensive industries.

Those researchers who looked at structures of whole network and examined network cohesiveness or density have produced contradicting findings (Dumbach, 2013). In general, scholars have followed three lines of argument: the benefits of dense networks for innovation; the benefits of sparse networks for innovation; or the moderating effect of environmental aspects on network cohesion. A first group of studies followed the arguments of Coleman (1988) and proposed that dense networks with strongly connected ties are beneficial for innovation (called in the literature as 'network closure'). Obstfeld (2005), Ahuja (2000), Tortoriello and Krackhardt (2010), and Baba and Walsh (2010) are examples of studies in this line of argument. A second group, on the contrary, follows the arguments of Granovetter (1983) and suggested that sparse networks are beneficial for innovation (called in the literature as the 'strength of weak ties'). Scholars like Rodan and Galunic (2004), and Zaheer and Bell (2005) have published papers on such topic.

A third group, which arose from the contradicting theoretical arguments of the two previous opposing groups, suggested that these two views might complement each other. Scholars who belong to this research stream proposed that network cohesion is not per se good or bad, but that the benefits and drawbacks of both structures depend on environmental moderators (Dumbach, 2013). For instance, Mors (2010) came to the conclusion that partners of consulting firms who operate in homogeneous contexts benefit from most sparse networks as these network structures are associated with non-redundant information and, as a consequence, with innovation performance. In contrast, dense networks are beneficial for partners whose networks span across geographic and firm boundaries. In such circumstances, dense networks provide suitable context to integrate the knowledge acquired.

Similarly, Gilsing and Nooteboom (2010) proposed in their paper that innovation network effects depend on the industry and on whether the focus of a network is on exploration or on exploitation. Besides, next to density and strength of ties one should also look at their content, for example in terms of types of knowledge, technology and competence for innovation. As another example, Tiwana (2008) explored the tensions and complementarities between weak and strong ties in innovation-seeking networks. While weak ties provide access to diverse, structural hole-spanning perspectives and capabilities, strong ties help integrate them to realise an innovation. Likewise, Schilling and Phelps (2007) showed that firms in networks with high clustering and high reach (short average path lengths to a wide range of firms) will have greater innovative output than firms in networks that do not exhibit these characteristics.

Studies on the *management of innovation networks* deal with the role of different coordination mechanisms and their effectiveness within innovation networks. Despite the recognised significance for network effectiveness, relatively little knowledge exists about how innovation networks are managed (Hurmelinna-Laukkanen et al., 2014). Part of the literature on this research stream discusses innovation management in open innovation processes and innovation networks, but the perspective taken is almost exclusively from the view of a single firm (e.g. Dhanaraj & Parkhe, 2006; Ojasalo, 2008) rather than from a broader geographical system of innovation. Some exceptions include Tidd (2001) who argued for the need to take a broader view on innovation management, and Levén et al. (2014) who discussed aspects of innovation in dyadic and interorganisational settings.

Another discussion present in this research stream is to what extent innovation network can be managed. In the one hand, for one group (e.g. Ritter et al., 2004; Ritala et al., 2009) networks are only weakly manageable, that is to say orchestrated, and no single "hub firm" can provide direction or control to the entire network. Studies on network orchestration fall into this category. On the other hand, scholars representing strategic research (e.g. Dyer & Nobeoka, 2000; Järvensivu & Möller, 2009; Möller &

Rajala, 2007), the resource-based view, and those that focus on network organisations with intentionally created structures argue that networks can, and indeed must, be managed in order to be efficient.

A very recent research stream (Heidenreich et al., 2014; Humerlinna-Laukkanen et al., 2009; Ritala et al., 2012) states that both of these views are relevant to understand innovation networks, how organisations behave and how to manage within network contexts. However, very few empirical examinations explicitly state in which situations different forms of coordination would function best (Levén et al., 2014; Najafian & Colabi, 2014; Provan & Milward, 1995). Thus, there is a need for research that takes into consideration the interplay between innovation network characteristics, its evolution, and the potential coordination mechanisms (Hurmelinna-Laukkanen et al., 2012; Ojasalo, 2008; Ritala et al., 2012)

Studies on the *performance of innovation networks* evaluate, through the use of indicators, the outcomes achieved as a result of participation in such networks. Following Provan and Sydow (2008), studies in this research stream fall into two categories: process and outcomes. Since the effects of structural aspects for innovation as dependent variable have often limited utility, these indicators were not considered here. Because performance-based outcomes are difficult to obtain and assess, researchers attempting to investigate innovation networks frequently rely on process indicators. Studies on process indicators typically focus on those actions and activities, like learning and trust, which are likely to result in effective outcomes (Provan & Sydow, 2008). While it may be somewhat difficult to specify exactly what measures are process indicators as opposed to outcomes, it is possible to notice in this research stream that learning is one of the most cited consequences of innovation network involvement (Dougherty & Hardy, 1996).

Although this literature is quite diverse, a general consensus seems to be that certain types of network have a positive effect on learning. Hagedoorn and Duysters (2002) found that learning through exploratory networks is better for innovative performance than learning through exploitation networks. Similarly, Powell et al. (1996) stated that firms learn from exploration and synergies between different types of alliances. Collaboration between firms not only enhances learning about new development, but also strengths internal competencies. Some recent studies went further by adding that whether a firm collaborate for the purpose of exploration or exploitation will depend on external conditions like stage in the industry life cycle (Rothaermel & Deeds, 2004) or the growth phase of the firm (Oliver, 2001).

Trust has been the focus of a limited amount of research in relation to innovation networks (McEvily & Tortoriello, 2011; Yakovleva et al., 2010). Trust is a key element of bonding social capital, and is generally seen both as critical for holding a network together and as an outcome of network involvement (Provan & Sydow, 2008). Researchers suggested that trust arises as a result of network formation. For instance, Tortoriello and Krackhardt (2010) pointed out that close ties in innovation networks facilitate knowledge transmission, what as a consequence facilitate common understanding and norms, reduce miscommunication and carry out coordinated action to tackle tasks. The open communication channels allow for the development of trust within such networks, making these ties very effective at knowledge transfer, boundary spanning, creativity, and innovation. Although trust has proved difficult to measure since it can be interpreted in a variety of ways, and few innovation networks are formed with the intention of creating trust as an outcome in its own right; its existence seems critical for innovation network maintenance and success (Shazi, 2014). Thus, it can be considered as a process indicator for innovation network evaluation as it is a necessary condition for enabling organisations and their managers to work together in ways that can ultimately produce desired outcomes (Provan & Sydow, 2008).

Innovation networks can also be evaluated based on what they are set out to achieve. In contrast to other indicators, these outcome indicators are often specified and determined by societal institutions such as regulatory bodies, what make managers have limited flexibility when responding to these outcome demands (Provan & Sydow, 2008). Much recent studies in this area focused on the biotechnology industry (Powell et al., 1996; Owen-Smith & Powell, 2004) with a focus on the introduction of new patents and new products.

The review of the literature showed that there are some gaps in relationship to interorganisational networks and innovation. First of all, the empirical researches are very fragmented and context dependent (Howells, 2006; Winch & Courtney, 2007). They address innovation networks in a variety of settings and different countries (Najafian & Colabi, 2014). Besides, the focus of most studies in interorganisational networks and innovation has been on product innovation (Provan & Sydow, 2008). Moreover, since the studies are spread across different industry and national settings, considering institutional factors like coordinating innovation networks seems necessary (Dhanaraj & Parkhe, 2006; Rampersad et al., 2010). Finally, another promising area of research is considering the role of social and informal activities within networks in line with other formal activities that lead to innovation. So a research effort is needed to explain the mechanism through which these informal activities influence network innovative performance (Najafian & Colabi, 2014).

Thus, taking these issues into consideration, the management of innovation networks is a promising area of research (Hurmelinna-Laukkanen et al., 2014). Despite their recognised significance, relatively little knowledge exists about how innovation networks are coordinated (Möller & Rajala, 2007). The network literature has focused mainly on network that emerge, often incidentally, from dyadic interactions (Raab & Kenis, 2009). Goal-directed, consciously formed networks have received much less attention (Provan et al., 2007). A key question is to what extent network actors can purposefully manage innovation networks (Ritala et al., 2012). Understanding innovation network coordination and the capabilities involved is therefore a core issue for companies and government agencies (Hagedoorn et al., 2006). Another limitation of extant studies is their tendency to regard innovation networks as relatively generic. With few exceptions (e.g. Möller & Rajala, 2007; Powell & Grodal, 2005), authors did not distinguish between networks relating to, for instance, scientific discoveries, creation of breakthrough technologies, or commercialising first generation applications. This is a major issue as different innovation networks pose diverse challenges for network coordination (Hurmelinna-Laukkanen et al., 2012).

This study will address this knowledge gap from two perspectives. First, it will further investigate the most idiosyncratic characteristic of innovation networks – the diversity of its members. Then, it will be argued that the relative complexity and uncertainty in innovation networks influence their coordination potential, as well as the mechanisms and capabilities involved. The subject seems to be relevant as it can help to understand the effectiveness of innovation networks and their evolution. While the issue of actors' heterogeneity has generated active debate in strategy and organisational studies, there has been little discussion in exploring the role that diversity plays in affecting collaboration in innovation networks (Corsaro et al., 2012). The next section will further explore this concern.

3.1. Innovation Networks and its Idiosyncratic Characteristic – The Diversity of its Members

As discussed in the previous sections, innovation network is a well-established phenomenon that has been studied under different perspectives, with a common agreement on the relevance (and challenges) of the diversity of actors composing it (Corsaro et al., 2012). Innovation is the result of the interaction among several actors, often belonging to different industries and businesses, social, and technological networks (Provan & Kenis, 2008). They can be firm, universities, research centres, governmental institutions, and many others, all engaged in reciprocal, preferential and supportive actions (Powell, 1990).

Until now, studies that explored actors' heterogeneity could be found mainly in strategy (e.g. Rodan & Galunic, 2004) and organisation studies (e.g. Lee, 2010). Much less has been discussed with respect to innovation networks (Dhanaraj & Parkhe, 2006), where researchers tended to study heterogeneity in the process of innovation diffusion and implementation rather than in the development of collaborative innovation (Corsaro et al, 2012). Besides, studies have investigated the impact of single actors' attributes like age, ethnicity and gender on intra-firm or team performance, instead of focusing on their combination. And finally, past studies on innovation networks at interorganisational level considered actors involved in these collaborations as a structural feature of the network, thus focusing on their geographical diversity.

For scholars following the above-mentioned argument, geographical proximity is of utterly importance for effective teamwork and knowledge integration (Powell et al., 2002; Rallet & Torre, 2000; Whittington et al., 2009), especially in the case of research and innovative activities (Canals et al., 2008). Such propinquity enables face-to-face communication and interactions, what would reduce uncertainty and solve problems of coordination. However, there is a recent debate in the literature known as "the proximity paradox", which casts doubts on the benefits of physical nearness, postulating that geographical proximity per se is neither a necessary nor a sufficient condition for effective collaboration to take place: at most, it facilitates it (Boschma, 2005; Cantner & Graf, 2006; Meder, 2008). Even when participants are close in terms of geographical distance, they may still be diverse because of other attributes, like their different backgrounds, cultures and interests.

During the early 1990s, influenced by the dominant role played by industrial economics and innovation analysis in the field of economics, a group of geographical economists created the *French School of Proximity Dynamics* to investigate other dimensions of proximity, which are key to understand innovation within networks (Carrincazeaux et al., 2008; Torre & Rallet, 2005). This plural sense of proximity, which can be perceived as a degree of closeness between two individuals' attributes, has contributed to extending the use of this concept into many other forms of proximity that are currently found in the literature. According to Amason (1996), such distinction could shift the focus of analysis away from quantitative aspects of team diversity into its more qualitative aspects. This study builds on the work of Boschma (2005) to consider five dimensions of proximity relevant for knowledge flow between actors in innovation-related activities: geographical, cognitive, organisational, social and institutional. Proximities function by helping to overcome uncertainties inherent within innovation processes (Caniëls et al., 2014).

Geographical proximity is defined in terms of spatial or physical distance between actors (Svensson, 2010). Being geographically proximal implies that actors have the same nationality and/or cultural commonalities. One of the reasons why does geographical proximity matter in innovation is because (tacit) knowledge can be easier shared when actors of the innovation process are in appropriate distance to each other. These localised and frequent interactions can likewise be reinforced by socio-cultural values that are embedded in a geographical area (Doloreux, 2002). Another reason why does geographical proximity influence innovation is the economy of agglomeration. The shorter geographical distance between participants, the less will be the cost of exchanging knowledge and information and the faster will be communication between actors (Gust-Bardon, 2012). A number of concepts have emerged from the research on the role of geographical proximity in the innovation process. These include: innovative milieu, industrial districts, clusters, regional innovation systems and learning region.

Cognitive proximity refers to similarities in terms of individuals' expertise and experience in certain knowledge areas (Boschma, 2005). That is to say, partners share common and complementary skills and knowledge (Knoben & Oerlemans, 2006). Having expertise and experience in similar knowledge areas facilitates understanding one another, whereas individuals from different cognitive backgrounds may encounter misunderstandings (Werker et al., 2014). Caniëls et al. (2014) suggested that reputational standing of individuals could also affect cognitive proximity, as it relates to one's cognitive ability in a certain knowledge field. In case of a collaboration between university researchers and industry researchers, for example, it is likely that there will be some cognitive distance between them as one part is focused on fundamental research, whilst the other is oriented toward the application of science. Notwithstanding, such cognitive distance may not be an issue. It might increase the potential for innovation as long as knowledge bases are complementary (Nooteboom, 2000). Moreover, such cognitive distance is necessary to prevent cognitive lock-in, which hampers innovation (Boschma, 2005).

Organisational proximity is defined as the extent to which relations are shared in an organisational arrangement (Boschma, 2005). Collaborators are organisationally close when they are working towards similar or complementary objectives. Such similarity can be expressing in output goals (e.g. publications, patents, obtaining research grants), but also in the time span available to achieve those goals. For instance, when it comes to academic engagement with firms, there is likely to be a significant different in the organisational set-up and goals. Firms have an interest in appropriating research findings in order to reap commercial benefits, while university scientists adhere to the public good principle of their output. Besides, there will be differences also in terms of time span (long term vs. short term) and output (advancement of science vs. product development). There is a clear conflict, and to turn from pure research-driven to commercialisation-driven activities requires sufficient organisational proximity, in terms of organisational arrangements and goals (Caniëls et al., 2014).

Social proximity has its roots in the social embeddedness literature, a mechanisms to build trust among individuals and reduce opportunism in social transactions (Granovetter, 1983). Boschma (2005) defined social proximity in terms of socially embedded relations between agents at micro-level. Relations between individuals are socially embedded when they involve trust that is based on friendship, kinship and experience through repeated interaction (Boschma & Frenken, 2010). The concept point out that collaboration is difficult, or even unlikely, between people who do not know each other and hence who do not share trust, any enjoyable relationship or who do not expect valuable outputs from each other. In research collaborations between academics, social proximity is likely to exist as scientists affiliate with similar social and professional associations within their field of knowledge. It is less likely for social proximity to exist between potential collaborators from academia and industry (Werker et al., 2014). Thus, too little social proximity may result in a decline of the innovation capacity of companies caused by lack of trust and commitment, whereas too much of it can inhibit innovations, caused by the existence of cliques which are not open to new ideas (Menzel, 2013).

Whereas social proximity is defined in terms of socially embedded relations between agents at the micro-level, *institutional proximity* is associated with institutions at the macro-level. Both formal institutions (such as procedures, laws and rules) and informal institutions (like norms and values) influence the extent and the way organisations coordinate their actions (Boschma & Frenken, 2010). One example of a lack of institutional proximity is in university-industry-government relations, where different key actors operate in different institutional regimes (Etzkowitz & Leydesdorff, 2000).

These different forms of proximity are relevant for collaborative endeavours as geographical proximity allows regular interaction; social, institutional and organisational proximity build conscious trust; and cognitive proximity provides subconscious rules that align thinking. These dimensions relate individuals' outward characteristics without taking into account their personality traits, behaviours and preferences (Caniëls et al., 2014).

The following table summarise the different forms of proximity and their distinct attributes.

Table 3: Types of Proximity and its Distinct Attributes

Types of Proximity	Distinct Attributes
Geographical	Location; close physical distance
Cognitive	Expertise and experience in certain knowledge areas
Organisational	Shared relation in organisational terms (similar or complementary objectives)
Social	Trust based on friendship, kinship and experience through repeated interactions
Institutional	Formal and informal rules and regulations

Source: Based on Werker et al. (2014)

The literature suggests that these different types of proximity (or distance[8]) are interrelated and can coexist in the same innovation network (Caniëls et al., 2014). As far as the interrelations of types of proximity are concerned, extensive research has been conducted on demonstrating that geographical proximity may be important, but is simultaneously influenced by other types of proximity which complement and substitute it (Knoben & Oerlemans, 2006; Broekel & Boschma, 2012; Ozman, 2009). Boschma (2005) and Criscuolo et al. (2010) both investigated the interrelations among geographical, organisational and cognitive proximity. For them, organisational and cognitive proximity may substitute for geographical proximity when the task to be performed is divided between actors who are in the same technological field and have a common knowledge base and are coordinated by a central authority. When partners are cognitively distant, organisational proximity might be the necessary condition to induce individuals to integrate their knowledge.

[8] Distance is defined in this study as the inverse of proximity.

Corsaro et al. (2010) and Marrocu et al. (2013) both argued that cognitive proximity was more important than geographical proximity for the innovative capacity of a network. The appearance of ICT changed the methods of generating, absorbing, storing and diffusing information and knowledge. Hence, face-to-face communication could be substituted by communication via virtual or temporary geographical proximity (Torre, 2008). Mattes (2012) added the importance of organisational and institutional proximity, alongside cognitive, as critical enablers of innovation. With similar findings, Hansen (2014) investigated the substitution or overlapping effects of geographical proximity over non-spatial forms of proximity. Based on empirical analysis, he found that the relation between geographical and social dimensions is influenced by both the substitution and overlap mechanisms. And concerning organisational and cognitive dimensions, no evidence was found for the overlap effect, only for the substitution effect.

An interesting common observation from these studies is that the degree of proximity matters. Achieving an optimal level of mutual understanding is fundamental if network participants are to find a way to manage diversity, communicate with each other and work together in collective actions to build effectively and creatively on diverse knowledge (Parjanen et al., 2011; Vedral, 2010). According to Boschma (2005), dimensions of proximity reduce uncertainty and solve the problem of coordination, and thus, facilitate innovation. This explains why proximity is just as important as heterogeneity for innovation networks. However, even if it is well recognised that actors' diversity is a characteristic of innovation networks, with important effects on the innovation process, there is no agreement on the direction of these effects. Too little proximity might be detrimental to collaboration. In such conditions, mutual understanding could be lower, what would give space to different interpretations of the same events, misunderstanding and the misuse of knowledge (Vedral, 2010). As a consequence, communication and coordination conflicts could emerge and groups break up easily (Mattes, 2012). Yet too much proximity could also create "lock in" problems (Boschma, 2005), as the collaboration would not grant access to new knowledge.

Thus, a critical problem that innovation networks face is to find a balance between proximity and heterogeneity (Provan & Kenis, 2008), what involves a dynamic and constant trade-off between various dimensions of proximity in ways to enable that the involved heterogeneous actors transform their different specialised knowledge into an integrative cogenerated solution to innovate (Carlile, 2004; Leonard-Barton, 1995). The challenges of finding such balance have been chronicled in a number of arenas, such as knowledge management, social psychology, social network analysis and leadership. For instance, in a leadership study of immigrant networks in the United States, Saz-Carranza and Ospina (2011) found that network members spend considerable time managing the tension generated by simultaneous demands to nurture unity (e.g. bringing the organisations together to function in accord) and diversity (e.g. drawing out unique contributions based on their different). They suggested the need for both unity and diversity in a network as "*.... diversity and unity may easily undermine each other if diversity turns into disunity or if unity turns into similarity"* (Saz-Carranza & Ospina, 2011: 356).

This unity versus diversity tension resonates with Gray's research (2004; 2008) on social psychology, which showed that when there is too much diversity among network members on how they view or "frame" issues, the processes of collaborating to find an agreeable solution becomes exceedingly difficult. Squabbles among scientists about the validity of each other's conceptual frameworks, mismatches, and institutional disincentives impeded or prevented successful transdisciplinary endeavours. Moreover, the absence of process skills (such as decision-making, conflict resolution, and coordination) was also noted as a crucial detriment to collaboration.

Therefore, the types of actors taking part in an innovation network can, in fact, impact the coordination of the network (Ratcheva, 2005), the innovative outcome generated, and the effectiveness of the innovation itself (Corsaro et al., 2012). These difficulties of coordinating and combining knowledge that is decentralised throughout the network, of harmonising dissimilar frameworks and of building a shared understanding, can become major barriers to successful collaborations. The following section further discusses the effects of little proximity among network members in innovation networks.

3.2. Conflicts Caused by the Diversity of Innovation Network Members

Since innovation networks members hold diverse perspectives and interests, they often do not see eye-to-eye. As a consequence, they strive to understand and integrate concepts, frameworks and methodologies that may threaten their disciplinary comfort zones. Simple disagreements may escalate into serious conflicts, jeopardising the future of the collaboration (Gray, 2008). Conflicts, which refer to the degree of divergence in partners' preferences, interests and practices (Thomas, 2006), arise for various reasons. As Amason (1996) noted, some conflict are unemotional and characterised by a discussion of ideas and perspectives. Others, by contrast, are personal and highly emotional. Their sources affect cooperation in different ways, causing communication and coordination conflicts among members, possible free riders, disputes, and a certain level of inertia in the network. Collaborative efforts often fail because leaders are unable to management bitter conflicts between stakeholders (Ansell & Gash, 2012).

Intervention in the early stages of conflict can prove especially beneficial, because interpersonal tensions generate negative emotions that erode the open exchange of ideas. As so, Gardet and Mothe (2011) strongly recommended considering the issue of diversity from the perspective of its effect on conflict, as it may be that some types of diversity will lead to different types of conflict. There are four main types of conflict in innovation networks (Kolb & Bartunek, 1992):

- *Cognitive conflict* appears when partners disagree about a task. In innovation networks partners might have different views about what is the best technical solutions to employ (Amason, 1996; Mooney et al., 2007). It is a conflict rooted on partners' different knowledge base.

- *Affective conflict,* also called relationship conflict, involves personal disagreements and incompatibilities between parties. It can be very destructive to a network if unresolved as it may be stored long after the issues are resolved and forgotten. It manifests in feelings, distrust, stereotyping, anger, information withholding and distortion and a general desire to "beat" the other side on future issues (Das & Teng, 2002).

- *Administrative conflict*, also known as procedural conflict, exists when group members disagree about the content of the task and /or the procedure to be followed in accomplishing it. There is the inevitable clash between formal authority and power and those individuals and groups affected by policies, strategies and procedures. There are disputes over how revenues should be divided, how the work should be done, and how long and hard people should work. In essence, during administrative conflicts, group members disagree on *how* to disagree. Adopting formal rules (e.g. laws, constitutions, statements of policies) that specify goals, decisional processes, and responsibilities can minimise situations of administrative conflict.

- *Goal conflict* occurs when two or more desired or expected goals are incompatible. It may involve inconsistencies between the individual's or group's values and norms (e.g. standards of behaviour) (Borkowski, 2011).

Although these conflicts are distinct, they have related forms and often occur together. To address one while ignoring the other is to invite trouble (Amason, 1996). According to Gardet and Mothe (2011), the emergence – or not – of conflict may influence the type of coordination form employed. Although studies have debated about the needs and challenges of bringing together network members with diverse perspectives to arrive at innovative solutions to complex problems, they have not further explored the complex coordination mechanisms required to achieve agreement or unity within this context (Lawrence & Lorsch, 1967; Saz-Carranza & Ospina, 2011). Researchers like Boschma and Frenken (2010), and Humerlinna-Laukkanen et al., 2014 state that there is room for studies that explicitly take into account the complexity inherent in the process of coordinating collaboration in innovation networks, shedding light on the rise and dynamics characteristics of collaborative relationship. Since the premises of traditional or intra-firm coordination may not apply to innovation networks, a new approach is needed (Hurmelinna-Laukkanen & Nätti, 2012). Innovation networks require an adaptive coordination to facilitate collective action (Rycroft & Kash, 2004).

It is evident that coordination consists of the interaction between various organisations, and also among the individuals associated with those organisations. Because of that, coordination is both organisational and individual level phenomenon.

In fact, the relevance of focusing on both organisational and individual level has been documented in the innovation literature (Ritala et al., 2009). However, it is only recently that some writers (e.g. Gardet & Mothe, 2011; Hurmelinna-Laukkanen & Nätti, 2012; Norppa, 2014; Popp et al., 2014) have started to explicitly recognise that coordinating innovation networks requires concomitantly paying attention to these two levels, as coordination is sometimes situated on the organisational level, but other times strictly among key individuals (an intermediary third party). The next sections will discuss more in-depth these aspects.

4. Coordinating Diversity in Innovation Networks

As networks, many disciplines – including computer science, sociology, political sciences, linguistics, management, etc. – have all dealt, in a way or another, with fundamental questions about coordination (Malone & Crowston, 1990). In management research, coordination[9,10] has an established history, being considered as central to the very existence of organisations (Kleinbaum et al., 2008). As it can be observed in the table 4, through the lenses of traditional management – which mainly possess an intra-organisational focus –, coordination is associated with organising, planning and controlling to reduce variation and anticipate action.

[9] In this study coordination is not treated as a form of governance. Governance is the strategic task of setting the organisation's goals, direction, limitations and accountability frameworks. It determines the "what?" – what the organisation does and what it should become in the future. Coordination is about overseeing the day-to-day operations of the organisation. It determines the "how?" – how the organisation will reach those goals and aspirations.
[10] Coordination is considered as a function of management.

Table 4: Some Definitions of Coordination

Coordination is about structuring and facilitating transactions between interdependent components (Chandler, 1969)
Coordination consists of the protocols, tasks and decision-making mechanisms designed to achieve concerted actions between interdependent units (Thompson, 1967)
Coordination describes the integrative devices for interconnecting differentiated sub-units (Lawrence & Lorsch, 1967)
Coordination is composing purposeful actions into larger purposeful wholes (Holt, 1988)
Coordination is the integration and harmonious adjustment of individual work efforts towards the accomplishment of a larger goal (Singh, 1992)
Coordination is establishing attunement between tasks with the purpose of accomplishing that the execution of separate tasks is timely, in the right order and of the right quantity (Crowston et al., 2006)
Coordination is the act of managing interdependencies between activities performed to achieve a goal (Malone & Crowston, 1994)

Although research on coordination has been more extensively conducted in intraorganisational settings, and even so without forming a coherent body of theory, it has also been studied in interorganisational contexts, such as supply chain management (Mohr et al., 1996) and, lately, in networks (Rampersad et al., 2010). For the purpose of this study, coordination will be described as the mechanisms used to coordinate network actors into harmonious or efficient work relationships towards the aims of the network (Malone & Crowston, 1994; Melin & Axelsson, 2005). It is indisputable that the choice of instruments for coordination is influenced by the specific context and by the aims and tasks of coordination (Reger & Gerybadze, 1997). In this way, one must first identify the particular dependencies and the coordination problems faced by a network and then consider what alternative coordination mechanisms can be used to manage them.

From a network perspective, the impact of coordination on network effectiveness is debatable (Jarzabkowski et al., 2012). Arguments in this debate differ based on the researchers' views towards the ontological characteristic of networks and the level of analysis adopted. On the one hand, some authors (e.g. Gulatti et al., 2000; Jarillo, 1988), following a classical perspective on organisation theory, suggested that management-like control in networks is possible through formal coordination mechanisms. While other authors (e.g. Ford et al., 2002; Ritter et al., 2004), on another hand, in a more behaviourally oriented paradigm with roots in sociology and social psychology, took networks as adaptive systems that cannot be centrally directed, requiring then informal coordination mechanisms. A study by Ojasalo (2004) revealed that although actors in an innovation network do not like hierarchies, they would like an actor who has the highest authority and responsibility to ensure that outcomes are achieved. He argued that a coordinator, who adopts a different role to traditional management, might be necessary.

A recent third point of view, represented in the literature under rubrics such as the "networked" organisation (e.g. Kogut & Zander, 1996; Powell, 1990), praises that neither rigid hierarchies nor social categories necessarily play a dominant role in coordinating interorganisational interactions. According to this research stream, accepting both perspectives (formal and informal coordination mechanisms) when coordinating networks, in particular innovation networks, may be a viable approach due to the quite paradoxical and dynamic nature (Hurmelinna-Laukkanen et al., 2012; Kleinbaum et al., 2008). Balancing centralisation and decentralisation, formality and informality, permanent and ad-hoc strategies is needed. And this balance will be much influenced by the different characteristics of each network, its structure and the relationships between network members, what will have an effect on the way in which is possible and reasonable to coordinate it (Hurmelinna-Laukkanen et al., 2009; Reger & Gerybadze, 1997). "*Just like different types of networks form a continuum, the means of coordination in them can be more or less strict and clearly outlined*" (Hurmelinna-Laukkanen et al., 2012: 4).

Thus, there is space to employ two complementary ways for coordinating innovation networks: (a) "management" that focus on *coordination by commanding*, (b) "orchestration" that focus on *coordination by enabling* (Hurmelinna-Laukkanen et al., 2014). Management, in one hand, refers to having explicit goals and timetables, as well as systems for coordinating collaboration and motivating partners. It also includes some kind of leadership, where the leader can set the rules (in collaboration with others) that are needed so as to monitor the fulfilment of these rules and the achievement of the wanted outcomes. Orchestration, on the other hand, refers to activities that enable (but do not dictate) the coordination of the network and bring about the innovation outputs. It is not about directing the network, but discreetly influencing network members and making sure that the premises for knowledge exchange, value appropriation and innovation are in place. These coordination mechanisms are by no means mutually exclusive, but more likely simultaneous, and their relative importance varies depending on the attributes (what kind of innovation network is analysed) and the phase of development of the network (and its projects) (Ritala et al., 2012).

Despite the importance of these two complementary ways of coordinating innovation networks, deeper understanding supported by empirical evidence is still lacking (Rampersad, 2008). Besides, studies have been undertaken on the level of analysis of the focal organisation, and thus, an overall network approach is still required (Möller et al., 2002). Moreover, despite abundant literature dedicated to networks and coordination, few empirical studies address the internal operations of these interorganisational networks (Dhanaraj & Parkhe, 2006). Most research has focused on the creation, structure or collapse of innovation networks (Léven et al., 2014). And finally, previous work on innovation networks has used a static approach, lacking a more integrative and dynamic perspective to analyse how these networks coordinate their work (Gardet & Mothe, 2011).

Kleinbaum et al. (2008) and Medlin (2006) went further in advocating a research agenda to address the complex organisational processes through which in practice the nature of interorganisational interdependences is identified and coordination mechanisms are adopted. Such understanding is fundamental to the competitive success of innovation networks, since innovation projects entail great transactional uncertainty and exchanges of tacit knowledge, requiring strategic efforts to maintain the network and extract value from it. The inherent paradoxical nature of innovation networks affects greatly its coordination. Thus, to explore the proverbial "black box" of coordinating mechanisms, the following sections further develop these issues.

4.1. Coordinating Innovation Networks Through Management – Coordination by Commanding

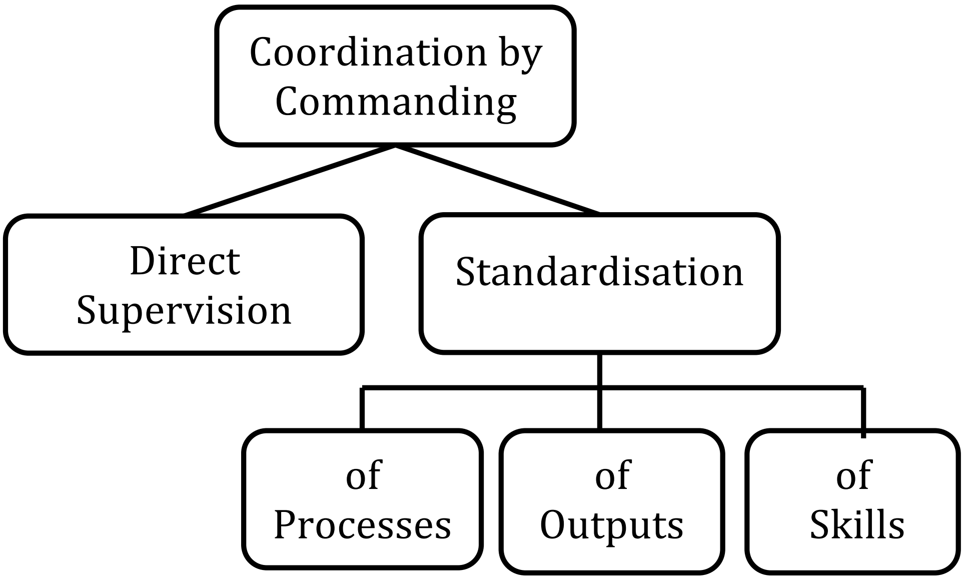
As noted earlier, the coordination mechanisms used to steer the innovation network may be influenced by the characteristics of innovation networks, its structure and the relationships between network members (Hurmelinna-Laukkanen et al., 2014). Taking this into consideration, for goal-directed innovation networks characterised by clearer positions and structures, formal division of labour and where considerable amount of explicit knowledge is exchanged, more traditional forms of management may be quite possible – if not even necessary – to apply to help with conflicts (Hurmelinna-

Laukkanen et al., 2009; Möller & Rajala, 2007; Leonard-Barton, 1995).

Coordination by commanding involves a hierarchical approach regarding issues that are critical for overall network maintenance and survival. It involves a clearly defined leadership authority by a single organisation, or a body elected by participants, that might take on some key administrative coordinating activities while leaving others to network members (Provan & Kenis, 2008). Such top-down coordination does not have to mean, however, that the situation would be characterised by a hub firm having centralised control. Although some members may have more formal power due to position, professional expertise or resources, this power cannot be wielded unilaterally the way it can be done in a traditional hierarchy. The innovation network has to be organised in such way that enable new business creation even if management in practice would take traditional and relatively tightly coordinated forms (Davis & Eisenhardt, 2007).

Although the literature on organisational theory has proposed several coordination mechanisms at different perspective levels (e.g. Crowston, 1990; March & Simon, 1993; Thompson, 1967), this study follows Mintzberg (1979; 1980) to consider direct supervision and standardisation (of work processes, outputs and skills) as formal (organisational-level) coordination mechanisms. These are considered to be the most well known set of coordination mechanisms and have therefore been chosen in this study, as represented in figure 4:

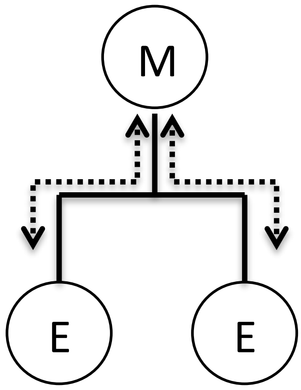
Fig. 4: Formal Coordination Mechanisms



Source: adapted from Mintzberg (1979).

Direct supervision or hierarchy is employed when one individual (typically a manager - M) gives specific order to others (employees - E), relying on legal means to issue instructions and coordinate their actions (Mintzberg, 1979). If the organisation is large enough, one person cannot handle all the members, so multiple leaders or managers must used. The efforts of these managers are then coordinated through structural coordination bodies (e.g. CEO, boards, committees). This type of formal coordination mechanisms is depicted in figure 5.

Fig. 5: Direct Supervision Mechanism



Source: Mintzberg (1979: 4)

Standardisation is a pre-programmed coordination in one of the three ways: work processes, outputs and work skills. In *standardisation of work processes*, the work is coordinated by the imposition of standards to guide the doing of the work itself (Mintzberg, 1979). It refers to the methods used to transform inputs into outputs. Such standardisation is accomplished through work rules, manuals, regulations, policies, job description, and so forth. An example is the assembly of a table provided by Ikea. Here, the manufacturer standardises the work of the customer ("Stand one of the table legs vertically with the bottom of the leg facing the ceiling. Slide the two bolts of the top of the leg into the two mounting holes in one of the corners of the table apron…").

In *standardisation of outputs*, the work is coordinated by the imposition of standards of performance or specifications concerning the outputs of the work (Mintzberg, 1979). It is achieved when the output (a product, service or performance) of the employee (E) meets the required standard or specification. The output could be achieved through standardised work processes or alternatively he[11] may be given some flexibility with regard to the methods used, provided the outcome meets the

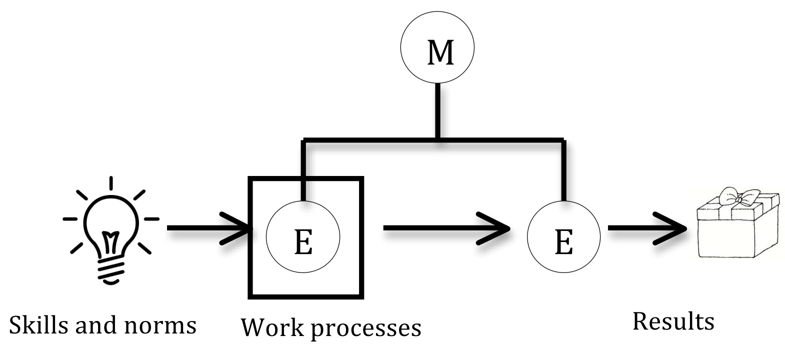
[11] Although in this dissertation it is used only the pronoun "he", it was not done to cause any gender inequality. It was done solely with the purpose of having a clearer writing style. It could be substituted by the pronoun "she" without causing any loss to the text.

specification for the product or service. Technical reports are a tool also largely employed to control results and behaviours. An example of this standardisation is a passenger when catching a taxi. He informs the taxi driver his final destination but not how to drive the cab.

In *standardisation of skills*, the work is coordinated by the internalisation of standard skills and knowledge, usually before workers begin to do the work. Skills (and knowledge) are standardised when a kind of training required to perform the work is specified. So, standardisation of skills achieves indirectly what standardisation of work processes and outputs does directly: it controls and coordinates the work (Mintzberg, 1979). An example is when an anaesthesiologist and a surgeon meet in the operating room to remove an appendix. They hardly communicate, but by virtue of their respective training, they know exactly what to expect from each other. Their standardised skills take care of most of coordination (Mintzberg, 1979).

Figure 6 graphically represents these three types of standardisation mechanisms.

Fig. 6: Different Standardisation Mechanisms: Work Processes, Outputs and Skills



Source: Melin and Axelsson (2005: 3).

Since several types of work, in particular non-routine knowledge-intensive activities that are full of fine-grain dependencies that might change on a daily or hourly basis, new mechanisms that support rapidly shifting coordination needs is required (Cataldo et al., 2006).

4.2. Coordinating Innovation Networks Through Orchestration – Coordination by Enabling

In innovation networks where knowledge takes a more tacit form and that are characterised by focusing on the interactions of autonomous loosely couple entities that collaborate for value creation without strict hierarchical authority, they do not comply with a traditional (top-down) management approach (Hurmelinna-Laukkanen et al., 2014). It can be agreed that in these networks a firm in a central position cannot exercise strong authority in the sense of commanding others and expecting them to follow (Reger & Gerybadze, 1997). The reconciliation and transformation of knowledge is done through a mutual adjustment mechanism (Mintzberg, 1979). Such mechanism achieves the coordination of work by a person-oriented process of informal communication, where control of work is in the hand of the doers and at an operative organisational level.

Nevertheless, if there are no supporting structures, common goals or coordination at all, the innovation network may be short lived. Thus, an adaptive coordination is required, where certain network members may possess capabilities that allow them to influence other organisations and the network as a whole in both building and coordinating the network, especially in those that generate innovations (Hurmelinna-Laukkanen et al., 2014; Rycroft & Kash, 2004; Ritala et al., 2012). This discrete influence has been described in the literature as "network orchestration" (Klerkx and Aarts, 2013). Dhanaraj and Parkhe (2006: 659) originally defined network orchestration as "*a set of deliberate, purposeful and evolving actions undertaken to create value and extract value from the network. Orchestration is different from managing, as it requires a more fluid approach that combines empowerment and trust*". As Hayek defined in 1945, it is the coordination of disparate actors without central planners.

The metaphor of the conductor of an orchestra is largely used to explain the function of network orchestrator. A conductor's job is to unify performers, set the tempo, execute clear preparations and beats, to listen critically and shape the sound of the ensemble. The conductor does this by coordinating the transitions during the performance and by giving particular sections a more prominent role. Hence, the orchestrator does not concentrate so much on exercising authority, but rather on facilitating the collaboration, making sure that the needed structures and forums for discussion are available when needed, and supporting innovation activities (Hurmelinna-Laukkanen et al., 2014). As so, a network orchestrator can influence network operations through different set of actions to ensure that the hand over of outputs from one actor to another takes place seamlessly and that the flows of information, resources and other inputs are unhindered (Haga, 2009).

Network orchestration in developing, managing and coordinating innovation networks, for Dhanaraj and Parkhe (2006) and for the majority of studies on it, is performed by a sole "hub" firm (or an external commercial firm). However, a recent strand in the literature argues that innovation networks that lack the dominant (hub) firm and consist of interdependent firms, with different power structures and loosely coupled to a high degree, require a somewhat different kind of network orchestration (Gausdal

& Nielsen, 2010; Hurmelinna-Laukkanen et al., 2014). In such cases, several studies (e.g. Haga, 2009; Reger & Gerybadze, 1997; Ritala et al., 2012) indicate that actors, who possess important abilities in terms of managing knowledge mobility[12], innovation appropriability[13] and network stability[14], often take up such network orchestration roles.

Despite their growing importance for the formation and development of innovation networks, network orchestration and the role of third parties in network management has been under researched (Dhanaraj & Parkhe, 2006; Hurmelinna-Laukkanen et al., 2014; Pittaway et al., 2004; Ritala et al., 2012). Batterink et al. (2010) and Winch and Courtney (2007) stated that further research into the multifaceted orchestration process in innovation networks remains essential if one wants to fully understand how innovation networks function and why they succeed or fail. And as Heidenreich et al. (2014) and Landsperger et al. (2012) also noted, there is a lack of research on the orchestrator's type, function and influence in networks. Furthermore, studies have been mainly conceptual. Authors like Freeman (1991) asked for more qualitative, inductive, and process-oriented study on innovation networks.

Hence, the aim of this study is to contribute to this gap, focusing on their network orchestrator types and functions. In this way, the following section presents insights from the literature on innovation intermediaries on different types and functions of innovation network orchestrators, who are they and what they (can) do.

[12] *Managing knowledge mobility,* which is at the core of an innovation network, involves sharing, acquiring and deploying knowledge (Dhanaraj & Pharkhe, 2006). To do so, it includes facilitating common meeting places for learning, and overcoming obstacles like tacit knowledge, epistemic barriers, lack of trust, diverging vocabulary, etc. (Brown & Duguid, 2001).
[13] *Managing innovation appropriability* is highly dependent on managing knowledge mobility. The ability to recognise innovative ideas and develop them further in a generative dance between tossing of ideas and realistic development of viable projects is critical in innovative networks.
[14] *Managing network stability* refers to the network members' willingness to continue the collaboration, which is related to dynamism of an innovation network (Orton & Weick, 1990).

4.2.1. Different Types and Tasks of Network Orchestrators

When reviewing the management literature on network orchestrators, one can first notice that studies have usually referred to them as innovation intermediaries. An innovation intermediary is defined by Howells (2006: 720) as "*an organisation or object that acts as an agent in any aspect of the innovation process between two or more parties… and that aims at eliminating obstacles for cooperation and innovation while stimulating and facilitating these processes*". Intermediaries, regardless of their formal position or hierarchical structure, are perceived as neutral actors in possession of integrity, capabilities and a set of working methods that allow them to bridge and influence other organisations, and serve as glue to the network (Morandi, 2013).

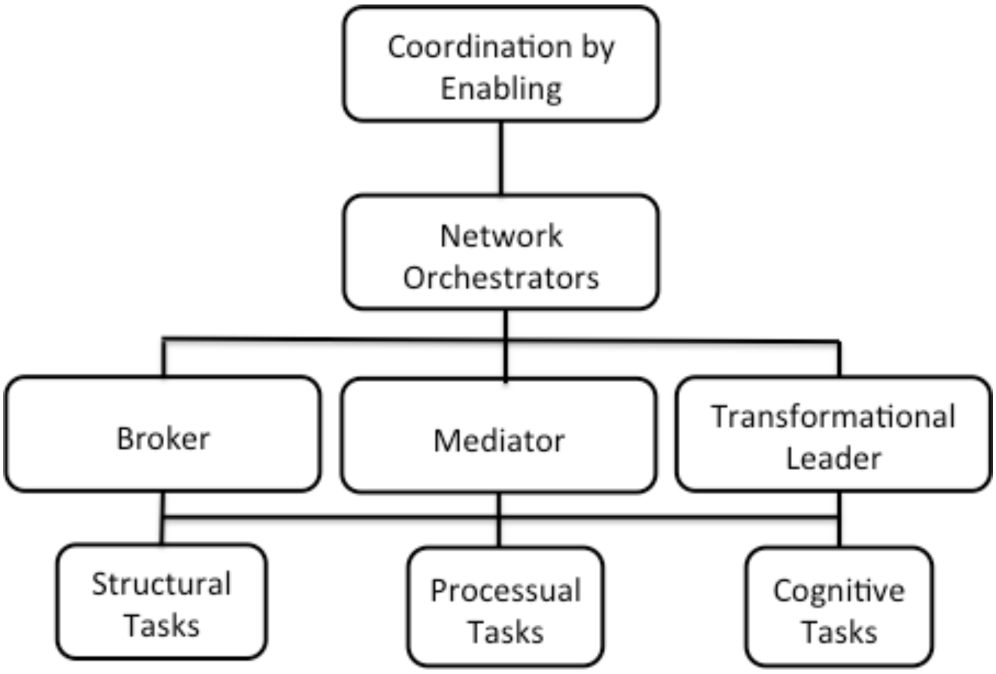
Although there is a growing literature on specialised intermediaries (those who have intermediation as their core activity) (e.g. Clausen & Rasmussen, 2011; Gredel et al., 2012; Klerkx & Leeuwis, 2009), this study will consider intermediation as a side-activity, a by-product of network members' principal activity (Howells, 2006). The importance lies on the catalysing function in the formation and maintenance of innovation networks (Klerkx & Aarts, 2013). Pittaway et al. (2004) noted in their systematic review of innovation networking that several authors found that parties which act as intermediaries have a positive impact on the development of interorganisational networks and innovation.

The innovation, knowledge management and interorganisational relations literatures have emphasised the relevance of intermediaries for overcoming diversity between network participants and for facilitating knowledge integration in innovation networks (Burt, 2004; Howells, 2006; Winch & Courtney, 2007). However, the majority of studies have taken the emergence of intermediaries for granted (Fleming et al., 2007; Ryall & Sorenson, 2007), concentrating on fragmented and disparate terminologies and functions of individuals (Klerkx & Leeuwis, 2009) or teams in intra-organisational contexts (Oke et al., 2008; Ratcheva, 2009; Williams, 2002; Winch & Courtney, 2007). Such perception fails to recognise the importance of better understanding the motives behind the emergence of intermediaries, what will be decisively to determine their subsequent functions in an innovation network.

Besides, most researchers who have investigated this phenomenon empirically followed a structuralist approach, using a quantitative method (social network analysis) to investigate how network ties and their connections impact on the dynamics of information diffusion (Burt, 2004; Owen-Smith et al., 2002). Finally, despite the increasing interest in it, this topic is still mainly conjectural, rather than an empirically proved construct (Nooteboom, 2009). Few studies have been able to capture the dynamics and evolving nature of intermediaries in bridging boundaries and coordinating collective work in interorganisational collaborations (Bouty & Gomez, 2010; Deken & Lauche, 2014; Rafaeli & Pratt, 2006). The literature calls for studies on intermediaries' actual practices to understand better their functions in innovation network contexts (Ottani & Bou, 2009a; Williams, 2002; Winch & Courtney, 2007).

In order to review the literature on intermediaries, this study follows Fichter (2009), Gray (2008) and Klerkx and Aarts (2013) to make a distinction between three types of network orchestrators (broker, mediator and transformational leader), grouped according to their main coordination tasks (structural, processual and cognitive) when tackling different barriers in orchestrating collaboration in innovation networks (see figure 7 for a representation). Busquets (2010: 482) noted that "*orchestrators can exert power by controlling resources or exerting a specific role*". Indeed, the ways in which different tasks, including the mutual information and the capabilities required to accomplish these, are carried out in orchestration may take many different forms (Obstfeld, 2005; Vedral, 2010).

Fig. 7: Informal Coordination Mechanisms



Source: Based on Fichter (2009), Gray (2008) and Klerkx and Aarts (2013)

Of course there are different tasks, functions and types of orchestrators present in the increasing discussion on innovation networks. However, this study aims to introduce one potential categorisation that may ease the examination of different orchestrators. Such categorisation will be explained in detail in the following sections.

a) Structural Tasks: Brokerage

Structural tasks address the network's need for coordination and information exchange – both within network members and external actors – in order to provide focus, define objectives, recruit the necessary expertise, and ensure the project's accountability (for deadlines, deliverables, etc.) (Gray, 2008). Research on boundary spanning and brokerage fall on this category (Klerkx & Aarts, 2013). Boundary-spanning activities are considered as critical for teams engaged in innovation because they enable teams to secure and convey information from groups outside network boundaries, understand their ideas and enable all involved experts to collaborate in the co-creation of new collective knowledge (Gray, 2008; Duijin et al. 2008).

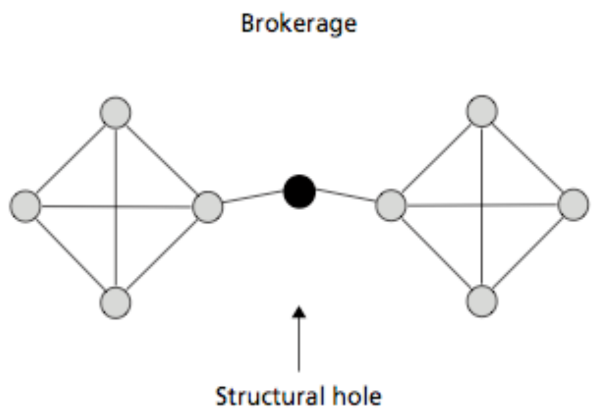
One form of boundary spanning essential for the construction and functioning of teams in innovation networks is brokerage (Long et al., 2013). Research on brokerage, first articulated in the seminal work of G. Simmel in 1950 and later explored by R. Burt in 1992, involves a strategic intent and effort to generate advantage presented by the disconnection between two parties (Obstfeld et al., 2014). A broker[15] is a human agent who translates and frames information from one community to another in an effort to promote coordination (Brown & Duguid, 2001). He occupies a key position within the network as he acts as a point of passage for the flow of resources, bringing in experience, expertise, and knowledge created externally to revitalise discussions and open new dialogues to enable the network to innovate (Haga, 2007; Winch & Courtney,

[15] It is possible to find in different literatures (e.g. knowledge management, sociology and organisational learning) different terminologies when referring to brokers. Terms like gatekeepers, boundary spanners, and representatives are commonly used to refer to individuals who play a major role in the transfer of knowledge (Tsoukas, 1996). Some researchers use these terms as synonyms or interlinked concepts (Ramirez & Dickenson, 2010), while others insist on their difference based on their position (in terms of belonging or not) to the groups they span (Katz & Tushman, 1980). However, for this study, following Cohen and Levinthal (1990) and Haas (2014), these terms are considered in an undifferentiated way as they all impact organisational innovation thanks to their strong networking inside and outside organisations, and their internal role, facilitating coordination and external communication.

2007). Hence, brokers intervene by using language; their cognitive power and persuasion to build linkages from one community to another and increase the information flow among parties (Boisot, 1995). They not only can leverage their knowledge expertise to identify and create new opportunities, but they are also viewed as attractive candidates to be included in these opportunities.

As early as the 1980s, research on social networks has been studying brokers. Following a structural perspective, these studies have applied a family of measures generally called centrality, which is a measure of a node's prominence and his importance in a network, to identify the broker through their structural position in the network. Often, the broker is a critical node that bridge structural holes, that is to say people or groups that are not otherwise interacting, as shown in figure 8.

Fig. 8: Brokerage



Source: own author

Although structural holes open opportunities for diverse information, they include implementation challenges regarding the language differences, unrelated interests and unique perspectives of different parties. Thus, building bridges between parties, despite the distance between them, is critical in terms of innovation (Ahuja, 2000). There has been a recent debate in the literature (e.g. Kilduff & Brass, 2010; Lingo & O'Mahony, 2010; Vernet, 2012) that highlights how brokers have to reconcile these two apparently opposing strategies: (a) keeping their contacts apart to benefit from better information, and (b) bring them together to help foster new collaboration and ease coordination and consensus. The following sections will further discuss these two strategies.

a.1) Tertius Gaudens Orientation

Brokers, with structurally important position, link pairs of unconnected actors and have bargaining power in exchanges of resources or information between these actors. People connected with networks that work as bridges between structural holes have an advantage in receiving more diverse signals. That helps them to detect rewarding opportunities before others (Burt, 2004). This brokerage action and the opportunities that rise from broker's advantageous position are traditionally seen in the light of exploitation of structural holes (Burt, 2000).

Burt (1992) offered a theoretical underpinning for the individual advantages that accrue to brokers due to their position of a tertius gaudens (the third who benefits). Because of his unique ties to structural holes, brokers individually benefit both from the novel information that such structure affords and control the benefits that allow him to leverage from the disconnected actors. The greater the degree to which an individual can uniquely connect non-redundant sources of information and social contacts, the greater the potential information and control advantages that are likely to achieve that individual. People with contacts in many different areas are more likely to see bridges between otherwise disparate fields and thus are able to contribute to creative and innovative outcomes (Burt, 2000).

Burt's (2004) model suggested that brokerage has four levels. He proposed that the simplest form of brokerage is making both sides aware of the interests and difficulties in the other group. Brokerage may develop further and reach a (second) level, in which the broker transfers best practices between parties and creates mutual added value. If the relationship advances further, the broker is able to recognise his counterparty's unique way of thinking and behaving. Such awareness requires previous experience from multiple organisational environments or groups. The third level referred to the broker's ability to draw analogies between groups and combine irrelevant matters in a way that may be beneficial for one's own group. The last level, and most advanced level of brokerage, was synthesis, where parties are able to combine elements from each other in the light of new belief and behaviours.

Many studies have employed this meaning of a brokerage, where the broker has a tie to two alters who are not tied to one another. This broad category of research treats brokerage as an action that can be undertaken to facilitate relations in situations of structural holes, which take place due to social structure. For example, Padgett and Ansell (1993) well-known study of Renaissance Florence, the Cosimo d'Medici's family benefited from their ties to elite families and the "new men", who were disconnected to the Italian society. Barley's (1996) ethnographic study of technical work described certain computer technicians as brokers or "cut points" who bridge otherwise disconnected work communities. Similarly, in their exploration of Initial Public Offering (IPO) deal networks, Pollock et al. (2004) introduced the idea of network architects as brokers who create and manage structural holes in mediated markets. Relatedly, Fleming et al. (2007) defined brokers as actors with ties to other collaborators who are not tied to one another.

Criticisms to this research stream rest on the justification that although brokers benefit from maintaining unique ties, achieving cooperation among these ties can be difficult. Execution requires collaboration with others to synthesise and implement good ideas. If innovation is a collective act (Hargadon & Bechky, 2006), then brokers must not only have good ideas, they must be able to elicit and synthesise the ideas of others (Lingo & O'Mahony, 2010).

According to Fleming et al. (2007: 462) brokerage under this tradition inhibited "*mutual ownership and understanding of the new* [idea] *combination*", and, though the idea was more novel, it was less likely to be reused than ideas arising from more cohesive networks. Of course, it is regarded the presence of structural holes as creating the potential for brokerage, but brokerage can occur without structural holes. The potential for brokerage is in the broker having ties to two or more parties, not in the ties or lack of ties among those parties. Thus, social network structure affects the ways that brokers do their brokering, but does not define it (Obstfeld et al., 2014).

a.2) Tertius Iungens Orientation

From the criticisms to the egocentric brokerage theories, arose another research stream that has focused on the relational process of brokerage that occurs in close, dense or cohesive networks (Coleman, 1988). The focus shifts from short-term profit gaining and self-interested exploitation tendency towards building long-term cooperative ties that help create trust and opportunities for resource sharing (Ahuja, 2000). Under such behavioural orientation, the gap-closing activity is directed by collective interests and affected by altruistic influences.

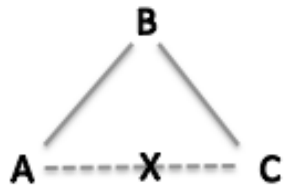
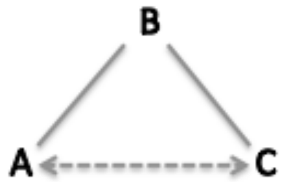
Unlike structural conceptions of brokerage, brokers do not need to foster distrust from those they connect, as "*brokers facilitate projects that represent combinations of people, ideas, and resources*" (Obstfeld, 2005: 103). While the structural conception of brokerage focuses mainly on the advantages that can accrue from a broker's unique access to information and social contracts, the process perspective of brokerage broadly emphasises how that unique information can be put to creative and innovative use. Brokerage in this sense close gaps in the social structure and creates direct contacts between the unconnected to facilitate coordination, collaboration, and pursuit of common goals (Lingo & O'Mahony, 2010). Additionally to the context of disconnected parties, the broker may also function in situations where parties already have existing ties, but they are unconnected in relation to a particular project or initiative.

One of the most cited studies in this research stream is of Obstfeld (2005), who focused on the behaviour orientation of focal actors in an automotive design firm. He suggested an orientation, tertius iungens (the third who joins), as the strategic, behavioural orientation towards connecting people in networks by either introducing disconnected individual or facilitating new coordination between connected individuals. In his study, Obstfeld (2005) found that the people who were playing a coordinating role in the context of cohesive networks were more likely to be involved in innovation. Therefore, in contrast to the traditional broker role presented by Burt (1992), this integrating tertius iungens behaviour build collective value that is embedded in the organisational system. Tertius iungens behaviour is generally supported by trust, reciprocity and reputational incentives.

A study conducted by Fleming et al. (2007) found that information flew more efficiently within cohesive social contexts, which supported the assumption that closer ties and trusts were beneficial in knowledge transfer and the creation of social capital. However, they also presented that cohesive brokerage structure supported innovation mainly when collaborators had a broad work experience from multiple organisations and they worked with external collaborators.

The table that follows (table 5) summarises the main aspects of each strategy presented: tertius gaudens and tertius iungens.

Table 5: Types of Brokerage

	Tertius Gaudens	*Tertius Iungens*
Forms of Brokerage	 B keeps A and C apart	 B introduces and coordinates new collaborative action between A and C, Where A and C have no prior tie
Focus of Approach	Structure	(Relational) Process
Key activities	- Introduce new parties - Information control and manipulation - Introduce "common development language"	- Introduce disconnected parties - Introduce new forms of coordination between connected parties - Introduce "common development language"
Source of Power	Control, separation of ties	Trust, cohesion, new collaboration
Strategy	"Divide and conquer"	"Unite and conquer"
Key authors	Simmel (1950) Burt (1992)	Obstfeld (2005)
Associated theories	- Boundary spanning - Technology brokering (Hargadon & Sutton, 1997) - Innovation brokering (Howells, 2006; Klerkx & Lewis, 2009) - Knowledge brokering (Hargadon, 2002; Meyer, 2010)	- Strong ties vs. weak ties (Granovetter, 1983)

Source: Based on Obstfeld et al. (2014)

One can find in the literature a variety of results supporting both arguments (*tertius gaudens* and *tertius iungens*), leaving the controversy to remain theoretically and empirically open. One reason for the failure to resolve the controversy may be that most previous studies have typically focused on the structure in which social interactions take place, with little attention to the personal attributes of the collaborators (Fleming et al., 2007), the dynamics or the content exchanged during brokerage

(Vernet, 2012).

a.3) Tertius Gaudens and Tertius Iungens as Both Parts of Brokerage Strategy

As a result of this debate, an emerging stream of research on brokerage (e.g. Lingo & O'Mahony, 2010; Nooteboom et al., 2010; Obstfeld et al., 2014) highlights that brokerage strategy often entail a combination of these two apparently opposing roles: keeping their contacts apart to benefit from better information ("*tertius gaudens*") and bringing them together to help foster new collaboration and ease coordination ("*tertius iungens*"). This conception of brokerage typically takes into account relational practices as well as a broker's structural position.

On the one hand, from a structural perspective, it is emphasised the consideration that brokers are conduits for access to information and thus can directly obtain information, power and control benefits from their individual use of that information. On the other hand, from a process perspective, it is more predominant the reflection that brokers must integrate different ideas, innovations and contributions from others and synthesise them into a coherent whole to obtain both individual and mutual benefit. However, the broker does not wish to optimise the level of mutual information between parties, otherwise his intermediary function becomes irrelevant. He wants to keep parties somewhat apart to control the amount of mutual information that develops between their respective knowledge sets. Therefore, brokers will try to actively maintain and exploit the separation between parties, with their mutual information kept at minimal level sufficiently to mobilise network members (Obstfeld, 2005). Such conception of brokerage composed by both structural and process strategies affords a better understanding of how organisations and their networks evolve (Obstfeld et al., 2014; Vernet, 2012). In this context, brokers cannot achieve benefits from their unique position on their own; they are pursuing collective goals that require the creative talents of others (Lingo & O'Mahony, 2010).

Hargadon and Sutton (1997) first broke ground in this direction by giving equal weight to the structure and practice of brokers – showing how the design firm IDEO's unique structural position as well as its process of information access, storage, and retrieval helped the firm to transfer ideas from one industry to another and produce innovative outcomes. Lingo and O'Mahony (2010) study of independent country music producers found that producers adjusted their brokerage practices in response to the ambiguity they confronted, but displayed combinations of *gaudens* and *iungens* activity at every phase of their creative process. Moreover, Davis (2011) concluded from his research on innovative alliances in the computer industry that active pruning of old ties may be necessary before managers can effective facilitate new ties, suggesting that sequences of *gaudens* and *iungens* behaviour are sometimes necessary. And finally, Vernet's (2012) study on cinematographers in France showed that agents that took a dual role allowed them to effectively broker the relationship between cinematographers and agents, influencing the prevalence of long-lasting relationships, helping cinematographers to get better deals on projects and keeping search costs for a technician to a minimum.

Taken together, these emerging examples demonstrate how effective brokerage strategies may require complex combinations and sequences of different brokerage behaviours over time and how skilled actors may command repertoires comprised of multiple brokerage behaviours for this purpose (Obstfeld et al., 2014). Depending on the context and the stage of development of the network, certain brokerage strategies might be pursued simultaneously or can evolve from one to another over time (Lingo & O'Mahony, 2010). This highlights an important aspect on the conception of brokerage under this viewpoint, which is the switching ability of brokers (Vernet, 2012). Levina and Vaast (2005) identified three conditions effective brokers need to meet: (1) brokers need to have sufficient knowledge and understanding of each of the fields they are about to brokerage to be perceived as legitimate and competent; (2) brokers need to be considered legitimate negotiators of their own field; (3) brokers need to possess the required communication and negotiation skills associated with this role. And they need to be willing to perform a bridging role between two different fields instead of becoming functional experts in one field alone. To mitigate this risk and support the brokerage function, they need to be able to rely on proper tools. One of these tools highly cited in the literature, but barely associated to the brokerage process, is boundary objects.

a.4) Boundary Object as a Brokerage Tool

Another coordination mechanism that has been frequently cited in the management literature, particularly knowledge management, is the use of boundary objects to orchestrate complex collaborations that require intersectional work from multiple social worlds (Gerson & Star, 1986; Thomas et al., 2007). Artifacts have been proposed as an important means of translating such multiple, overlapping but divergent representations in ways that reconcile and accommodate both diversity and synergy (Star & Griesemer, 1989). Using artefacts in an appropriate manner can free actors from the boundaries of their discourses as it facilitates mutual understanding and trust (Bowker & Star, 2000), mediates and defines social relationships (Knorr-Cetina, 1999;

Nicolini et al., 2012), and affect behaviours and actions (Trompette & Vinck, 2009). This particular characteristic makes boundary objects specially suited to provide coherence across intersecting social groups and help on their coordination (Canals et al., 2011; Gal et al., 2004).

Boundary objects are either physical objects or abstract concepts that actors rely on as a temporal support to allow them to work together without achieving consensus (Bowker & Star, 2000; Nicolini et al., 2012; Star & Griesemer, 1989). They are collectively built over time through common language, shared meanings and converging interests (Carlile, 2002). They are not things with fixed qualities but rather an open-ended projections oriented to something that does not exist yet, or to what one does not know yet for sure (Miettinen & Virkkunen, 2005). Table 6 gives a chronologically ordered selection of definitions of boundary objects.

Table 6: Selected Definitions of Boundary Object

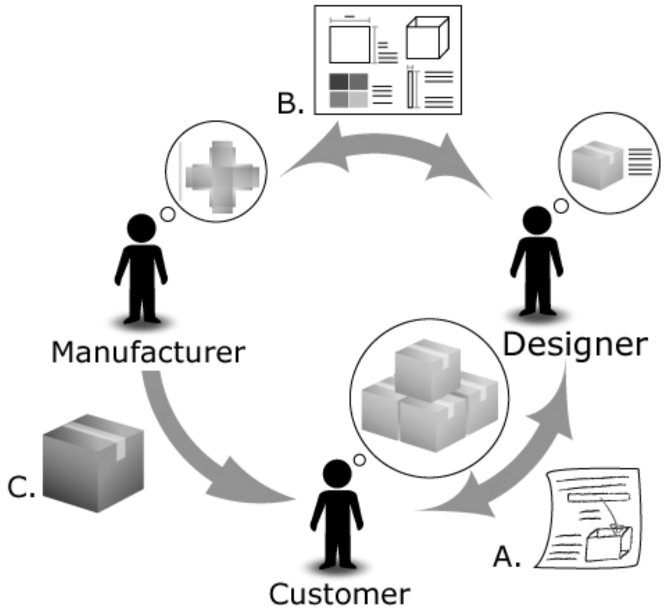
Source	Definition
Star & Griesemer (1989)	Boundary objects are objects that are both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use, and become strongly structured in individual-site use. They may be abstract or concrete. They have different meanings in different social worlds but their structure is common enough to more than one world to make them recognisable means of translation
Dodgson et al. (2007)	Boundary objects mediate interactions between different communities of practice by providing a common basis for conversations about solutions to problems.
Winter & Butler (2011)	By identifying 'lowest common denominators', critical points of agreements, or shared surface referents, boundary objects provide a sufficient platform for cooperative action – but they do so without requiring the individuals involved to abandon the distinctive perspectives, positions and practices of their 'base' social world.
Nicolini et al. (2012)	Boundary objects are defined by their capacity to serve as bridges between intersecting social and cultural worlds. Anchored in, and thus meaningful across these worlds, they create the conditions for collaboration while, by way of their interpretive flexibility, nor requiring 'deep sharing'.

These definitions highlight two central aspects of boundary objects: retaining a community's identity and interpretative flexibility (Abraham, 2013). To become a boundary object, an artefact has to be locally useful and possesses a common identity across sites, so actors can understand their significance (translation) and incorporate them into the practice of diverse fields (transformation) (Carlile, 2004; Koskinen, 2008; McGivern & Dopson, 2010; Spee & Jarzabkowski, 2009). This presupposes the existence of a minimal knowledge structure that is recognised by partners from different social worlds and can take very diverse forms (Trompette & Vinck, 2009), being subject to change of function over time. As they are created and situated in practice, their nature and function depend on the work, expected outcome and type of agents involved in the collaboration. "*They perform certain functions and then disappear behind the scenes* *until the plot requires them to resume centre stage*" (Nicolini et al., 2012: 37). Hence, the materiality of a boundary object derives from action, rather than from a sense of prefabricated stuff (Star, 2010).

On the account of these qualities, boundary objects can facilitate coordination by de-personalising the discussion (Bechky, 2003; Marick, 2015). By focusing on an object, which is used by both communities, the perceived threat to identities can be reduced. Further, objects have meaning. Via their plasticity of meaning they translate ideas, viewpoints and values across otherwise difficult to transverse organisational boundaries. When presented with an object, an individual attach additional knowledge to this object that can spark insightful connections that would have otherwise been missed (Hawking & Rezazade, 2012). In this manner, boundary objects objectify knowledge that serves as a coordination platform (Bechky, 2003).

The figure below (fig. 9) is a depiction of how a boundary object is – in this case a hypothetic component for a product – interpreted and used by different communities during a simplified design/manufacturing process.

Fig. 9: Boundary Object in Use



Source: Fong et al. (2007: 3).

The process starts in (A) between the customer and the designer. The customer desires a specific component and has a mental model of what that component is going to be used for. The customer needs to translate hi/hers mental model into a transferable form for the designer. To do so, a boundary object, in this example a sketch and a description of the component, is created by one party and interpreted by the other. When the designer looks at the drawing, he will translate it focusing on the technical properties of the component, rather than on its eventual use by the customer. The designer then translates his model to the manufacturer, as shown in (B). To do so, designer and manufacturer have to work together to create a boundary object, such as a technical drawing, that both parties can understand. This technical drawing contains the decontextualised knowledge from the designer, which can be recontextualised by the manufacturer. So when the manufacturer looks at the drawing, he will focus on the assembly aspect of the component. Once the component is manufactured, it becomes a boundary object, as shown in (C). If the customer is not satisfied, he will talk to the designer again. In each case, the component may be the same, but the problem setting shapes what approach each person will take to the artefact. In all of these cases, even though the artefact is the same, the ends and the specialised knowledge used to reach those ends are very different.

The study of boundary objects dates back to the 1930's, when the field of anthropology started to rely on the study of material artefacts in understanding human cultures. The emphasis was then placed on the role that these objects had for describing non-western cultures rather than on the nature of the objects themselves. In the 1970's, sociology studies, using historical and ethnographic methods, started to explicitly focus on the material artefacts of science and invention to detailed describe the historical evolution and social shaping of science and technology (Latour, 1996). In the field of organisational studies, there was no particular focus on material artefacts until Ed Schein, in 1985, started to examine artefacts as an initial means of understanding an organisation's culture. However, it was in 1989, when Star and Griesemer articulated the concept of boundary objects that it has received considerable attention from organisation and management theorists.

The common denominator of most of these studies lays on the agreement of the important role that boundary objects play in successfully mediating interactions between diverse organisations (Pratt & Rafaeli, 1997). For so, attention had been put on identifying different types of boundary objects, ranging from standardised forms (Star & Griesemer, 1989) to narratives (Bartel & Garud, 2009) and even some authors have conjectured that processes (Wenger, 2000) and knowledge (Carlile, 2004) can serve as boundary objects. For instance, Star and Griesemer (1989) proposed four types of boundary objects: repositories, ideal types (which are a symbolic abstraction or representation), coincident boundaries (which are objects representing different contents to different users but sharing the same boundaries), and standardised forms. Briers and Chua (2001) added another category to Star and Griesemer's original classification, named as visionary objects, which they defined as conceptual objects that have high levels of legitimacy within a particular community and that can evoke similar emotive or affective responses from a wide spectrum of people. Levina and Vaast (2005) offered a more basic classification of boundary objects discriminating between designated boundary objects and boundary objects-in-use. Such distinction drew attention to the fact that certain artefacts may possess characteristics that would apparently make them useful in boundary interaction and yet were not be adopted by the intended users due to their lack of relevance within the joint field of practice (Zduncyk, 2006).

Aside to boundary object types, the literature has distinguished their function in accordance to different contexts (Ewenstein & Whyte, 2009). For example, Yakura (2002) suggested that timelines as temporal boundary objects are interpretively flexible by different groups, and offer closure as an illusion of control over a project. Her analysis of timelines during information system implementation gave a compelling account of how did graphical representations of temporal units operate as a boundary object that remained abstract in use yet was able to reconcile diverse temporal arrangements.

In addition to what the use of boundary objects does in different settings, Carlile (2002, 2004) highlighted that their properties develop in respect to different types of knowledge boundaries (syntactic, semantic and pragmatic) that exist within a project team. The most basic type of knowledge boundary is syntactic, where informational dissimilarities exist. Semantic boundaries are constituted by the interpretive differences between social groups, where meaning is developed from within a unique cultural perspective. And pragmatic boundaries arise from the vested interests held by diverse groups.

Although these studies have emphasised the material aspects of boundary objects, few have investigated the internal dynamics of interacting organisations and the ways that these dynamics shape and are shaped by the use of boundary objects (Gal, 2008). In part, this is because the emergence and use of boundary objects have mostly been examined in a context of relatively stable setting or for short periods of time (Gal et al., 2005). It is important to bear in mind that different people may interact differently with the same boundary object (Ewenstein & Whyte, 2009), possibly leading to different outcomes. And the agency of an object is situated and might change over time and through space (McGivern & Dopson, 2010).

b) Processual Tasks: Mediation

Processual tasks include a host of activities for resolving intra-group conflicts and ensuring that interactions among network members are constructive and productive. These activities involve mediating relational conflicts that are likely to arise; building trust among partners; and ensuring that effective communication is occurring (Ansell & Gash, 2012; Young, 2000). As this study has previously discussed those tasks that resemble more traditional project-management tasks in section 4.1, processual tasks will be considered as those that require more interpersonally oriented skills in order to mediate workplace conflict. Research on mediation falls on this category (Gray, 2008).

Mediation is typically a dynamic, voluntary, informal, unstructured, neutral and morally binding process employed after it becomes apparent that formal procedures and direct negotiation between adversaries will not resolve their dispute efficiently or they would be unable to do so on their own (INTA, 2015). It is identified as relevant process for use in workplaces, especially in the early phases of the network, as it helps parties to resolve interpersonal disputes faster, in a cost-efficient way (Haga, 2009). Based on his status, legitimacy, persuasiveness and process management skills, an impartial third party (mediator) is chosen by the contending parties (Moore, 2003).

The mediator is a member of the network[16] not directly involved in the dispute, with personal and facilitative power (rather them solely relying on his authority) to influence and assist disputants towards a mutually accepted agreement (INTA, 2015). The mediator will not adjudicate on the issues, unless invited to do so by the parties (Wall & Dunne, 2012). The mediator wants to increase up to an optimal level the mutual information held by parties. In such level, he produces the concord of the colliding parties, whereby he withdraws after the effort of creating direct contact between unconnected or quarrelling elements (Obstfeld, 2005). He will try to convert what might initially appear to the parties as a zero-sum relationship into a positive-sum relationship.

Although the mediator is typically responsible for managing the mediation process, there are no standard procedures or fixed rules. Different mediation approaches can work to suit different organisational circumstances, such as (Podro & Suff, 2013):

- Exploring issues, feelings and concerns of all parties;

[16] The literature also discusses the use of both internal and external mediators. Issues like credibility and neutrality may be a challenge for internal mediators, although they may have greater insight into the context of a dispute and potential solutions (Sherman, 2003). Latrielle (2011) reviewed mediation practices and found that the use of external mediators to be more costly, subject to time delays, with lower resolution rates and associated by parties with the formalisation of the dispute. Some studies also refer to managers taking on the role of mediators as having benefits but also inherent risks if managers have some form of power over the outcome or are limited in dealing effectively with the situation due to their continuing relationship with the disputants (Banks & Saundry, 2010).

- Allowing those involved to understand and empathise with the feelings of those they are in conflict with;

- Giving participants insights into their own behaviour and that of others and opening up opportunities for change;

- Encouraging and improving communication, including clarifying misunderstandings and avoiding polarisation and escalation

- Helping people involved to find a solution that both sides feel is fair and offers a solution that favours them;

- Rebuilding relationships using joint problem solving.

Mediation has been in existence and practiced in a variety of forms for centuries (Kenny, 2014), however it has been used in workplace disputes since the 1930s (Herman, 2006). Yet there has been relatively little academic investigation into workplace mediation, with attempts to take theoretical approaches developed by social scientists and modifying them to give some practical value to managers (Banks & Saundry, 2013; Bouchier, 2013). It is in the field of law that mediation, as a form of alternative dispute resolution[17] (ADR), has been commonly studied and employed[18]. ADR refers to a set of practices and techniques aimed at permitting the resolution of

[17] The term dispute resolution is used interchangeably with conflict resolution.
[18] Management studies have more commonly investigated *conflict management* instead of *conflict resolution* methods and strategies. Conflict management refers to the long-term management and control of intractable conflicts. This approach is taken when resolution seems to be impossible, yet something needs to be done. Conflict management aims at making the ongoing conflict more beneficial and less damaging to all sides by minimising the negative outcomes of conflict and promoting its positive aspects with the goal of improving learning in an organisation (Rahim, 2002). Conflict management does not imply the resolution of the conflict. Taking this into consideration and also the fact that this study focuses on the resolution of conflicts that are harmful for the effectiveness and success of innovation networks, it will further investigate conflict resolution instead of conflict management.

legal disputes outside the courts in an informally and confidentially manner. It is normally thought to encompass mediation and arbitration (Mnookin, 1998). Studies on ADR have been very descriptive in analysing the determinants of mediation in a variety of domains and countries. Attention has been given to personal traits like acceptability, credibility, perceived neutrality (Wall & Dunne, 2012); experience (Walker & Hayes, 2009); good listening skills, empathy (Gray, 2008); emotional intelligence (Mareschal, 2002); as well as the ability to gain confidence and establish high levels of empathy and trust within the disputants (Poitras, 2009).

Studies have also focused on the mediation styles practiced by mediators, ranging from problem solving to relational. In terms of general orientation, the main difference between the two approaches to mediation is how a conflict is viewed or conceptualised in the mediator's mind. In problem solving mediation, as its name implies, mediation is a process focused on solving a problem by obtaining a settlement. This pragmatic approach, well expressed in the influential work by Moore (2003), considers that when conflict exists, a problem exists; and a problem exists because of a real or apparent incompatibility of parties' needs or interests.

Therefore, the mediator working within this problem-solving framework will assess the conflict between two parties and assist them in defining their differences in terms of a problem (Spangler, 2013). Through a process of reframing parties' position, the mediator will help parties to find a mutually acceptable, win-win solution for the immediate dispute. All of the mediator's actions are designed to facilitate that outcome. Sometimes the problem-solving mediator acts a bit like an arbitrator proposing a solution for the conflict. However, because his suggestions do not have any binding power, the mediator must try to persuade disputants to go along with his idea. Criticism to this approach is based on the consideration that when mediators practice this model, they focus on information that relates to the problem itself rather than exploring broader issues relating to the parties' identities and relationships.

In the prominent work by R. Bush and J. Folger (2005) on relational mediation, the authors contrasted their perspective on the practice of mediation with the more traditional problem solving approach. They proposed that mediation could affect much deeper changes in people and their interpersonal relationships, beyond just remedying a short-term problem. Under this view, mediation possesses the power to change how people behave not only toward their adversary in a particular conflict, but also in their day-to-day lives thereafter (Spangler, 2003). Thus, the transformative approach to mediation does not seek resolution of the immediate problem, but rather, focuses on parties' interactions, looking for opportunities for empowerment and mutual recognition of the parties involved. This approach, according to Bush and Folger (2005), enables parties to approach their current problem, as well as later problems, with a stronger, yet more open view. By doing so, responsibility for all outcomes squarely on the disputants.

Overall, while the problem solving approach is the most commonly used for workplace disputes (Mareschal, 2002), no mediation style has become predominant. Mediators may use a range of different approaches within the same mediation in the interests of participants, the mediator and the mediation context (INTA, 2014).

c) Cognitive Tasks: Transformational Leaders

Cognitive tasks largely consist of the introducing a new mental model of desired goals and the methods for getting there (Bass et al., 2003). It means that a network orchestrator motivates other network members by aligning their self-concepts and individual aspirations with the larger network mission (Gray, 2008). Studies on transformational leadership fall on this category (Gray, 2008; Young, 2000).

Transformational leadership is leading by motivating in an environment of conflict and change. Simola et al. (2012) defined transformational leadership as a type of leadership in which interactions among interested parties are organised around a collective purpose in such a way that transform, motivate and enhance the actions and ethical aspirations of followers. Through a variety of mechanisms, followers feel trust, admiration, loyalty and respect for leaders and are motivated to do more than they thought they could, or would do (Behery, 2008). These mechanisms include connecting the follower's sense of identity and self to the network mission and the collective identity of the organisation; challenging followers to take greater ownership for their work; highlighting important priorities; promoting cooperation and harmony; and so forth (Bass et al., 2003). Therefore, theoretically, it has been said that transformational leadership enhances followers' performance by maximising their level the mutual information between the knowledge sets held by parties (Yukl, 1998).

What sets the transformational leadership approach apart from many other leadership styles[19] is the leader's ability to influence others to follow them through a vision and frame that binds people to each other. Transformational leaders need to be able to envision how various disciplines may overlap in constructive ways that could generate scientific breakthroughs and new understandings in a specific problem area. Through visioning, leaders should help participants to break out of past mindsets and open up the content of new agendas (Gray, 2008). It can be done through content level

[19] Leadership is here defined as a process whereby one individual influences a group of individuals to achieve a common goal. To be an effective leader, the manager must influence his associates in a positive way to reach the goals of the organisation (Northouse, 2001).

(by building a common understanding of a problem under consideration and imagining the desired futures that network members could pursue) and through encouraging the process of working collaboratively (by employing attributes like patience, tolerance, openness, listening and conflict-resolution capability) (Gray, 2008).

Nevertheless, transformational leaders must have more than just a vision. They have also to know which path to follow in order to attend it. To persuade followers to accept and implement change, transformational leaders engage in frame alignment (House & Podsakoff, 1994). Framing is a powerful tool by which leaders influence how others see and interpret reality through the (re) construction of a mental model that creates an opening in which previously unthinkable can become a reality. While visioning encourages members to reframe their extant conceptual frameworks, framing requires the suspension of current assumptions and the introduction of a vision that turns participants' current mindset upside down, provides sense-making for team members, capture their beliefs and abilities, and motivates them to work productively together (Gray, 2008).

Framing must also contend with the problem of language, which arises because the same words are used in quite different ways in different disciplines. By recognising this potential problem, transformational leaders can foster the development of a common language that is meaningful for network members along with the development of respect for each contributor's models and methods (Gray, 2008). Leaders can use language to influence follower's perceptions of the work, the meaning of events, beliefs about causes and consequences, and visions of the future. These frame shifts can result from the introduction of a new metaphor, from the adoption of a new gestalt, from moving up or down a level of abstraction in thinking, or from deciphering meaning that transcends two cultures (Gray, 2008).

Transformational leaders can be found in various levels and groups throughout the organisation. According to Wang and Howell (2010), in the first instance, the aim is to understand employees' abilities, skills, and needs, and offer them mentoring to overcome any weaknesses. At the group level, transformational leadership develops common values and beliefs, and inspires unity in order to reach group goals. In this situation, leaders behave equally towards all members of the organisation. In both levels, the likelihood of an individual displaying transformational leadership skills depends on his personality traits, charisma and ability to influence and make a change on the followers through example, articulation of an energising vision and challenging goals (Casimir et al., 2013). The leader thus can be said to be a model of integrity and fairness, encouraging people and providing support and recognition, stirring the emotions and passions of people, and getting people to look beyond their own self-interest and reaching for higher and clearer goals (Warrick, 2011). To put it sharply, the success of the transformational leaders is defined by their ability to offer other something that goes beyond self-interest; they provide followers with an inspiring mission and vision and give them a collective identity (Bass, 1990).

Since the first studies on transformational leadership, many researchers have been dedicating their analysis to the characteristics and behaviours of such leaders, particularly for differentiating between transactional leadership[20] and transformational leadership. Burns (1978), who first introduced the concept of transforming leadership in his descriptive research on political leaders, stated that such moral leadership emerges

[20] Transactional leadership style is more concerned with maintaining the normal flow of operations. Such leaders use disciplinary power and an array of incentives to motivate employees to perform at their best. It is a leadership style reactive or responsive to problems as they arise (Bass, 1990). Transformational leadership, on the other side, goes beyond managing day-to-day operations. It challenges the status quo, focusing on team building, motivation and engaging followers with a vision of the future. It is a proactive leadership style that addresses issues before they become problematic (Hater & Bernard, 1988).

from and always returns to the fundamental wants and needs, aspirations and values of the followers. As so, it does not depend on the circumstances, but rather on the attitudes, values and actions of the leader. Another researcher, Bernard Bass (1990), extended the work of Burns and presented a formal transformational leadership theory. Through a questionnaire - Multifactor Leadership Questionnaire –, subordinates described how their superiors act when they are "leading". Such tool allowed him to identify individuals who exhibit transformational as well as other more traditional leadership behaviours, how transformational leadership could be measured, as well as how it could impact followers' motivation and performance.

Later on, Bass and Avolio (1993) grouped the qualities distinguishing transformational leadership by four patterns of behaviour known in the literature as the Four I's: idealised influence, inspirational motivation, individual consideration, and intellectual stimulation. Idealised influence (or charisma) refers to the leader being a role model for followers in terms of high ethical behaviour, instil pride, gain respect and trust. Inspirational motivation is related to the way in which leaders are capable of articulating a vision that is appealing and inspiring to followers. Individualised consideration indicates to what extent the leader attends to each follower's concerns and needs, and acts as a mentor or coach to them. And intellectual stimulation refers to the degree to which the leader challenges assumptions, takes risks, solicits followers' ideas and encourages creativity in them.

Although numerous studies indicate how transformational leader behaviour can generate substantial organisational rewards (Bass, 1990; House & Podsakoff, 1994), such leadership style also has several weaknesses that have been the subject of numerous critiques (Yukl, 1998). The Four I's, for example, each pattern of behaviour appears to overlap with one another, while other characteristics seems to be shared by other conceptualisations of leadership (Tracey & Hinkin, 1998). Brayman (1992) suggested that transformational leadership appears to be more a set of personality traits rather than a series of behaviours that leaders can learn and develop. Although transformational leadership has enjoyed exceptional empirical support, many have questioned the practical application of Bass's construct for everyday, frontline leaders and managers. Some scholars have suggested the need to examine it within a situational context. Other key criticism rests on the consideration that transformational leadership has the potential for the abuse of power (Barnett et al., 2001). Moreover, some followers may have dependent characters and form strong and unfortunate bonds with their leaders, undermining values as shared decision-making and consensus (Marion & Gonzales, 2014).

Despite all the criticism, transformational leadership are yet useful to be applied in organisations as it offers a general way of thinking about leadership practices through vision, inspiration, innovation and individual concern (Lee, 2014). Becoming an effective transformational leader is a developing process and depends greatly on the personal qualities of the leader.

From the previous discussion on the different types of network orchestrators, it is possible to notice that the suboptimal connectivity between innovation network participants may lead to the informal assignation of intermediaries (Dalziel, 2010; Orlikowski, 2002; Ottani and Bou, 2009b; Parjanen et al., 2011). Indeed, specialisation leads to different thought worlds (Dougherty, 1992) with different perceptions and situated representations (Boland & Tenkasi, 1995) that in turn create communication barriers, failures of interpretation and problems of coordination (Boisot, 1995; Ratcheva, 2005). These barriers and difficulties are often observed when partners lack deep ties (Hansen, 1999), shared processes for integrating their ideas (Okhuysen & Eisenhardt, 2002), and previous common experiences (Tucker et al., 2007) that could facilitate knowledge integration (Majchraz et al., 2012) and innovation. These difficulties of managing and combining knowledge that is decentralised throughout the network, of harmonising dissimilar cognitive frameworks and of building a shared understanding, can become major barriers to successful collaborations in innovation networks (OECD, 2001).

The informal assignation of network orchestrators becomes then of central importance to help innovation networks enhance their performance by mediating relational capabilities, overcoming cognitive boundaries and connecting ideas for the generation of innovation (Burt, 2004; Nooteboom, 2006; Obstfeld, 2005). The conceptual distinctions among different types of network orchestrators presented in this study might help to shed light in the analysis of network coordination mechanisms. Ensuring an environment where networks members are confortable to work with different perspectives and through disagreements, then, becomes critically important (Popp et al., 2014). Managerial implications can be found in the importance to align and match network type and coordination type (Ritala et al., 2012). This will be discussed in the next section.

5. Managing and Orchestrating Innovation Networks – A Hybrid Approach to Coordination

There is an inherent need for certain coordination in innovation networks (Gardet & Mothe, 2012). However, coordination needs to be carefully planned and approached so that the network can achieve adequate levels of freedom to support innovation (Hurmelinna-Laukkanen et al., 2012). Making sure that this happens is challenging. Since the premises of traditional or intra-firm innovation management may not apply to innovation networks, a new approach is needed for such network coordination (Heidenreich et al., 2014).

As previously mentioned, different studies (e.g. Gray, 2008; Hurmelinna-Laukkanen et al., 2014; Kleinbaum et al., 2008; Reger & Gerybadze, 1997) have emphasised the need of both managing and orchestrating innovation networks through the use of both formal and informal coordination mechanisms. These coordination mechanisms are by no means mutually exclusive, but more likely complementary and their relative importance varies depending on the attributes and the phase of development of the innovation network (Ritala et al., 2012). Rizova (2006) noted that reinforcing innovation networks with the help of formal organisational structures might be needed for successful innovation. Similarly, while examining new product development and teams, Bonner et al. (2002) observed that leader-imposed process controls are not that good for project success if implemented during the development of the projects, but that early and interactive decision-making on control mechanisms is important. In this case, traditional management seems to be called in the early stages, and orchestration is needed as the project gets started.

The use of a hybrid coordination process, which combines formal and informal mechanisms, may actually provide a viable approach to innovation networks (Hurmelinna-Laukkanen et al., 2014). The novelty of these mechanisms lies in the fact that they cut across organisational structure and hierarchy, and overlaps them (Reger & Gerybadze, 1997). In classical researches in organisation theory and in some contemporary theorising, formal structure reigns supreme; in more behaviourally oriented work with roots in sociology and social psychology, informal structure occupies a central position; and in a more recent stream of the literature, the image is one of a federation of organisational members woven together in lateral and fluid communication structures (Kleinbaum et al., 2008). Just like different types of networks form a continuum, the means of coordination in them can be more or less strict and clearly outlined.

The problem is, however, that existing literature has not addressed thoroughly in which situations different forms of coordination would function best (Ritala et al., 2012) nor the potential impact of different dimensions on coordination mechanisms and how are they implemented (Gardet & Mothe, 2011). It has been shown that innovation networks come in different sizes and shapes, and this surely influences the need of coordination and its implementation (Möller & Rajala, 2007). Although there are numerous dimensions that can affect collaboration[21], and it was not possible to be exhaustive, this study follows the most representative and widely studied dimensions. The network purpose and stage of development (Möller and Rajala, 2007; Powell & Grodal, 2005), its degree of formalisation (Grandori and Soda, 1995), the characteristics of involved actors (heterogeneity vs. homogeneity) (Cantner & Graf, 2006; Mattes, 2012), their prior exchange relations (if they had or not previous relations) (Gardet &

[21] External factors (such as industry or economic context) were not considered in this study, even though their influence over network issues cannot be denied.

Mothe, 2011), and conflict type (Das & Teng, 2011; Wall & Dunne, 2012), all might have an effect on the possibilities to rely on certain forms of coordination as well as the efficiency of the coordination (Ritala et al., 2012).

Network purpose and evolution. Innovation networks are not alike. Among the many characteristics that make them differ, the level of determination of innovation networks (e.g. how determined/purposeful the network is towards certain objectives) is the most interesting one, since it enables the investigation of their evolution and change (Powell & Grodal, 2005). In one end, innovation activities are the based on basic research, with loosely connect and diverse actors such as universities, institutions and company-based research organisations. These networks typically generate radical innovations and influence emerging business and technological fields (Möller & Rajala, 2007). The knowledge held in such innovation networks is often highly tacit, individual and widely dispersed, and there is a high level of ambiguity (Ritala et al., 2012). At another stream is a more target-oriented innovation network, focusing on establishing a dominant technology design in an emerging field of business. Their existence is typically justified by the fact that it is difficult for one firm to achieve a dominant design on its own. These networks typically involve collaborating and competing companies, together with other stakeholders such as officials and financial institutions (Ritala et al., 2012).

Finally, innovation networks can aim at creating business applications with commercial potential from technological innovations. A hub company generally drives these networks, with complementary technology producers as well as pilot customers, reflecting the tighter connection with actual commercialisation. Moreover, the knowledge utilised becomes more explicit and codifiable (Möller & Rajala, 2007; Ritala et al., 2012). Although innovation networks are settled for filling a certain purpose, innovation networks can evolve from one stage to another when the technologies and business models develop from highly explorative basic research to more exploitative commercially specifiable forms, as their goals are modified or realised, as relationships are activated and deactivated, as expectations change and adaptations are made accordingly.

Degree of formalisation. Formalisation is the extent to which rules and procedures are followed in an organisation. Contractual theories mainly suggest two measures for determining the degree of formalisation: the existence (or not) of a contract, as well as of formal exchange mechanism. These include standardised procedures, technical reports, budgeting and planning, as well as confidentiality agreements and contracts. Informal exchange mechanisms, on the contrary, include implicit and verbal mechanisms, such as the creation of joint teams, seminars, meetings, staff transfers, as well as decision-making methods (Gardet & Mothe, 2011). Though informal modes are less costly and reduce the risk of conflict, they also require more time to implement (Das & Teng, 2002). In assessing the degree of formalisation, one needs to use care. In some organisations many rules are codified in huge manuals, but no one pays attention to them. In others, little is written down, but rules are informally understood and followed. This element varies greatly across innovation networks.

Characteristics of network members. It refers to the level of heterogeneity or homogeneity between network members. As previously discussed in section 3.1, different dimensions of proximity (geographical, social, organisational, institutional and cognitive) can affect collaboration in different ways (Boschma & Frenken, 2010; Knoben & Oerlemans, 2006). They can interact over time in a dynamic process, strengthening or weakening, substituting or overlapping each other's effect at a certain point in time.

Prior relations. Innovation networks can be created either with partners with no prior relations (unfamiliar) or with previous acquaintance (familiar). With unfamiliar partners, contractual agreements and formal mechanisms are introduced in order to deter opportunistic behaviour. Due to a lack of mutual understanding and trust, partners may feel uncertain about the future of their relation (Dyer & Singh, 1998). Familiar partners develop a better understanding of their partners' procedures, management systems and cultures. Such previous collaborative relations can be helpful as it enhances mutual trust between partners, creates mutual knowledge of partners' procedure, mitigates conflicts and may reduce the need of contractual safeguards (Gardet & Mothe, 2011; Gulati, 1995).

Conflict type. As previously seen in section 5, innovation networks partners have their own individual interests that are not necessarily congruent with their partners (Das & Teng, 2001). Conflicts may arise for several reasons, and this will affect the cooperation in different ways (Mooney et al., 2007). Four main conflict types were previously discussed: cognitive conflict, which occurs when the ideas and thoughts between individuals are incompatible; affective conflict, which emerges when the feelings and emotions between individuals are incompatible; administrative conflict, which occurs when people differ over the process to use for resolving a particular matter; and goal conflict, which involves inconsistencies between individual's or group's goal. Das and Teng (2002) underlined the importance of taking this dimension into account when analysing how cooperation agreements function and how they are coordinated.

Thus, depending on these dimensions, the means of coordination in innovation networks may vary accordingly. In line with what has been discussed in this study, two coordination mechanisms may be employed: coordination by commanding (through the use of formal mechanisms) and coordination by enabling (through informal mechanisms such as broker and boundary object, mediator, and transformational leader). On one side, formal coordination mechanisms are authority-based coordination tools, defined and decided in a formal structured fashion (Molenveld & Verhoest, 2014). Decision-making bodies and input processes are designed to ensure coordination by the power of command. These mechanisms are more control-oriented and less interactive, and mainly involve written communication of formal rules for action (Hurmelinna-Laukkanen et al., 2014). On the other side, informal coordination mechanisms are based on negotiation and mutual adjustment. These person-oriented mechanisms are important for obtaining mutual understanding and commitment since highly interactive negotiations occur at group level (Norppa, 2014).

These coordination mechanisms are by no means mutually exclusive, but more likely simultaneous, and their relative importance varies depending on the attributes and the phase of development of the innovation network (Hurmelinna-Laukkanen et al., 2014; Möller & Rajala, 2007; Tikkanen & Renko, 2006). In her in-depth study of six R&D projects, Rizova (2006) noted that reinforcing informal social networks with the help of formal organisational structures might be needed for successful innovation. According to Hurmelinna-Laukkanen et al. (2014) in the case of networks aiming at creating technological standard and commercial applications, orchestration and management both have their distinct roles in coordination, where the former is used throughout the network to communicate vision and build social capital, and the latter is used to coordinate those phases that reside closer to commercialisation of innovations.

The more complex a strategy, the more coordination effort is needed, which results in the implementation of both formal and informal mechanisms (Ebner, 2013). Because of the issues and paradoxes of innovation networks, it is therefore difficult to give an ex ante description of a coordination mechanism (Gardet & Mothe, 2011). Nevertheless, achieving adequate levels of network management and orchestration require careful alignment so that multiple actors can be efficiently connected. This issue will be illustrated and further discussed in the following chapters.

Chapter 3

RESEARCH DESIGN AND METHODOLOGY

The first part of this chapter describes the research's design, including research problem, research questions, units and levels of analysis. Thereafter, the research methodology is explained, in particular the sampling, data collection and data analysis. Since the results of the pilot study were used to define the subsequent qualitative phase of this study, a description of the pilot study and its findings will be presented at this chapter.

1. Research Design

1.1. Research Problem and Objectives

As discussed in the theoretical chapter, prior researches suggest that coordinating innovation networks is of considerable importance as firms must interact with each other and manage these relationships to develop innovation projects (Gardet & Mothe, 2011). Nevertheless, innovation networks are difficult to coordinate because of their managerial complexity (Park & Ungson, 2001), the dynamic and ambiguous nature of collaborations (Huxham, 2003). Moreover, even the form that coordination takes is seen as paradoxical in the literature. According to the existing knowledge, depending on the characteristics of the innovation network, coordination can take various forms (Dhanaraj & Parkhe, 2006; Möller & Rajala, 2007).

Yet, there have been fewer studies that are able to explain how these networks are coordinated (Norppa, 2014). The existing literature does not really explicitly state in which situations different forms of coordination would function best (Ritala et al., 2012). This lack of research is even more surprising when considering that interorganisational networks fail due to poor coordination (Meyer, 1999). Besides, few empirical studies have addressed the internal operations of innovation networks (Ahuja, 2000; Dhanaraj & Parkhe, 2006). Most researches have focused on innovation networks from the point view of their creation, structure, or the factors leading to their collapse (Goerzen, 2007). Furthermore, research on coordination mechanisms has essentially addressed these mechanisms individually (Gardet & Mothe, 2011). And finally, little study has taken a further step to analyse the details of different implementations of network coordination mechanisms. Therefore, it is sensible to analyse the network coordination phenomenon in more detail in this unexplored context.

To shed light on these research gaps, the main research objective of this study is to investigate the role of coordination in innovation networks so as to facilitate innovation. This will be done by analysing the coordination mechanisms that are created within two different innovation networks to overcome diversity and conflict, the manner in which they are implemented and their evolution in the course of the cooperative innovation process. Hence, drawing on the study of practice as a reference, the main research question is: ***how does diversity and conflicts in innovation networks affect the coordination mechanisms employed.***

Secondary questions deriving from the central problem and research question are presented in table 7.

Table 7: The Main Research Question and Secondary Questions

How does diversity and conflicts in innovation networks affect the coordination mechanisms employed?
• What are the challenges in network coordination? • What are the coordination mechanisms that can be used to overcome internal conflicts and help coordinating innovation networks? • How could diversity be managed in order to avoid conflicts? • What are the similarities and/or differences of network coordination mechanisms in innovation networks created for different purposes and with different structures?

Source: own author

1.2. Rationale and Significance

This research broaches a key, underexplored issue in network coordination and innovation, with implications for researchers in network coordination, strategic management, and interorganisational relations. It aims to contribute to these fields by offering new insights and empirical evidence on network coordination practise. The novelty of this study's approach lies in explicating how does network coordination mechanisms of management and orchestration change depending on the characteristics of innovation network and on its stage of development. The research intends to provide researches with a better understanding of the theory of network coordination as it is applied in the environment of innovation networks, and of the theory of interorganisational network relations as it is examined from a qualitative and exploratory point of view.

At the same time, given the practical implications of both the research question and the field in which this research is part of, this study may also make a managerial contribution by providing insights on the role and mechanisms of network coordination for managers of innovation networks, what will allow them to increase the process effectiveness, to ensure that the network evolves in the desired directions, and in considering the role of their companies in this development.

1.3. Unit and Level of Analysis

The unit of analysis of this study, the innovation network, is consistent with the research question (Yin, 2002). The level of analysis is broadly interorganisational. However, it varies because interaction between actors in network coordination may occur at different interorganisational levels. First, interaction may occur between the network coordinating unit and the organisational members. Second, interaction may occur among network members. Third, interaction may occur between the network as a whole, via the coordinating unit or a member on behalf of the network, and external actors. This research focuses, then, on the following level of analysis: on the interaction between the coordinating unit and the members. This level of analysis deals with the internal coordination of the innovation network.

It was discarded looking explicitly at inter-member interactions, since covering these interactions qualitatively is not realistic give the time and resources available, and the number of organisations in these coalitions (ranging from 27 to over 175)[22]. Nevertheless, it was able to capture some inter-members interactions by focusing on coordinating unit-member interaction as well as during observation of network-wide events.

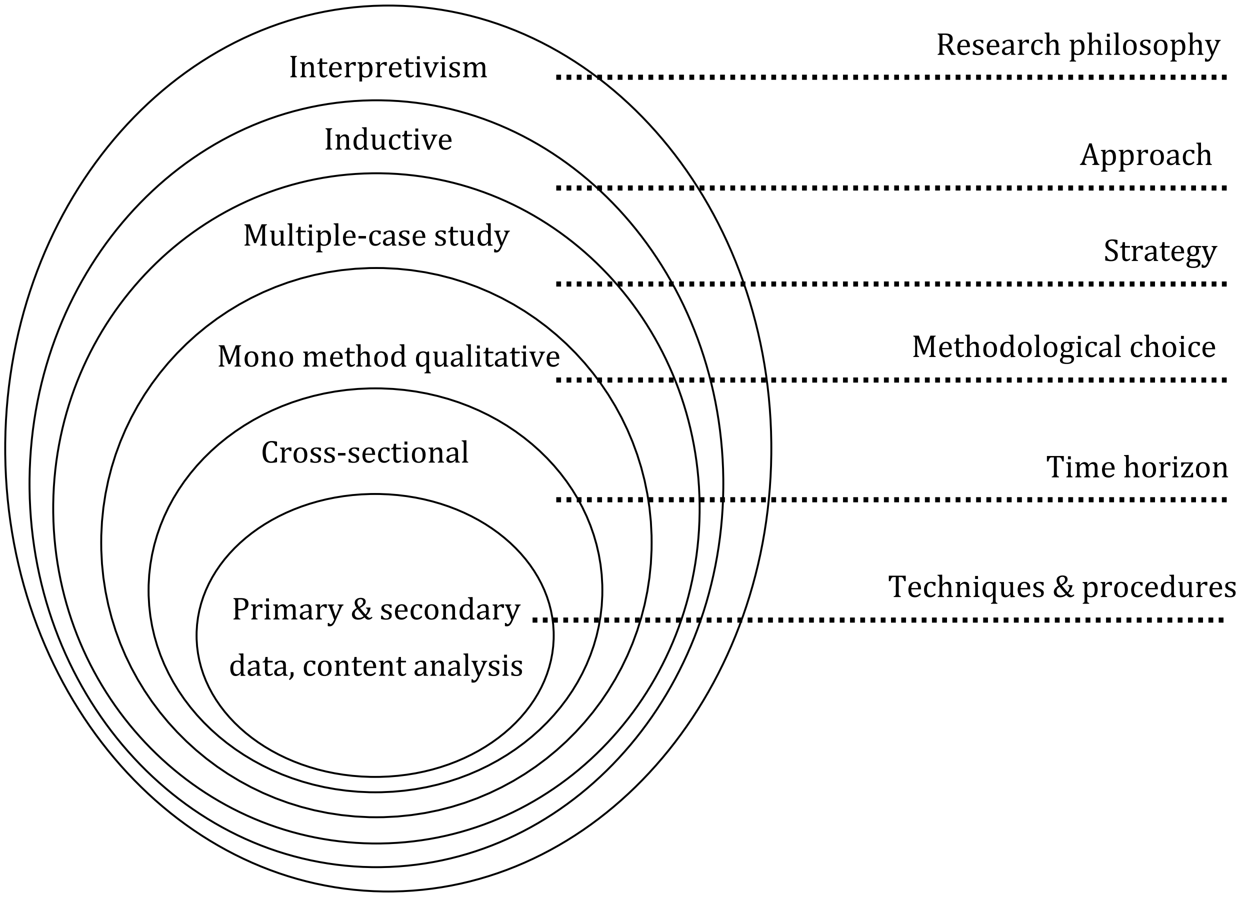
2. Research Approach and Methodology

2.1. Research Strategy

The research approach of this study is presented in figure 10 below.

[22] This could have been captured using social network analysis but it would not have informed the research question and secondary questions.

Fig. 10: Research Approach



Source: Based on Norppa (2014)

The research philosophy of this study is interpretivist. The nature of reality is seen as socially constructed, subjective and subject to change as the world of business and management is far too complex to be theorised only by fixed laws (Saunders et al., 2009). This study is approached from the inductive research perspective, which means that there is a continuous interaction between theory and the empirical data throughout the research process (Dubois & Gadde, 2002). Since this research is about a new and debated topic, it is approached inductively by generating data, analysing and reflecting upon what the theoretical themes and data are suggesting. The existing literature on the research topic was used to formulate the research question, objectives, and theoretical framework, and to guide and organise data collection and analysis. However, space for the occurrence of new finding is left as well for generalisations deriving from data. Therefore, it can be said that the research moves from theory to data and vice versa, or in other words, adopts an inductive approach.

Given the complex, dynamic, innovative, under-researched character of the topic of this research and also the incipient and fragmented nature of the field of interorganisational network relations, a qualitative exploratory study is the most appropriate research methodology to be employed (Kenis & Oerlemans, 2008; Saunders et al., 2009). The strategy of the research is the multiple-case study method. A multiple-case study enables the researcher to explore differences within and between cases, to "*investigate a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident*" (Yin, 2002:13). Indeed, the research took place with real practitioners in their actual professional environments. On the other hand, the fact of being an instrumental case study is coherent with the study objectives as it aims to provide insight into an issue. Therefore, the case is of secondary interest and it plays a supportive role because it allows us to understand something else (Stake, 1995). Two innovation networks were selected for this research in order to be able to compare the results of the study in different contexts.

The methodical choice of this study is mono method qualitative. Qualitative research seeks to understand a phenomenon in context-specific settings (Golafshani, 2003) and it is defined as any kind of research that uses data or produces findings that are not quantifiable or statistical (Strauss & Corbin, 1998). Moreover, qualitative research is used as a synonym for any data collection technique or data analysis procedure that produces or uses non-numerical data. Data is based on meanings expressed through words and the results are collected in non-standardised data requiring classification into categories, and the data analysis is conducted through the use of conceptualisation (Saunders, et al., 2009). Besides, field study was conducted in a cross-sectional manner. Cross-sectional research is best defined as the study of a particular phenomenon at a particular time. In this case, the coordination of innovation networks was researched at the time conducting the research.

For the purposes of this research, primary and secondary data was obtained from different sources of evidence, such as observation, semi-structured interviews, written documentation and archival records. The interviews were recorded, and subsequently transcribed and analysed by using content analysis method. A more detailed description of data collection methods and phases will be discussed in the following sections.

This research involved a sequence of steps. They encompass: a literature review; a pilot study; an overall plan for the design of the research; data collection, analysis and validation. Although the phases involved in conducting research are usually explained sequentially, one must stress that this is an interactive process. This means that data is not first collected and then analyses. On the contrary, data is collected and analysed at the same time. It is therefore cyclical research (Ambert et al., 1995). In the same way, the outcomes and results of this research were validated during the study not only by the members of the innovation networks under study[23], but also by the academic

[23] When negotiating access into the two innovation networks for data collection, it was presented this study's motivation; objectives and expected impacts that could hereafter help on their management. It was agreed that final results would be internally presented and made available for them. Besides, in one of the innovation networks – KIC InnoEnergy – data collection would be part of an internal research project, which objective was to inquire how different coordination mechanisms could be used to ensure effective collaborations that would lead into desired innovations.

community with papers presented at international congresses and academic workshops[24].

2.2. Overview of the Information Collected

As mentioned previously, data was collected through different sources of evidence, which are summarised in Table 8.

Data on each of the two innovation networks was collected through the analysis of written documentation (e.g. administrative documents and previous studies on these networks) and archival records (e.g. organisational charts, internal policies and procedures). Besides interviews with practitioners, participant and direct observation were also employed, especially for gathering data on organisational culture, the diversity of network members and internal conflicts.

[24] During the development of this study, at different investigation phases, results were presented in different academic peer reviewed conferences. These conferences were: EGOS (European Group for Organisation Studies), OLKC (International Conference on Organisational Learning, Knowledge and Capabilities), Strategic Management Society Special Conference; ESADE-HEC Symposium on Transversal Topics; Conference Knowledge for Growth. Presentations, with a time span of about 10 to 20 minutes, were followed by a discussion with academics.

Table 8: Areas of Information and Sources

Areas of Information	Secondary Data (internal documents, website, articles, archival records, etc.)	Direct Observation	Participant Observation	Interviews
Background information on innovation network				
• History and structure	✔			
• Org. culture	✔	✔	✔	✔
• Diversity of members	✔	✔	✔	✔
Internal Conflicts		✔	✔	✔
Understanding practice: coordination by commanding (management)	✔			✔
Understanding practice: coordination by enabling (orchestration)		✔	✔	✔
Use of boundary objects as a coordinating tool		✔	✔	✔

Source: own author

In the one hand, in order to understand how coordination by commanding was employed in practice, secondary data was relevant. Administrative documents, and archival records on their processes (e.g. process manuals, organisational charts, procedures) were used in understanding the elementary information about practice. Finally, interviews with practitioners helped to go further on the understanding of their internal operations. On the other hand, to understand how coordination by enabling was conducted in practice, (participant and direct) observation was especially relevant.

Practitioners were observed in relevant events in their practice (e.g. working meetings, in-company training). Participant observation was relevant as the researcher played the role of a network member, giving the opportunity to understand their practise from within. At the same time, seen as a peer, by other network members in these events, the researcher had the opportunity to collect data from informal conversations with members. The interviews were vehicles to capture aspects of network management and to go further on the understanding aspects previously seen in the observation phase. In this sense, the research transitioned from individual to network (micro-macro) but, in doing so, it is not assumed that the network is merely the aggregation of individuals nor that the network level phenomena are always predicted, perceived, or intended by individuals (Saz-Carranza, 2012).

Data on how different artefacts are articulated in practise to become a boundary object was collected through (direct and participant) observation and interviews with practitioners.

In general, all meetings were taped. Data from (direct and participant) observation was also collected through field notes (only in one of the innovation network in the study). All interviews were also taped and transcribed. Participants in the study were guaranteed confidentiality. In fact, at the beginning of each interview a short explanation of the objective of the study was given. Participants were also assured that the recorded material as well as taped meetings would not be publicised, expect for academic and research purposes, and that their names would not be cited.

2.3. Plan and Methods of Data Collection

The data collection methods included the following steps:

- Literature Review and First Research Proposal
- Pilot Study
- Selection of Study Sites and Units
- Document and Archival Records Analysis
- Observation
- Researcher's Journal
- Interviews with Practitioners

Each of the above mentioned steps are going to be discussed separately in the following sections. Although the literature review and the first research proposal do not constitute any data collection method, they should be mentioned as they encompass the first stages of the study and influence the data collection process.

2.3.1. Literature Review and First Research Proposal

The literature review has been a rich and ongoing process of intellectual research. As previously mentioned, the cyclical style of this research has affected the literature review as it has been an ongoing process of study from beginning to end, playing different roles at different stages.

Initially, it allowed the field of study to be framed, which was presented and defended in an official examination (Master of Research)[25] in July 2008. Subsequently, the advancement of the literature review helped to start drawing up the initial research questions and also gave rise to a first research proposal, which was presented and defended in an official examination (PhD Research Proposal)[26] in July 2009. On passing this academic assessment, the tribunal confirmed that the research proposal – including the research methodology – was sufficiently sound for the field analysis to begin.

During the course of the study and while data was being gathered and analysed, literature helped to understand empirical gaps that had previously received little attention and to redefine and refine this intellectual framework, paying special attention to the ongoing contributions in the field. Furthermore, participation in congresses, in research groups and teaching on the topic also provided opportunities for this intellectual enhancement.

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[25] Through a comprehensive approach, this dissertation ("Networks: A Journey Through its Evolution – Schools, Contents and Issues") intended to review the network literature by highlighting the relative strengths and differences of disparate characterisations of networks, stressing theoretical gaps and suggesting points for further developments. By doing so, the purpose was to develop an encompassing perception about network, its structure, relations and inner contradictions, analysing the concept since its beginning until the current stage to then pose new queries, discuss current issues and existing gaps, find compelling points for further considerations and propose some basis for subsequent works on a more in-depth analysis of the network phenomenon.

[26] The first PhD Research Proposal ("Knowledge Transfer Process in Innovation Networks: The Challenge of a Socio-Cognitive Approach") was an initial reflection on the empirical gaps in the field of interorganisational innovation networks. On that occasion, it was identified the need of an intermediary (e.g. broker) to help bridging different knowledge domains and to bond network members for a more effective and efficient transfer of knowledge, that would lead into successful innovations. Questions like how do relational and cognitive dimensions affect/ influence the process of knowledge transfer orchestrated by intermediaries in innovation networks; what is the role of intermediaries in this network process; and, what tools and mechanism are used to overcome internal network challenges were formulated.

2.3.2. Pilot Study

Before focusing on the empirical field, a pilot study was run from February 2008 to July 2009. This pilot research was conducted in order to accomplish a series of objectives: to analyse to what extent the research problem could be studied, as there is little empirical research into the topic; to assess the collection methods; to test the quality of data which could be gathered; and to help to redefine and complement the research objectives.

In order to facilitate this stage, it was decided to collect data in an easily accessible innovation network. Access for conducting research was granted as researchers participated in the GRACO Research Group[27], one of the partners of the innovation network in question. Besides, this innovation network was selected as the pilot case due to the possibility of analysing this innovation network since its inception as well as having access to the network as a whole, what allowed focusing on the impact of coordination mechanisms at the network level. Furthermore, the great diversity of network members fostered a highly complex collaborative environment, what made this innovation network a relevant and interesting case to analyse if the coordination mechanisms employed helped to lessen or to overcome difficulties and obstacles that rose in the network.

The pilot case was the SUCCESS Project (Searching for Unprecedented Cooperation on Climate and Energy to Ensure Sustainability). This was a pilot project

[27] The GRACO Research Group (Grup de Recerca en Aprenentatge i Coneixement en les Organitzacions) was one of ESADE Research Group. Researchers conducted investigations in the following areas: research and innovation management; knowledge in organisations; team learning and communication; and networks and interorganisational relations.

that, together with other three pilot projects[28], was funded by the European Commission in an attempt to establish new efficient and effective structures of collaboration between science and industry. It was observed that the European innovation policy – as traditionally designed – had not been as decisive as expected and that the investment in research had not automatically lead to innovation. The European Commission (EC) envisioned that it was high time for a real change of mindset, where the human capital was put back at the centre of innovation and that the new governance schemes would maximise the use of available resources and increase in turning R&D (research and development) results into commercial opportunities. A first step towards this change was the creation of these four pilot projects.

With a budget of around € 1 million in funding, The SUCCESS Project ran from December 2007 until November 2009. The field of sustainable energy and climate change was the underlying subject. The strategic objective of the project was to design, implement and test a new model of coordinating large-scale cooperation between science and industry so as to maintain the competitiveness of Europe in the long term. The project's goal was not the technical or scientific solution of a given problem in the fields of energy and climate change, but rather the creation of cooperative structures that would facilitate knowledge sharing and technology transfer.

The SUCCESS Project was formed by eighteen partners[29] and twenty-eight associated network partners[30] from twelve countries and belonging to large-scale

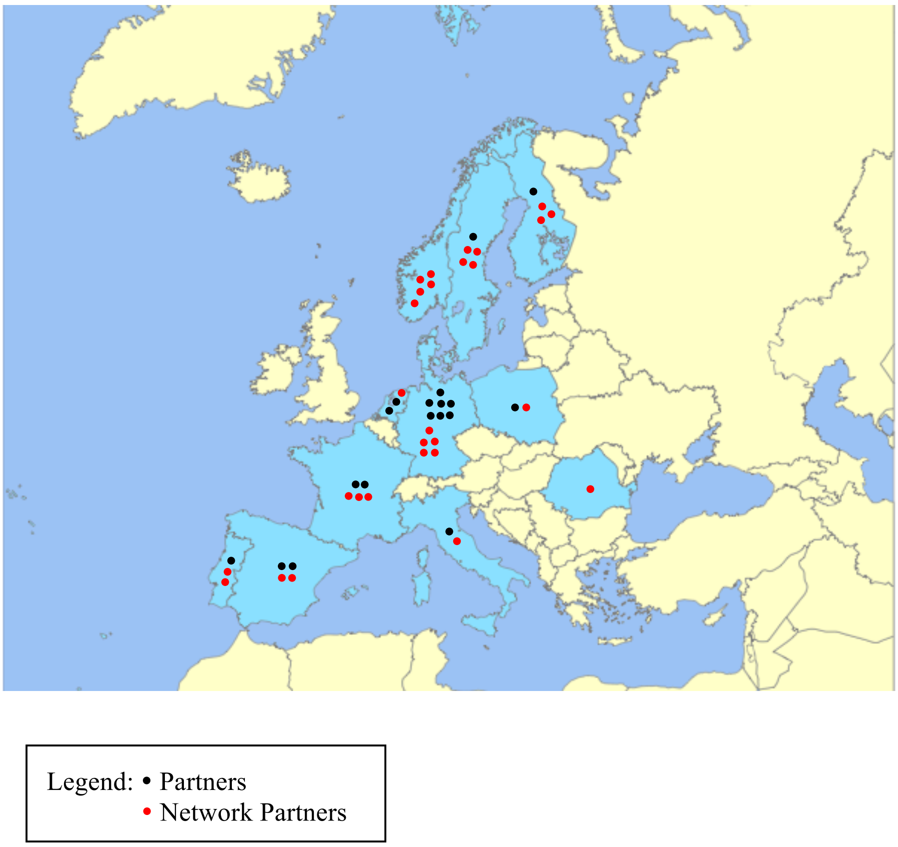
[28] Aside from The SUCCESS Project, there were three other pilot projects: BRIDGE (Bridging Biomaterial Research Excellence between Industry and Academia Across Europe), ComplexEIT (Complexity from Nano to Large Electronic Systems), and GAST (Green and Safe Road Transportation).

[29] Partners were considered as those network members that actively participated in the project, making contributions in terms of performing activities, producing deliverables, and providing human, infrastructural and financial resources.

[30] The role of network partners was on sharing their experience in the energy and climate change sectors. These members participated in workshops, advisory boards and congresses.

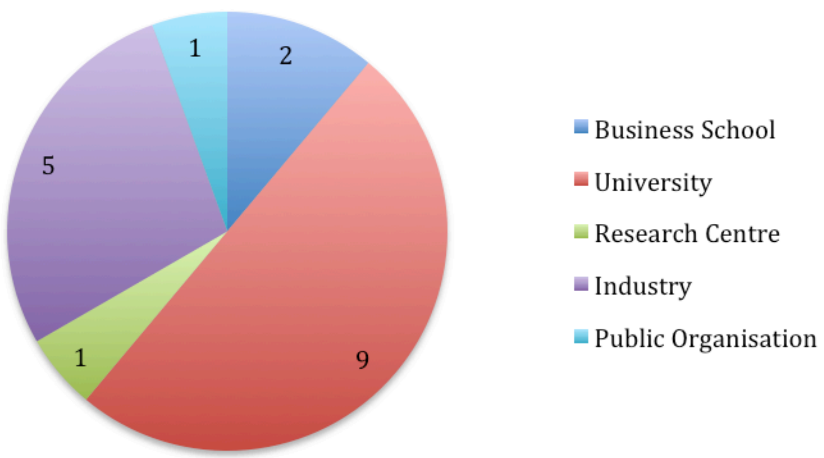
research institutions, universities, industry, public organisations, and network association with high innovation potential, as represented in Figures 11, 12 and 13. Membership was based on acquaintance; these partners (with few exceptions) had previously worked together in other collaborative researches. A consortium agreement was signed between network partners and the European Commission, where it was defined the obligations as well as the rights for each contractors. Tasks, relevant resources, exit strategy and commitments of all partners were all settled in this document.

Fig. 11: The SUCCESS Project – Partners and Countries



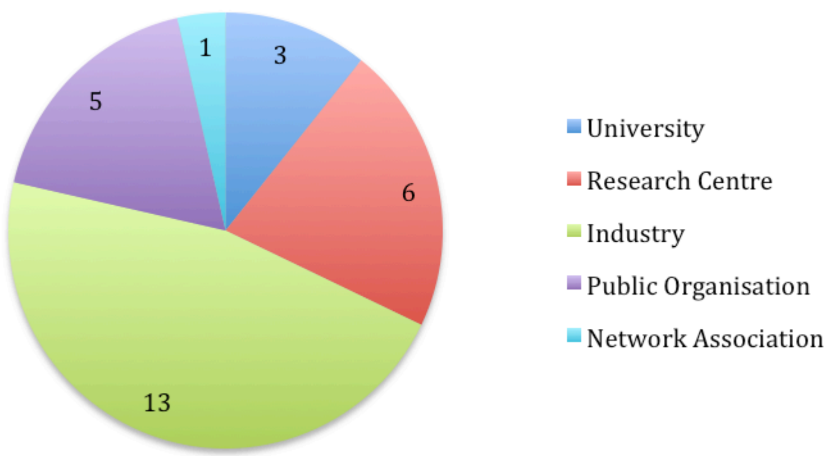
Source: SUCCESS (2007)

Fig. 12: The SUCCESS Project – Number of Partners According to its Institutional Sphere



Source: SUCCESS (2007)

Fig. 13: The SUCCESS Project – Number of Network Partners According to its Institutional Sphere

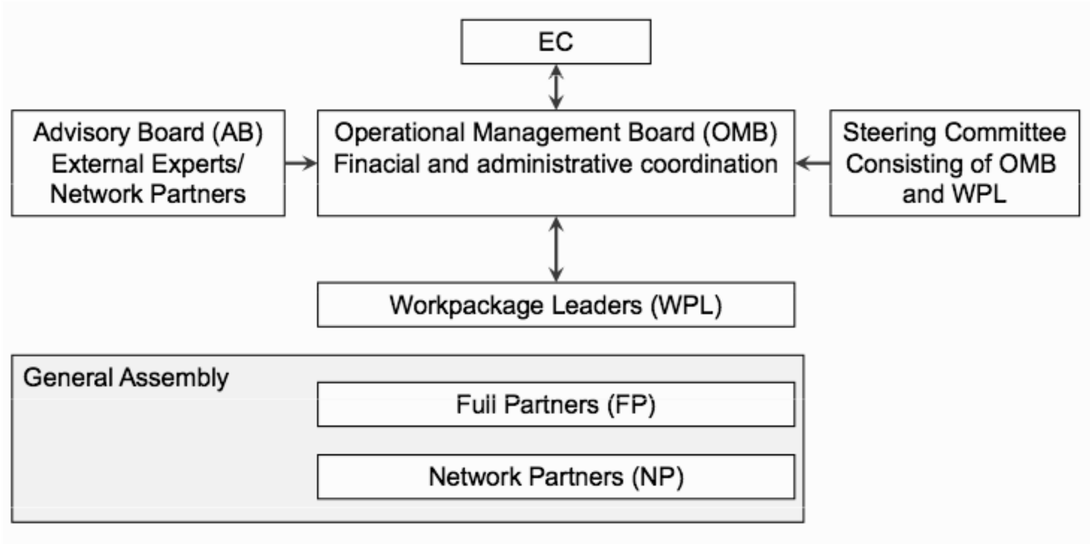


Source: SUCCESS (2007)

The SUCCESS Project had a formal management structure as represented in

Figure 14. The European Commission (EC) was responsible for the overall supervision and monitoring of the project. The Operational Management Board (OMB), formed by two universities and a public organisation, was responsible for the financial and administrative coordination. They were in this position as one of these two universities was responsible for organising the project and filling in all the paperwork, and it then invited the others to join in based on previous partnerships and also due to their experience with European projects. The Steering Committee (SC) was responsible for making decision on high-level management issues including financial, technical, planning and control matters. Members of OMB and work package leaders composed this committee. They physically met three times during the project, at the kick-off meeting, at the midterm of the project and at the final meeting. Aside from these meetings, they had phone call meetings on a regular basis. The Advisory Board (AB) consisted of external experts (including network partners), mainly from the industry, called to give specific advice on the innovation process within the industrial sector and on the exploitation possibilities of the results of the project in the fields of sustainable energy and climate change. Members of the Advisory Board were selected by the Steering Committee.

Fig. 14: The SUCCESS Project Organogram



Source: SUCCESS (2007)

The SUCCESS Project was organised in three phases:

- Phase 1 (WP1) was dedicated to identify existing models of collaboration in energy and climate change in regional, national and international perspectives, highlighting their strengths and failure. By doing so, it would also allow members to better understand the motives and barriers to transdisciplinary collaboration;
- Phase 2 (WP2) referred to the elaboration of a network model of collaboration (from its inception to its development and management) involving different European partners dedicated to higher education, research and business innovation. This model should be feasible on a mid and long term basis and should take into account results from phase 1 so as to avoid previously identified barriers and bottlenecks;

- Phase 3 (WP3) was committed to evaluate the new governance structure proposed in phase 2 in a series of experiments focusing at different variables of the model and to disseminate the results within the European innovation community.

The data collection in the pilot study involved participant observation in which the researcher played the role of a partner (explained in detail in Tables 9 and 10), a focus group exercise and four semi-structured interviews (with a member of the Operation Management Board [OMB], a member of the Steering Committee [SC], a work package leader, and a partner) in which participants were informed that the aim was to study the collaboration. Secondary data was also used, resorting to internal e-mails, documents, reports and other project outcomes. The use of multiple data sources allowed for data triangulation so as to avoid single-method bias.

Table 9: Observation Sampling in The SUCCESS Project

Event	Type of Observation	Date	Location	Participants
WP1 Meeting	Participant	February 15th, 2008	Copenhagen	WP1 members
WP1 Meeting	Participant	April 3rd, 2008	Amsterdam	WP1 members
WP1 Internal Meeting	Participant	April 10th, 2008	Barcelona	WP1 selected partners
WP1 Internal Meeting	Participant	April 11th, 2008	Barcelona	Business Schools
WP1 Internal Meeting	Participant	April 22nd, 2008	Barcelona	Business School
WP1 Internal Meeting	Participant	May 6th, 2008	Barcelona	Business School
WP1 Internal Meeting	Participant	May 13th, 2008	Barcelona	Business School
WP1 Internal Meeting	Participant	June 4th, 2008	Barcelona	Business School
WP1 Internal Meeting	Participant	June 10th, 2008	Barcelona	Business Schools
Final WP1 Meeting	Participant	June 18th – 19th, 2008	Stockholm	SUCCESS members
WP2 Internal Meeting	Participant	July 18th, 2008	Barcelona	Business School
WP2 & WP3 Kick-off Meeting	Participant	July 27th, 2008	Barcelona	WP2 and WP3 members
WP2 Internal Meeting	Participant	July 28th, 2008	Barcelona	Business Schools
WP2 Internal Meeting	Participant	September 25th – 26th, 2008	Barcelona	Business Schools and WP2 leader
WP3 Meeting	Participant	October 7th, 2008	Torino	WP3 members
WP2 Internal Meeting	Participant	October 10th, 2008	Barcelona	Business School
WP2 Internal Meeting	Participant	October 24th, 2008	Barcelona	Business School
WP2 Internal Meeting	Participant	October 27th, 2008	Barcelona	Business School
WP2 Internal Meeting	Participant	October 29th, 2008	Barcelona	Business School
WP2 Internal Meeting	Participant	November 3rd, 2008	Barcelona	Business School
WP2 Internal Meeting	Participant	November 12th, 2008	Barcelona	Business School
WP2 Meeting	Participant	November 20th, 2008	Amsterdam	WP2 members
WP3 Meeting	Participant	November 21st, 2008	Eindhoven	WP3 members
Mid-term Meeting	Participant	November 26th – 27th, 2008	Karlsruhe	SUCCESS members
WP2 Internal Meeting	Participant	December 11th, 2008	Barcelona	Business School
WP2 Internal Meeting	Participant	January 14th, 2009	Barcelona	Business School
WP3 Meeting	Participant	January 19th, 2009	Munich	WP3 members
WP2 & WP3 Cross Project Meeting	Participant	February 12th, 2009	Barcelona	WP2 and WP3 members
SUCCESS Workshop	Participant	May 20th, 2009	Karlsruhe	SUCCESS members

Source: own author

Table 10: Participant Observation in the SUCCESS Project

Details of Participant Observation	
Field Observation (number of months)	14
Number of Meetings Attended	32
Number of Hours of Meeting Attended	138
Hours of Recorded Audio Files	25

Source: own author

a) Findings and Analysis from the Pilot Study - The SUCCESS Project

The interorganisational collaboration formed for the SUCCESS Project was settled by a group of members who had previously worked together in other European projects and who joined together with a double objective: to develop in the short-term a generic model of collaboration with an underlying long-term objective of preparing themselves for being an accredited innovation network.

To achieve such aims, participants from different European countries, belonged to a wide range of areas in sustainable energy and climate change (from renewable to nuclear energy) and to different institutional backgrounds (technical universities, research centres and industry). Even with no shared physical space, partners relied on the use of Information and Communities Technologies (ICTs) (e.g. e-mail, videoconference, online communication tool) as a substitute for geographical proximity (Goff-Pronost & Lethiais, 2008). The use of ICTs, according to Boisot (2011), fosters a virtual collaboration to take place and reduces the need of face-to-face interactions. It does so by increasing data processing and data transmission capacities trough two effects: diffusion and bandwidth. The diffusion effect is about the fact that ICTs can process and transmit more data to more people per unit of time, increasing learning. And the bandwidth effect is about the fact that given a target audience, it can be reached with lower levels of condition and abstraction, with a richer message.

Hence, through the use of ICTs, partners alleviate to some extent the constraints of geographical distance, allowing them to developed their activities at their home institutions and exchanged e-mails to collect information and remotely coordinate their activities with distant partners. Partners did not see the geographical distance between them as a problem for the development of the project.

Vignette 1: "People were coming from different countries, but I think that everybody was very committed to the collaboration, so this was not a significant barrier. Besides, the use of virtual communication helped to overcome geographical distance and enabled us to work together. Perhaps the barriers were more because of the type of institution that partners belonged, than because of the country they were from […]" (Source: SUCCESS Project interview WP leader - engineer)

Vignette 2: "But geographical distance was not a problem. We had our travels and meanwhile we used e-mails and videoconference to develop our activities" (Source: SUCCESS Project interview partner - engineer)

Vignette 3: "[…] we had teleconferences and emails. I think that the geographical distance was not very important if there is a strong relationship with the other partner. For instance, partners from other business school and I, I consider that we work together […] but the important thing is that previously, there was a strong link between us. I mean, there was a previous relationship, for a long time, and so in that sense, geographical distance was not important […] I'm saying that not because you are far away you cannot work together [...]" (Source: SUCCESS Project interview SC member - social scientist)

However, the use of ICT tools requires partners to share common codes and practices of communication, which are tacit (Rallet & Torre, 1998). This is why the need for physical proximity by the temporary mobility of partners (e.g. travels for attending physical meetings) had an important weight in the project, for developing affective relations and promoting trust between partners (thus, increasing social proximity), easing collaboration and for the effective coordination of activities. It is assumed that this process of trial and feedback is facilitated by face-to-face interaction, which permits reciprocal exchanges, negotiations, and deep communication during the complex process of innovation (Rallet & Torre, 1998).

Vignette 4: "I think that physical meetings were rather important because working just by e-mails creates misunderstandings and misunderstandings are sorted out when you see each other. We had these travels where we visited each other and had our conferences and I think this was very fruitful to get to know each other and also to fulfil the tasks and talk about the issues that are necessary to bring the project forward. We had these face-to-face meetings where we also had a working dinner beforehand, so one gets to know people and gets to know them with time, also a little bit more private, which I think creates also trust as you don't know only the official side, and so it was really better at the end of the experiments" (Source: SUCCESS Project interview partner - engineer)

Vignette 5: "[…] So there were regular face-to-face meetings, which was something very important. I found them very useful, mainly when the group was more reduced, and then you met these people from time to time. So you had more or less a continuous relationship with that person." (Source: SUCCESS Project interview WP leader - engineer)

Vignette 6: "[…] From my personal experience, getting together with people, especially the socialising events on the evening before, was tremendously important, because then you would have a face with the email, which you had formally, and the face to the phone number you'd been calling formerly, and you would get a discussion other than project-related, of course there were project-related discussions as well, but to get to know the person and not only the collaborator or the colleague. And I think this helped a lot to contact people on specific issues, it was less problematic for me to address people, when I knew them person to person, when compared to the point at when I did not know them personally, and I guess this was similar to all other participants as well." (Source: SUCCESS Project interview OMB member – social scientist)

Such temporary proximity as expressed above allowed for a solution to the proximity-distant dilemma (Torre, 2008; Maskell et al., 2006). Thus, without denying its role, geographical proximity is not necessarily permanent, including activities associated with uncodified knowledge exchange. Temporal geographical proximity reflected the needs for physical interaction when dealing with certain phases of the project, for instance during the division of labour, report of activities and delivery of results (Carrincazeaux & Coris, 2011).

Despite geographical distance was not an issue due to the low complexity of knowledge; social and cognitive distances between partners were relevant, being a great source of affective and cognitive conflicts. Differences between engineers from different specialisation fields even existed, but it was not seen as an issue and it did not caused as much conflict as the ones caused by the diversity between engineers and social scientists. Engineers had no prior relations with social scientists. They did not see things through the same looking glass, what made them even questioned the credibility of partners from business schools as researchers. Altogether, this made the level of trust between them to be relatively low.

Vignette 7: "[…] people use terms when speaking about the same matter, but they use different terms, and it wasn't easy to adapt, to understand perfectly what is wanted because when there are then tasks coming it's not easy to understand which tasks one has to fulfil. This of course creates a problem." (Source: SUCCESS Project partner - engineer)

Vignette 8: "[…] We had three different kinds of people working in the project. Essentially, most of the people were, and I was included in this group, engineers specialised in sustainable energy, another group of engineers working on climate, there was a minor difference between these two tough, and then there was a third group of people related to social sciences, who were partners from the business groups. This last group had a great difference with other two." (Source: SUCCESS Project interview WP leader - engineer)

Vignette 9: "Well, it was difficult, in the sense that when you have to know that we were partners that we were coming from the social scientist side, and most of the other partners were coming from the technological or scientific part, related to energy […] for instance in a meeting in Barcelona one of the participants said, "well, what you are saying there is like, we could do it as a brainstorming session," so this means that even our methodology, our models, our way of understanding science was not understood by them. It was not legitimised. And I think that this provoked us also, like some kind of situation in which we…I don't know how to express it…but we felt like, "okay, they consider what I am doing as something that is not science; I am doing just brainstorming sessions, and this kind of silly things". So that provokes that the relationship is not as smooth as possible, so somehow there is a lack of respect in that sense [...] When we started to work in the project, it was rather difficult because we were completely strange people for them, we were coming from completely different worlds [...]" (Source: SUCCESS Project interview SC member – social scientist)

Besides, engineers did not understand the participation of the social scientists in the project, as it was a project about sustainable energy and climate change. However, as participants started to work, they realised that they did not possessed the required knowledge to propose a new generic model for structuring and managing collaborations. This brought the members from business schools to the fore in the network. At a first moment, this was a problematic issue as these members would have a more important role than previously expected and also because of the institutional distance that existed among network participants.

Vignette 10: "One of the most complex aspects in the project was probably that the engineers, scientists, and technicians could understand that the nature of this project wasn't technical. This was quite difficult from the beginning, essentially all the people were thinking about that we were going to do something technical, scientific or related to research, and in fact, this wasn't the case, it was related of course to research management, this was not something purely technical. So probably this was the main barrier." (Source: SUCCESS Project interview WP leader - engineer)

Vignette 11: "So at the beginning, it was quite frustrating… even without knowing the partners, but you have to know about the projects, about sustainability in energy, I mean I talked to the dean, "I think you have sent me to the wrong project, because this has nothing to do with us". And he said, "no, no, no. It is right". Our participation is going to be minor, and it's not going to be very important, but this has to do with this type of innovation networks and so on. And then, after the kick-off meeting, my reaction was, we started in a such a huge room full of people, and all the people were explaining technical things about energy, and then I thought, and I told this to the dean, "what are we doing in this project?" I mean, I cannot even understand what they are talking about and I cannot see exactly what we have to do here". Because at the very first beginning, apparently, the main objective of the project was technical-related. Then, suddenly, a person from the European Commission arrived. And he started saying, "No, no, this is not the objective. This project is not a technical project. It has to do about discovering new ways of collaboration" […] So afterwards, when we started the project, apparently at that moment the objective was much more clear, and then when we started working in the project, it was rather difficult […]" (Source: SUCCESS Project interview SC member – social scientist)

The climax of conflict was reached when, as a consequence of the greater involvement of the two business schools in the development of activities in the first two work packages, the project leader redistributed the resources between partners. Members started then to diverge in terms of how activities should be undertaken and who should be assigned to complete them, leading into disagreements and confrontations. The diplomatic position assumed by project and task leaders did not help on the development of trust among members.

Vignette 12: "[…] one of the problems of this project was the design phase. And I think that the objectives were not very clear for all the partners. I mean, there was a first distribution of who would participate on which phases, so, for instance in work package 1 some people who were not in the planning to work on that work package, they worked finally. And others who expected to work there they didn't do as much work as they had planned. So this provoked a huge conflict, and it's been the first time that I have seen it in a European project, that the budget was reallocated. So, in the work package 2, I assume that many people thought, based on what happened in work package 1, that if in work package 2 in the planning it is supposed that I have to collaborate with three man-hours or whatever, and I don't do anything, then this funding is going to be reallocate and I'm not going to receive this funding. It will probably go to the people who have done the work. So there was this type of pressure to say, so what is my work? What do I do? But at the same time there was no attempt to come closer […]" (Source: SUCCESS Project interview SC member – social scientist)

This was very problematic as innovation within the SUCCESS Project relied on the combination of knowledge between these two institutional fields in order to produce the new model of collaborative governance. Indeed, interactions are based on common or sufficiently codified practices, where collective learning involves the sharing of a common cognitive basis (Carrincazeaux & Coris, 2011). However, the cognitive distance between them caused some difficulties in understanding due to their different lexicon, knowledge base and mental models. This made collaboration very difficult, especially in work package 1 and work package 2, whose activities were developed and led by the two business schools.

Vignette 13: "[SUCCESS] was very different because partners from the technical field behaved quite differently than those from the social sciences and for me it was difficult because I am not a social scientist, and it is in part a social scientist's project so for me it was difficult to move into the area of social scientists and I had to learn a lot [...] I tried to understand what things really meant, because there is a certain type of terminology used with some terms I didn't understand, so I had to look it up in Wikipedia or in Google what it really meant, or in my books, to understand what is really dealt in work package 1 and 2. But the language was easier in WP3, where we all were kind of engineers and tried to do our best, whereas it was getting super professional in WP2, and I sometimes didn't know perfectly what the meaning was, so I had to read it two or three times to understand. For example, the model took me a certain while to understand, because I am not a modelling person, if you know what I mean." (Source: SUCCESS Project interview partner – engineer)

Vignette 14: "[…] When we started to work in the project, it was rather difficult because even if were speaking in English, we

> thought that (and when I say "we" I mean the social scientists) we were not completely understood… [There were many] misunderstandings, in the sense that we didn't exactly understand the same things, I mean the interpretation was different. Finally, we had conflict here. Because I think that perhaps we were not completely aware of this situation. I said, okay these people are not following, they don't want to follow the steps, or they don't want to do it in a proper way, or even perhaps they cannot understand it, so this involved conflict and at the very beginning there was a huge gap in conflict terms. I mean, we didn't quarrel, but we discussed a lot, so I think those are some of the consequences of working with the diversity, with a lot of partners" (Source: SUCCESS Project SC member – social scientist)

To regulate such affective and cognitive conflicts caused by cognitive and institutional distances, and enable the sharing of knowledge among the SUCCESS partners, the project would need the establishment of a strong organisational proximity. According to Kirat and Lung (1999), it is through organisation proximity that the practices and strategies of agents are defined within a set of formal mechanisms (e.g. norms and routines) and informal ties (especially interpersonal). It refers to the ability to coordinate diverse sources of knowledge, reflected in the interactions among network members, and hence organisational routine and collective learning (Carrincazeaux & Coris, 2011; Knoben & Oerlemans, 2006).

However, even with a lead organisation-governed network (Provan & Kenis, 2008), the organisational proximity in the SUCCESS project was low. One university (that was in the Operational Management Board) had an important coordination role of coordinating all major network-level administrative activities and key decisions regarding financial and accounting management, besides reporting and delivering results to the European Commission. However, it did not rule all major decisions and activities as a Steering Committee and an Advisory Board advised it. Although this lead university provided administration for the network and facilitated the activities of SUCCESS partners in their efforts to achieve network goals, it did not diminished organisational distance. Partners lacked the development of a common language base and the clear establishment of norms and rules.

Despite this coordination, partners lacked formal coordination mechanisms, e.g. structural coordination bodies and standardisation (manuals, R&D policies, etc.), since for goal-directed interorganisational networks some form of formal coordination mechanism is necessary to ensure that participants engage in collective and mutually supportive action, that conflict is addressed, and that network resources are acquired and utilised efficiently and effectively (Provan & Kenis, 2008; Reger & Gerybadze, 1997).

Vignette 15: "I think that there was a gap between objectives and how the project was design, we didn't have a common set of rules. We were a big group, and sometimes the objectives were not very clear. [So], to coordinate such a group is quite a difficult task, and if you don't take into account these kinds of gaps in advance, it is very difficult to solve them... So you can take two different positions. The coordinator adopts a more administrative role in the sense that, okay, I send the agenda, I write the minutes and so on, which is something very, I mean, it is basic. To have someone that does this role is very important. But apart from that, I think that…and this is something that is also in terms of experience. As we were such a diverse group, everybody wanted to speak, everybody wanted to contribute. But, there was no consensus, there were different perspectives, and we would have needed a bit of order, modifying ideas. Yes, to try to unify the different perspectives, because the thing that all of us were equal, but that sometimes provokes that with so many people, a little bit of disorder is there. So, in order not to come to disunity, we would have needed to have a bit stronger role, and active role of the managerial side. But I think that both of the roles that I explained to you are very important to have in this type of project because if you don't have someone who really puts order in the more administrative side in the sense of which is the agenda, which is the point, etc. then it leads to disaster." (Source: SUCCESS Project interview SC member – social scientist)

Vignette 16: "[…] our meetings were not effective enough, so perhaps it's important to define very clearly the objectives of the meeting, they should be given to the participants with proper time in advance, and they think that should be important that the chairman of the meeting, probably stress a little bit, not being of course a dictator, but stress a little bit the way that we go through the different objectives of the meeting […] I am thinking that the project leader has been very important, perhaps he has not been the person sharing all the activities, since for any reasons in the physical meetings perhaps the chairman or chairwoman were someone else, and many times in teleconferences he was not there. I think it could have been better if he could have taken this role more extensively. I think he has been doing a very nice work coordinating everything, with the work, with emails, with the web server, with everything, and when it was necessary in the meetings and on the teleconferences, but perhaps I think that I am missing a little bit more. I think it could have been better, so from my view, the involvement of the project leader in this role could have been much deeper." (Source: SUCCESS Project interview WP leader - engineer)

Since (affective and cognitive) conflicts were mainly caused by cognitive and institutional distances, and with little formal coordination mechanisms to help solving internal misunderstandings, it was possible to notice the emergence of three partners acting as orchestrators to resolve these conflicts. One of these partners was a member from a business school (member A). She was brokering the exchange of information between business school partners and engineers, so she could have access to information and integrate these contributions into a coherent whole to develop the governance model suitable for the sustainable energy and climate change sectors.

Vignette 17: "Well, I think that member A's participation was quite helpful at some points in time because she had a way to structure thoughts and to guide everybody towards a common solution. I was not surprised when I heard that she has been doing work as a consultant, because when she is in the discussion, she can give a direction in a discussion and extract the results, and make them visible to all the others, so she has often been the one who was guiding discussions to a result. She didn't guide it to a result she wanted. But she was guiding them to any result." (Source: SUCCESS Project interview OMB member – social scientist)

Vignette 18: "Maybe the person who has been most relevant at the end was member A. Although the model has been designed by the group of member A, this member was who has been really involved in explaining the details of the model to everybody, trying her best so everybody could understand it, especially making engineers understand a model of collaboration framed in management terms, and I think that she has been extremely proactive, and this person has been member A […]" (Source: SUCCESS Project interview WP leader - engineer)

Another partner who acted in an orchestration role was the leader of work package 2 (member B). The objective of work package 2 was to deliver a model of governance for interorganisational collaboration in the fields of sustainable energy and climate change. The objective of work package 3 was to select certain aspects of this governance model and evaluate it. Unfortunately, these two work packages happened concomitantly. The business schools were working by themselves in the elaboration of the model, what created some conflicts with participants from work package 3 – who wanted to have full access to the model before it was finished and delivered.

Member B mediated the relationships (and affective conflicts) between business schools and work package 3 members by ensuring that effective communication between them was occurring (especially between engineers and social scientists), selling one side's case to the other (e.g. explaining social scientists in work package 2 that work package 3 partners would need some information to start working, and telling partners from work package 3 that the model could not be sent in a whole in a written document as there was a need of explaining it in a physical meeting since they were not familiar with managerial aspects) and trying to build trust between the two quarrelling sides (Wall & Dunne, 2012).

Vignette19: " The way WP2 and WP3 were designed was very difficult. So member B was very helpful because he was in both WP, so he was like a bridge to connect us, making us talk, showing who was doing what and how business was being organises, calming us down […]" (Source: SUCCESS Project interview partner – engineer)

Vignette 20: "Also, there are some people that help to do it [align diversity in the project]. For example, member B also helped. I mean it was a different role. I think that at least he was like the telephone between the social scientists at a certain moment that we didn't, we were like a little island, and the others, so sometimes he was participating in those capacities so he could see what work package 2 was doing, what work package 3 was doing, so he could keep some communication between one group and the other. But it was a different role. But finally I think that somehow he showed with the results that the social scientist part was doing a very good job on that, so that somehow he made them realise that they needed us. And then, we had to integrate some kind of map of knowledge, yes" (Source: SUCCESS Project interview SC member – social scientist).

Concomitantly, another member of work package 3 (member C) also helped on the orchestration of the relationships between work package 2 and 3. His degree in social science made him able to understand better the jargons and ways of working of business school partners. His background legitimated him to act as a transformational leader, motivating participants of work package 3 to be open-minded to new contents being proposed by the business schools (Gray, 2008) and encouraging them to work collaboratively with social scientists by employing patience, tolerance, openness and listening to their ideas and considerations.

Vignette 21: "[…] I think that member C also helped, probably because he was able to speak in the technical language, and he was able also to speak the social sciences, he was very respectful, I mean in the sense that he was very humble also when he was explaining what he thought, he didn't express any type of superiority, and sometimes he was looking for the team more than for his individual institution or his individual role. Well, I think that he did a very good job [...]" (Source: SUCCESS Project interview SC member – social scientist)

Vignette 22: "I think in the beginning of WP3, we had a little bit of problems if we talked about topics to be developed and this made a little bit of chaos, and I think we also misunderstood slightly who in the beginning what we had to do, so this took us a certain while until this disagreement had been settled, and so it was a bit chaotic in the beginning. It was a bit easier afterwards. Member C encouraged us to get through things, to try our best to work with a terminology that was not ours [...] Because there was a time not perfectly coordinated by the direct coordinator, so we simply put together what everyone has done, and so there was a kind of degree of freedom for who could do what, but this was of course more chaotic, but on the other hand there was also more freedom about who could do what, so it wasn't too bad. It took a longer time to write it all together, because there were so mixed contributions. Yes, member C used a lot of patience with us. I personally got on very well with member C, …what I like more of people like him is those who display a certain calmness and comfort. I really don't like it when people are getting off in their despair and hectic and over productive and a little bit desperate, because that creates a climate which is bringing each other difficulties. Sometimes people are desperate to fulfil the needs that are all getting exaggerated and then the climate is very hectic, especially if you have several persons who are like that. So I get on very well with people who spread certain calm and are good at rhetoric to combine, to handle people's temperaments and emotions, and I think this is rather important." (Source: SUCCESS Project interview partner – engineer)

Despite the importance of this informal coordination to facilitate collaboration between SUCCESS members and the development of activities in the project, these three partners were not aware of their orchestrating role. For instance, when they engaged in situations of orchestrating knowledge within the network, they did it so they could establish a shared understanding that would allow them to carry on with their work.

Vignette 23: "Well, I don't think that this diversity has been formally managed; I think that the process has been a little bit spontaneous. My feeling is some people like member A, member B, and I (member C) have taken special care of managing this. Perhaps we were more worried to reach the desired outcomes, so we helped others without thinking of doing it. In a sense we were trying to get over issues so we could develop our tasks." (Source: SUCCESS Project interview WP leader - engineer).

Although partners stated that with the development of the project, they got to know each other and the level of trust increased, the SUCCESS Project did not succeed in promoting organisational proximity among its participants. Activities were completed and reports were delivered, but after the project was over, partners divided themselves in two groups to present competing proposals for the call of the European Commission for the development of the future KICs (Knowledge and Innovation Communities).

Vignette 24: "And the most complex thing in the project was that we had different expectations of what we were trying to do. I mean, to coordinate such a group is quite a difficult task, and if you don't take into account these kinds of gaps in advance, previously, I mean, it is very difficult to solve them. I think that pressure of having deliveries done has been important. Because we could be discussing a lot, but if we have to finish this work package or this delivery for that day, the need to have these objectives, it pressures you. You agree, or you agree, you have to […] The communications improved. The transparency improved, but there were not chain activity. I think that it impacted on the way that how the relationships evolved. I missed an integration phase between working together on some common aspect. So, more or less, work package 2 was doing the job and work package 3 was doing the job […]" (Source: SUCCESS Project interview SC member – social scientist)

Vignette 25: "Yes, I think it has changed, but of course, I think that here

> there is some other external factor from the project that has been very important, which has been the preparation of the KIC proposals. I think that during the project the level of trust of the different partners was growing, I think, but for some reasons […] at the end, two KIC proposals have been growing from the partners of the Success Project. So then, I mean that for some reason, perhaps this is a big misalignment that I was trying to explain subtly before, perhaps at the end there are some conflicting interests that may arise not within the project [...] But anyway, the conflict of interest at the end is coming because the resources are limited, but partners of the Success project, some of them, about half of them are involved in one KIC proposal, and the other half in another one. So I think that essentially, the level of trust among the partners has increased, of course, having some misalignment, but I think this misalignment is more related to the strategic objective of some of the partners in the long term, than with the Success partners. So I mean that the Success Project cannot solve this misalignment for sure. For sure." (Source: SUCCESS Project interview WP leader - engineer)

These findings from the pilot study helped to observe various aspects that are relevant in understanding the nature of innovation network, the need and the importance of coordination mechanisms in such networks. Although the SUCCESS project objectives were fulfilled, this innovation network was not successful in terms of its coordination as partners were divided at the end of The SUCCESS Project into two groups that presented separate proposals for the KICs. On that account, the pilot study had an important role in providing relevant data, which helped to redefine and complete the research design.

2.3.3. Study Sites and Units

Once the pilot study had been conducted, its findings were presented in important academic peer-reviewed conferences in the field of strategy, knowledge and organisational studies. Such occasions provided opportunities to further discuss the topic under research with other specialists and to carry on with the development of the literature review. Based on this, decisions about study sites and units were taken. First, since the characteristics of the context would be of outermost importance to illustrate the topic under research, it was decided to look for possible cases of interorganisational networks related to innovation. Through the review of the literature, it was possible to observe that this topic is frequently discussed but seldom studied empirically (Provan et al., 2007). One possible explanation may lie on the fact that these networks are perceived by some researchers as outliers, deviant organisations that are deliberately taking a different path or working from a different set of assumptions (Canals et al., 2011). Yet it is an important area of research since these networks are developing practices that enable large-scale, transformative innovation, thus being a source of inspiration and insight.

Hence, the cases here used primarily refer to innovation networks, the unit of analysis, but also incorporate the domain in which the networks are embedded. Besides, these networks had to be interorganisational goal-directed networks, as they represent a distinct challenge to the coordination of networks that requires strategic action at the whole-network level (Saz-Carranza & Ospina, 2011). It was decided to choose two innovation networks: KIC InnoEnergy and ATLAS Experiment at CERN.

KIC InnoEnergy, an interorganisational network formed with the purpose of providing innovative products and services in the field of sustainable energy in Europe, functions under conditions of high uncertainty (i.e. regulatory issues in the energy sector differ across countries; funding is partially dependent from the European

Commission), complexity (i.e. partners belong to different institutional spheres; different individual objectives to join in) and a highly centralised top-down planning. Collaboration and mutual understanding take place in an environment where tightly control and clear rules govern behaviours.

ATLAS Experiment at CERN, an interorganisational network formed for research on high-energy physics creating innovations as a spin-off of their investigations. ATLAS operates under conditions of high uncertainty (i.e. outcomes are to some extent unpredictable, technological development required to run the experiments), complexity (i.e. the intricacy of the experiment, number of participants involved) and a distributed bottom-up planning. Collaboration and mutual understanding take place in an environment where loose control and vague boundary rules govern behaviours (Güttel et al., 2012). The next chapter describes each of the cases in detail.

These cases were selected as examples of innovation networks since their primary focus is on fostering an environment where collaboration among diverse members is promoted with the goal of enabling innovation (Dhanaraj & Parkhe, 2006; Hoberecht et al., 2011). To do so, these networks have created innovative elements so collaboration could take place. Besides, the reasons for choosing two innovation networks settled in different institutional spheres, with different purposes, characteristics, and stages of development are two-fold. First, if under these different circumstances it is still possible to arrive at common conclusions, this will imply the possibility of a certain generalisation (Yin, 2002). Second, to a certain extent, it will give the opportunity of studying whether interorganisational network structure and its nature may exert an influence on the research questions. Therefore, this study is an illustrative multi-case study where the contexts of the two cases differ in order to show what a situation is like, to make the unfamiliar familiar and to give readers a common language about the topic in question.

2.3.4. Documents and Archival Data Analysis

Documents and archival records will help to better understand the study sites of this research, to reconstruct events, social relations and the issues participants faced when collaborating. A wide range of written documents was used such as memoranda, organisational charts, minutes of meeting, business proposals, project deliveries, reports, non-written materials (e.g. videos on YouTube) among others. One of the most important uses of documents and archival records is to corroborate evidence gathered from other sources.

AS KIC InnoEnergy is a younger endeavour in comparison to ATLAS Experiment, written documents and archival records from KIC InnoEnergy are fewer when compared to the volume of information available for ATLAS Experiment. However, since physical access to KIC InnoEnergy was easier in comparison to ATLAS Experiment, (direct and participant) observation was developed in order to compensate this aspect. This will be discussed in the next section.

2.3.5. Observation

Another data collection method employed was observation, which complemented interviews by exploring possible difference between what people do and what they say (Eden & Huxham, 1996) and by capturing both social interaction and the particular settings where these occur. The data collected included audio recording, and also making written notes in a research's journal, which included some quotations, commentaries, research's feelings and ideas.

Two types of observation were employed: participant and direct observation. Participant observation is a unique mode of observation in which the researcher may actually participate in the events being studied. Among the roles that the participant observer can adopt, this research is based on the role of *participant as observer*, which entails that the researcher reveals his purpose to those whom he is mixing in the research setting (Saunders et al., 2003). Besides, data generated by participant observation is based on primary observations, which are those where the researcher will note what happen or what is said at the time (in formal or informal conversations also). Direct observation is distinguished from participant observation, as a direct observer does not try to become a participant in the context. The researcher watches rather than take part, what makes direct observation to be more focused than participant observation.

Table 11 illustrates the sampling of observations. These observations contributed to illuminate the context that characterises innovation networks. It also allowed for better understanding how both innovation networks are coordinated. In one hand, access to KIC InnoEnergy was easier and lengthier. Aside from participating and observing at various meetings, the researcher worked as a participant research in INDU (Innovation Development Unit) in one of KIC InnoEnergy's office in Barcelona for 14 months. On another hand, access to ATLAS Experiment was more limited, due to other numerous researches taking place at their premises. It was allowed to spend uninterrupted six days visiting CERN facilities in Switzerland and France. Besides, the researchers made three visits to IFAE's facilities in Barcelona (Spain). This limitation was overcome by resorting to other data collection sources, such as interviews and secondary data.

Table 11: Observation Sampling

Event	Innovation Network	Type of Observation	Date	Location	Subtype
Family Day	KIC InnoEnergy	Participant	November 4 – 5th, 2011	Freiburg	Network-wide meeting
In-company Training on Diversity	KIC InnoEnergy	Participant	January 24 – 25th, 2012	Barcelona	Working group
Innovation Projects Review	KIC InnoEnergy	Direct	July 5th, 2012	Barcelona	CC Iberia meeting
CC Iberia Info Day	KIC InnoEnergy	Direct	July 6th, 2012	Barcelona	CC Iberia meeting, Public Relations event
OTS Annual Meeting	KIC InnoEnergy	Direct	20 – 21st September, 2012	Barcelona	Innovation project meeting
Family Day	KIC InnoEnergy	Participant	November 19th – 20th, 2012	Barcelona	Network-wide meeting
IFAE visit	ATLAS	Direct	October 11th, 2012; November 7th, 2012; January 23rd, 2013	Barcelona	Daily activities
ATLAS visit	ATLAS	Direct	November 11 – 16th, 2012; March 20 – 23rd, 2013	Geneva	Daily activities

Source: own author

2.3.6. Research's Journal

As the research project developed, information was also gathered by writing field notes, feelings and ideas. This was especially important during the periods of observation in the two innovation networks. This method was very useful for gathering data that cannot be collected in other ways. For instance, many of the notes may refer to the way participants express themselves, body language, where they sit during a meeting and so on. Furthermore, this data was also useful to recall situations, which also facilitated data analysis.

2.3.7. Interviews with Practitioners

Another source of primary data collection was interviews. Norppa (2014) pointed out that with interviews it is possible to collect valid, reliable, rich and detailed set of data that are relevant to the research questions and objectives of the study. In order to get as much insights as possible about the cases, semi-structured interviews were considered as most appropriate for the research. In semi-structured interviews the researcher has a list of themes and questions to be covered, although they might vary from interview to interview (Saunders et al., 2009). The topics during the interviews were designed to cover as much as possible regarding network coordination functions taking place within the innovation networks. The interview cover letter[31] and guide are presented in Annex 2.

23 participants from different network levels were interviewed (as detailed in

[31] It is presented in Annex 2 the interview cover letter for the interviews conducted at KIC InnoEnergy. Access to the ATLAS Experiment was granted with the help of one of my PhD advisors who have been conducting research at ATLAS.

Table 12). They were selected to offer different perspectives on network coordination: those more involved and those that are under the coordination of others. The interviewees chose where the interview took place, so that it would be conducted in an environment that was comfortable for them, and the language of the interviews: English, Spanish or Portuguese. The interviews did not follow a closed structure, but more like a conversation with the practitioners. First, it started with opening questions about the interviewee's background and work. Thereafter, the internal management of the network was discussed. And finally, the interviewees were consulted regarding possible future changes that would benefit the development of the innovation network under study.

Interviews were audio-recorded, after permission from the interviewees to do so. The duration varied depending on how talkative the interviewee was, but mainly it lasted more than one hour and a half. Interviews were recorded, transcribed, translated to English if needed, and subsequently analysed by using the content analysis method. It is relevant to mention that some of the interviewees felt quite confident to speak openly. This fact was an advantage in terms of gathering accurate and sincere data from participants. This latter aspect was reinforced by the fact that, once again, they were reminded of confidential terms under which this study was being carried out.

Table 12: Interview Sampling

Innovation Network	Country	Subtype
KIC InnoEnergy	Portugal	Innovation project project coordinator (engineer)
KIC InnoEnergy	Portugal	Innovation project manager (engineer)
KIC InnoEnergy	Portugal	Former Innovation project manager (engineer)
KIC InnoEnergy	Portugal	Innovation project manager (engineer)
KIC InnoEnergy	Spain	Innovation project participant 1 (engineer)
KIC InnoEnergy	Spain	Innovation project participant 2 (engineer)
KIC InnoEnergy	Spain	Innovation project participant 3 (engineer)
KIC InnoEnergy	Sweden	Innovation project work package leader 2 (engineer)
KIC InnoEnergy	Sweden	Innovation project work package leader 1 (engineer)
KIC InnoEnergy	Spain	Innovation project participant 4 (engineer)
KIC InnoEnergy	Spain	Innovation project work package leader 3 (engineer)
KIC InnoEnergy	Spain	Co-location Centre manager (engineer)
KIC InnoEnergy	Spain	Innovation project participant 5 (social scientist)
ATLAS	Portugal	Subdetector system project leader (physicist)
ATLAS	Spain	Subdetector system participant 1 (physicist – IFAE)
ATLAS	Spain	Subdetector system participant 2 (physicist – IFAE)
ATLAS	Italy	Subdetector system participant 3 (physicist – IFAE)
ATLAS	Italy	Subdetector system participant 4 (physicist)
ATLAS	Spain	Subdetector system participant 5 (physicist)
ATLAS	Sweden	ATLAS Resources coordinator (physicist)
ATLAS	Belgium	Subdetector system participant 6 (physicist – IFAE)
ATLAS	Italy	ATLAS Technical coordinator (physicist)
ATLAS	France	Subdetector system participant 7 (physicist – IFAE)
ATLAS	Spain	Subdetector system participant 8 (engineer)

Source: own author

2.4. Plan and Methods for Analysing Data

Taking into account that the study was exploratory, there was an evolution in analysing the data. From very general and broad analysis, it was finished with a shorter and definitive list of codes that arose from subsequent discussions with my supervisors (see table 13).

Table 13: List of Codes

Main Theme	Sub-theme	Categories
1. Organisation	1.1 Hierarchy / decision-making	1.1.1 Bottom up 1.1.2 Top-down
	1.2 Degree of formalisation	1.2.1 Formal mechanisms 1.2.2 Informal mechanisms
2. Members	2.1 Prior relations	2.1.1 Familiar 2.1.2 Unfamiliar
	2.2. Diversity	2.2.1 Cognitive proximity 2.2.2 Social proximity 2.2.3 Geographical proximity 2.2.4 Institutional proximity 2.2.5 Organisational proximity
	2.3. Conflict	2.3.1 Cognitive 2.3.2 Affective 2.3.3 Administrative 2.3.4 Goal
3. Coordination	3.1 Commanding / Authority based	3.1.1 Direct supervision 3.1.2 Standardisation of process 3.1.3 Standardisation of skills 3.1.4 Standardisation of outputs
	3.2 Enabling / Negotiation and mutual adjustment	3.2.1 Broker – structural task 3.2.2 Boundary object 3.2.3 Mediator – processual task 3.2.4 Transformational leader – cognitive task

Data was analysed through a qualitative abductive content approach. In abductive analysis method, the analysed themes or categories are derived from data, however prior research and theories may be used as help or guidance in the later stages of the analysis (Norppa, 2014). The abductive approach was chosen so that the research would relate to previous scientific discussion, but not too strictly, so that space for the occurrence of new findings is left as well. Data was codified with the use of computer assisted qualitative data analysis software: Nvivo. Annex 3 presents the results of data codification.

Triangulation was used in the analysis phase. Not only data come from different sources, but more than one research also analysed the data. By doing so, it aimed to avoid single-observer bias and to capture a more complete and contextualised portrait of the phenomenon under study.

2.5. Reliability and Validity

In all research the aim is to avoid mistakes, therefore the quality of the research should be evaluated (Norppa, 2014). Reliability and validity are issues that any qualitative researches should take into account while designing a study, analysing results and evaluating the quality of the research (Patton, 2002). Reliability of the study can be proved by demonstrating that the operations of the research, such as data collection and analysis procedures, can be repeated over and over again (Yin, 2002). In order to strengthen the reliability of this study, the procedures and findings are documented in detail, so that they can be repeated and transferred to other contexts.

According to Yin (2002), the validity of a case study should be assessed. The basic validity question is whether the research actually measures what it intended to measure. However, this does not apply to qualitative research, as their purpose is not to measure anything, but rather to generate understanding. Thus, the validity of the data in qualitative research depends on the purpose of the study. When the purpose is generating understanding of a social phenomenon, good validity is created if the informant is part of the phenomenon and he is given the opportunity to freely talk about it, i.e. by choosing the informants well and using non-forcing interview method (Stenbacka, 2001).

The empirical data gathering focused on informal interview settings and in-depth discussion with informants who were clearly part of the phenomenon and experts in their businesses. The interviewees were encouraged to share their own thoughts and experiences on the research issue without restricting the scope of interview by tightly structured interviews. Still, the subjectivity of the researcher and the informants may lead to a lack of rigor. Subsequently, in the interview phase it was used as much observational data as possible. Besides, triangulation, or the combination of multiple methods, empirical and researcher's data, is an alternative to validation (Flick, 2009), which "*adds rigour, breadth, and depth to any investigation*" (Denzin, 1989: 4). Moreover, the fact that it is a multi-case study enhances these aspects.

Moreover, external validity refers to the extent to which the study's findings can be generalised (Yin, 2002). The limitations concerning external validity of this research lie in its explorative, case-based approach, which limit the generalizability of the results. Multiple-case studies can be more robust than a single case study and, thereby depending on the results, strengthen the external validity. Further, as the study is conducted only in two innovation networks, the results of the study cannot be directly applied to other contexts due to the various differences, such as network development stages, purposes and degrees of formalisation, among others.

Chapter 4

CASE STUDIES

In this chapter it will be presented in detail the two innovation networks studied in this research – KIC InnoEnergy and ATLAS Experiment –, followed by a brief comparison between the two cases.

1. Multiple Case Study

1.1. KIC InnoEnergy

1.1.1. The European Institute of Innovation and Technology (EIT) and the Knowledge and Innovation Communities (KICs)

Before the end of the pilot projects (such as the previously discussed SUCCESS Project), and to start putting in practice a new approach to innovation, the European Commission established in March 2008 the European Institute of Innovation and Technology (EIT). The EIT was set up in order to address Europe's innovation gaps and shortcomings and to be the European Union's flagship institute designed to integrate innovation, research and growth across Europe. Based on the concept that innovation is a key driver of growth, competitiveness and social well being; the EIT's mission is to enhance Europe sustainable growth and competitiveness, reinforce the innovation capacity of the EU Member States, create the entrepreneurs of tomorrow and prepare for the next innovation breakthroughs.

Within the EIT, it was launched in 2010 three Knowledge and Innovation Communities (KICs) in areas considered relevant for the forthcoming development of Europe: Climate-KIC (addressing climate change mitigation and adaptation), EIT Digital (addressing information technology) and KIC InnoEnergy (addressing sustainable energy). KICs are structured partnerships in the form of European innovation networks that bring together to collaborate actors from higher education institutions, research centres, companies and public organisations with the aim of boosting the innovation process from idea to product, from laboratory to market, and from student to entrepreneur. Although each KIC could build up their strategies and governance structures as they would consider being the best, each KIC are characterised by (EIT, 2012):

- **High degree of integration**: each KIC is organised around an independent legal entity, gathering world-class partners from all the innovation dimensions. The specificity of the KICs is to integrate, for the first time at EU level, education and entrepreneurship with research and innovation.
- **Long-term perspective**: each KIC was set up for a minimum of seven years to contribute to overcoming fragmentation via world-class, long-term, integrated partnerships. This long-term perspective enables

partners to commit to a strategic initiative for a longer time than in traditional innovation policy initiatives. It also ensures that the KIC is able to focus on short, mid and long-term objectives, remaining agile and flexible to adapt to emerging needs from the fields in which they operate.

- **Efficient governance**: each KIC was set up as a legal entity and appointed a CEO to run its operation. The EIT provided the KICs with a great degree of autonomy to define their legal status, internal organisation and working methods. KICs must produce annual business plans, including a portfolio of activities from education to business creation, with clear targets and deliverables, looking for both market and societal impacts.
- **The co-location model**: each KIC consist of five or six innovation hubs called 'co-location centres' that are spread across Europe. A co-location centre brings together diverse teams of individuals from different institutional spheres in one physical place acting as a hub for many KIC activities, and combining competences and skills developed in different areas of specialisation at a pan-European level.
- **KICs culture**: KICs embrace an entrepreneurial culture, by integrating education and entrepreneurship with research and innovation, and operating according to business logic and with a results-oriented approach.

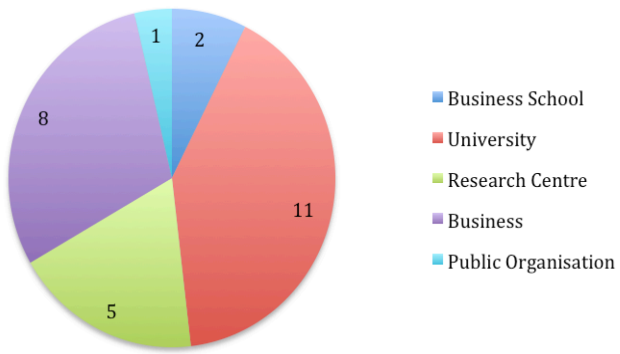
EIT contributes on average a maximum of 25% of the overall budget of each KIC. The EIT financial contribution is decided on an annual basis, following the assessment of each KIC's individual performance and a competitive review between them, which included the evaluation of KIC's past performance, future plans and the level of co-financing from other sources. The funding for the initial period (2010 – 2013) was of about € 308.7 million, and it rose to € 2.7 billion for the current planning cycle (2014 – 2020) (EIT, 2012).

1.1.2. KIC InnoEnergy – Pioneering Change in Sustainable Energy

Among the three KICs, KIC InnoEnergy has the vision of becoming the leading engine for innovation and entrepreneurship in sustainable energy in Europe. Its main goals are to reduce the cost of energy, to increase the productivity of the energy system, and to reduce the green house gas emissions. To put this in practice, in December 2010 KIC InnoEnergy was legally constituted as a commercial company (incorporated as Societas Europea[32]) with 27 shareholders (or full partners) that include top rank industries, research centres and universities; all of them key players in the energy sector (see Figure 15 for a representation of full partners according to its institutional sphere). Shareholders are formal members of KIC InnoEnergy that are fully committed to the development of the innovation network, contributing to the management of the KIC through their membership (KIC InnoEnergy, 2015b). Some of these partners had collaborated before in The SUCCESS Project.

[32] The European Company is a type of public limited-liability company regulated under a mixed system of EU and national legislation. It offers a simpler and more flexible way of operating business in more than one EU country.

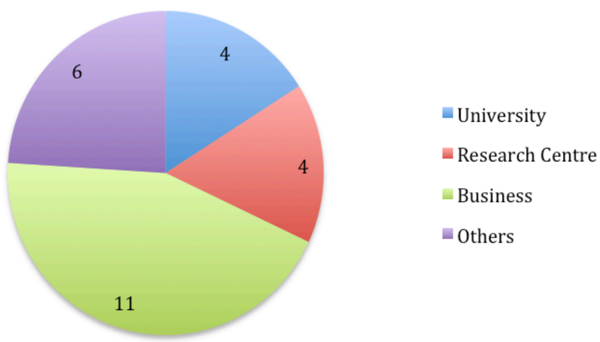
Fig. 15: KIC InnoEnergy – Number of Full Partners According to its Institutional Sphere



Source: KIC InnoEnergy (2015b)

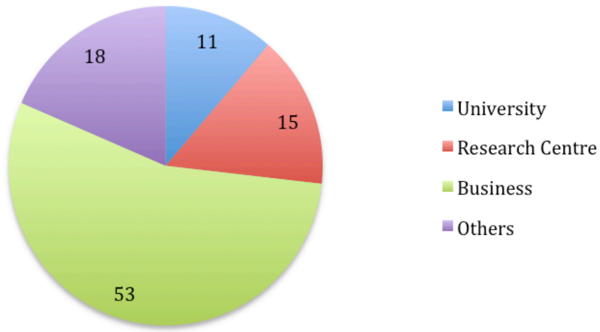
Around 150 additional partners (including associate and network partners) contribute to their activities (see Figures 16 and 17 for a representation of associated and network partners according to its institutional sphere). Associate and network partners have more limited rights as well as obligation and are mainly linked to the co-location centre and/or specific innovation projects (as can be seen in table 14).

Fig. 16: KIC InnoEnergy – Number of Associated Partners According to its Institutional Sphere



Source: KIC InnoEnergy (2015b)

Fig. 17: KIC InnoEnergy – Number of Network Partners According to its Institutional Sphere



Source: KIC InnoEnergy (2015b)

Table 14: Rights and Obligations of KIC InnoEnergy Partners

		Formal Partners	Associated	Project (max. 2 projects, otherwise AP/FP)
Rights				
Governance & Operation KIC level	Shareholders of	KIC	No	No
	Member of General Assembly (GPA design and agreement, appointement of Supervisory Board members, Approval of Annual Accounts)	Yes	Invited but no voting rights	No
	Approving strategy	Yes	No	No
	Approving yearly Budgets	Yes	No	No
	Appoint CEO	Yes	No	No
	Admitting new shareholders	Yes	No	No
	Member of EDU Dev Unit	Yes	No	No
	Member of Inno Dev Unit	Yes	No	No
	Member of R&T Dev Unit	Yes	No	No
	Member of IP Committee	Yes	No	No
	Member of Industry Committee	Yes	Yes	Yes
Governance & Operation CC level	Shareholders of	Yes	Yes	No
	Member of CC General Assembly or equivalent (GPA design and agreement, appointement of Supervisory Board members, Approval of Annual Accounts)	Yes	Yes	Invited but no voting rights
	Appoint CEO	Yes	Yes	No
	Admitting new shareholders	Yes	Yes	No
Activities	Thematic areas allowed	All	All	All
	Lead Innovation Projects	Yes	Yes	No
	Lead Inno Edu Programmes	Yes	Yes	No
	First customer call in Bus Creation	Yes	Yes	No
Grant	Maximum Grant allowed (per year)	No limit	400K€	100K€
Obligations				
€	Minimun yearly cash contribution	100K€	30K€	None
	Minimun yearly in-kind contribution	900K€	270K€	None
	Sign the IA to get funds	Yes	Yes	only if Grant>20K€

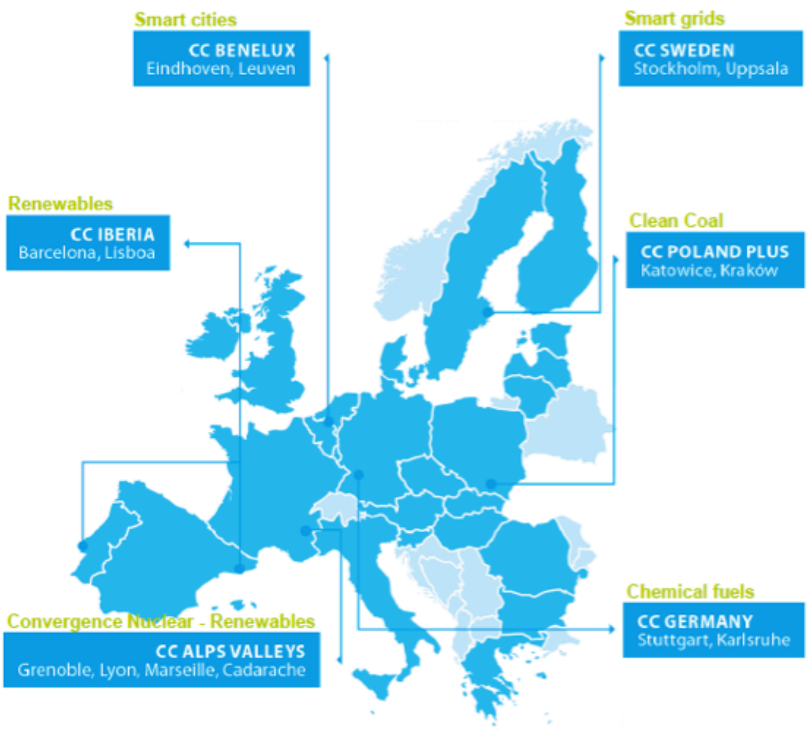
Source: KIC InnoEnergy (2015a)

a) KIC InnoEnergy – Structure

The management structure of KIC InnoEnergy is not markedly different from a business organisation. KIC InnoEnergy's organisational structure is output-oriented and a driver for the aims of the KIC. It is run like a company, monitoring its performance through specific indicators (at EIT and/or KIC-levels), the objectives and outputs achieved, and the generation of both economic and societal impact. Although KIC InnoEnergy is profit oriented, it has a 'not for dividend' financial strategy since they reinvest profits in their activities. KIC InnoEnergy budget was € 26 million in 2010 and € 300 million in 2014 (KIC InnoEnergy, 2015b).

With its headquarters located in Netherland, it manages its activities through a Europe-wide network of local offices (also know as co-location centres) situated in eight European countries (figure 18).

Fig. 18: KIC InnoEnergy – its Co-location Centres and Thematic Themes



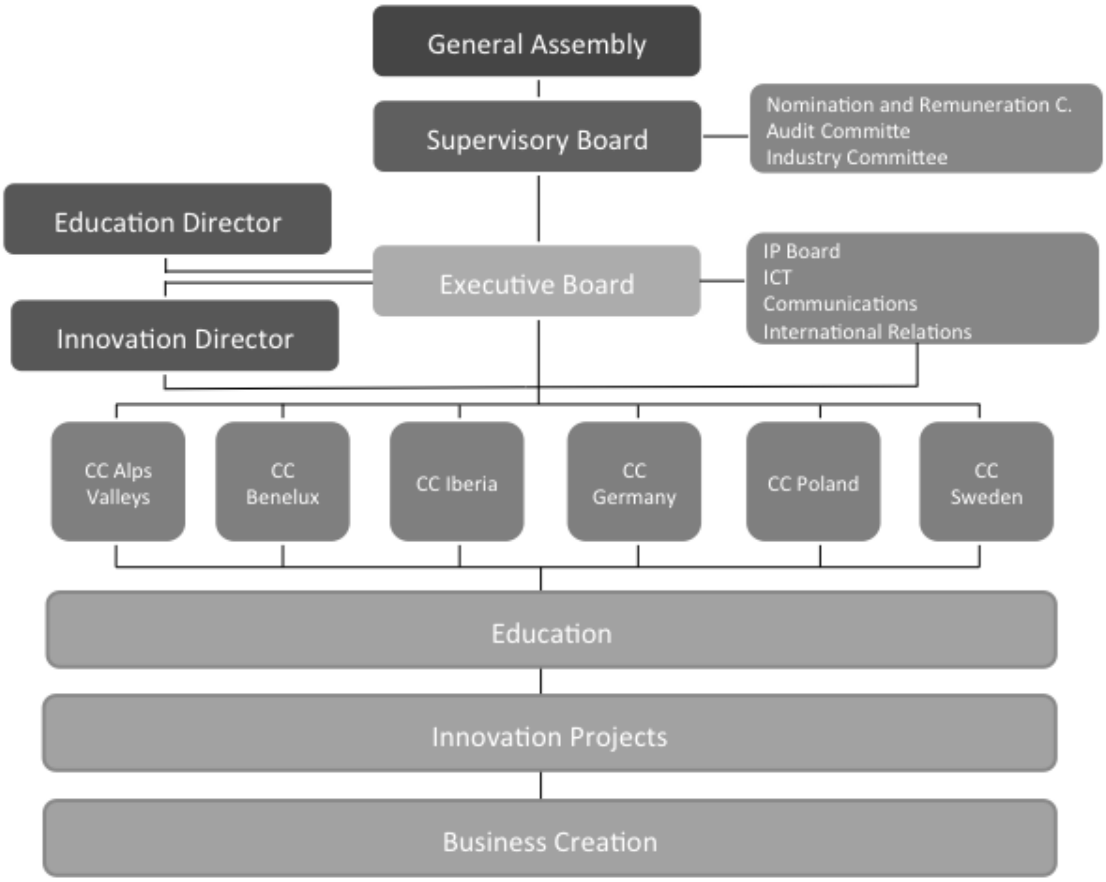
Source: KIC InnoEnergy (2012)

Each co-location centre (CC) is responsible for coordinating KIC InnoEnergy's joint expertise in a certain thematic area (KIC InnoEnergy, 2015b):

- CC Alps Valleys – Sustainable Nuclear and Renewable Energy Convergence
- CC Benelux – Intelligent and Energy-Efficient Buildings and Cities
- CC Germany – Energy from Chemical Fuels
- CC Iberia – Renewables (Wind, Concentrate Solar Power, Photovoltaic, Wave and Tidal Energy)
- CC Poland – Clean Coal Technologies
- CC Sweden – Smart Grid and Electric Energy Storage

KIC InnoEnergy has a hierarchical organisational structure as represented in Figure 19.

Fig. 19: KIC InnoEnergy Organogram



Source: KIC InnoEnergy (2014b)

The shareholders of KIC InnoEnergy form its General Assembly (GA). The GA is responsible for the general partnership agreement; appointment of Supervisory Board (SB) members; approval of strategy, annual accounts, and yearly budgets; appointment of CEO; admittance of new shareholders; and profit appropriation. Associated Partners are invited to participate in the GA, but they have no voting rights.

The Chief Science Officer (CSO), who is a shareholder member of KIC InnoEnergy, a deputy chairman, and thirteen board members form the Supervisory Board (SB). Half of the members from the SB are from the energy industry and the other half from universities. The SB is responsible for oversight and general direction of

KIC InnoEnergy, including the appointment of the Executive Board (EB). Three Committees support the decisions of the SB: Nomination and Remuneration Committee, Audit Committee and Industry Committee (formed by shareholders, associated and network partners).

A full-time devoted executive team has been appointed and is in charge of managing, coordinating and supporting the efforts of the KIC and the regional eco-innovation systems represented by each CC. The CEO (chief executive officer), the CFO (chief financial office), the SCOO (senior chief operations officer) and the COO (chief operations officer), the ID (innovation director), the ED (educational director), and the six CEOs of the CCs form the Executive Board (EB). The EB is responsible for elaborating and implementing the business strategy and the annual business plan, coordinating the cooperation between CCs, besides the day-to-day business. They have executive power over the management and finance of KIC InnoEnergy. An Intellectual Property (IP) Board, formed by shareholders, advise the EB on IP matters. The Educational Director is responsible also for managing an Educational Development Unit. The same applies to the Innovation Director, who is responsible also for managing a Business Creation Unit and an Innovation Network Development Unit (INDU).

Each of the six CCs, with their own organisation structure and managing a specific thematic area (as previously mentioned), is responsible for developing the activities of KIC InnoEnergy. These activities are divided in three pillars (KIC InnoEnergy, 2015b):

- *Innovation projects* – KIC InnoEnergy provides support for transforming available knowledge into new market products and services related to the field of sustainable energy that create positive impact on market and society.

- *New educational programmes* – which boost the capabilities and skills of students and middle managers, so they become the leaders of the future Energy sector or entrepreneurs in their own right. KIC InnoEnergy's educational activities cover a Master School with seven Master degrees [33], a PhD School, Executive Education and Post Master Programmes[34].
- *Business creation services* – through KIC InnoEnergy Highway[35], KIC InnoEnergy supports early stage start-ups in strengthening their technological business idea, the supporting business model, the team composition and the access to finance.

The output targeted, such as Master and PhD students, scientific articles, patents, spin-offs and start-ups as well as new products and services introduced to the market, is generated at CC level. Each CC represents in itself a complete innovation chain and enables the relevant stakeholders to work together on a regional and interdisciplinary scale. The activities of the CCs are strongly interwoven, with the development of joint

[33] These Master degrees are: Master of Science in Clean Fossil and Alternative Fuels Energy; Master of Science in Renewable Energy; European Master of Science in Nuclear Energy; Master of Science in Environmental Pathways to Sustainable Energy Systems; Master of Sciences in Energy Technologies; Master of Science in Smart Electrical Networks and Systems; Master of Science in Energy for Smart Cities.

[34] It includes Executive Master of Science in Energy Engineering and Management; Master of Science in Innovation and Entrepreneurship; Professional Doctorate in Engineering in Smart Energy Building and Cities, Learning Module on Social Innovation and Transition in Energy.

[35] KIC InnoEnergy Highway is a start-up accelerator, where selected entrepreneurs can have access to value added services for improving their business ideas. After a preliminary assessment in which KIC InnoEnergy evaluates the soundness and maturity of the business idea presented, the entrepreneurs sign up for a managed process. During this process, they work on improving four dimensions of the business idea, together with KIC InnoEnergy: technological, market, human and financial dimensions (KIC InnoEnergy, 2015b).

innovation projects and activities involving two or more CCs.

Funding to each CC is allocated according to the fulfilment of pre-defined key performance indicators (KPI) and benchmarking processes. Each CC will operate a specific yearly business plan, which is aligned with those of other CCs and subsequently integrated into an overall KIC InnoEnergy business plan developed by the EB. This process is elaborated in a bottom-up approach.

Access to KIC InnoEnergy was granted through CC Iberia. The organisation of this co-location centre will be discussed in detail in the following section.

b) Co-location Centre Iberia – Structure

With offices in Barcelona and Lisbon, CC Iberia is composed of five full partners and four associated partners as shown in Tables 15 and 16, respectively.

Table 15: KIC InnoEnergy CC Iberia – Number of Full Partners According to its Institutional Sphere

Institutional Sphere	Number of Participants
Business	1
Business School	1
Research Centre	1
University	2

Source: KIC InnoEnergy CC Iberia (2012)

Table 16: KIC InnoEnergy CC Iberia – Number of Associated Partners According to its Institutional Sphere

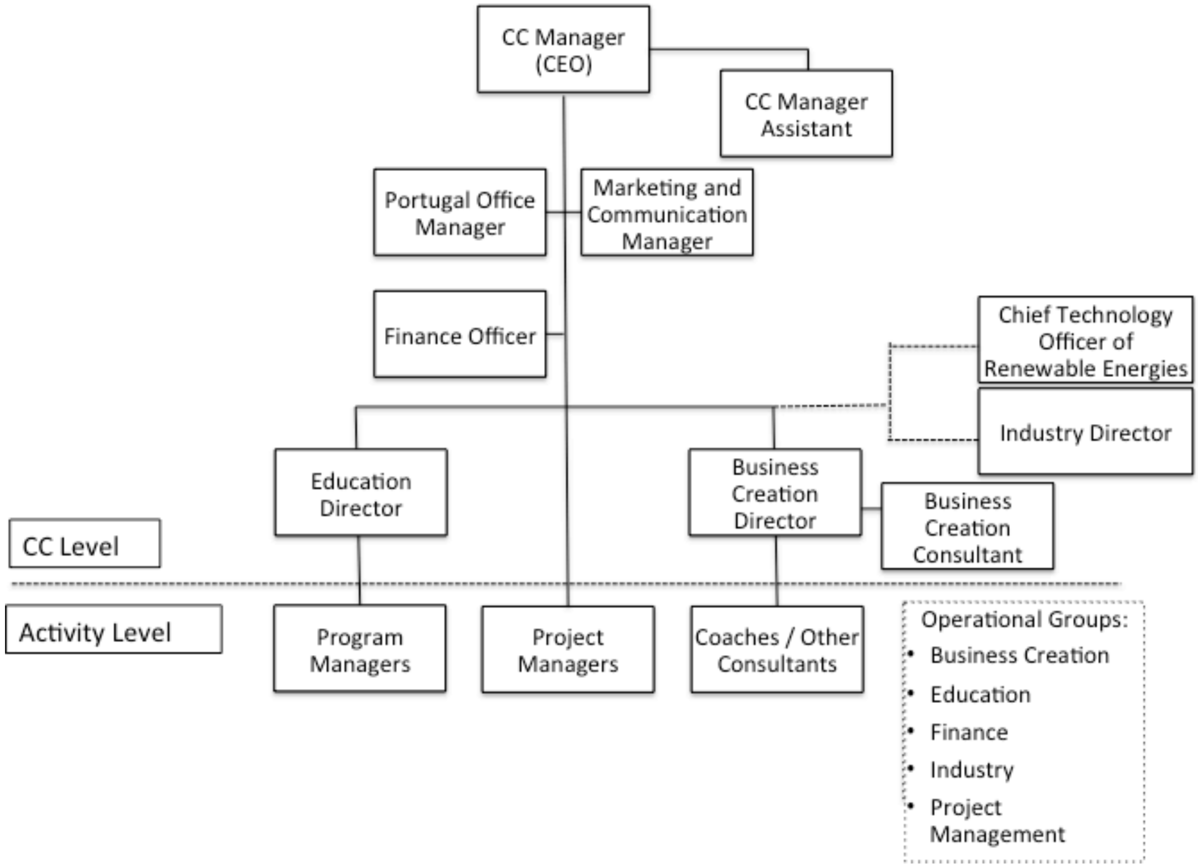
Institutional Sphere	Number of Participants
Business	2
Research Centre	2

Source: KIC InnoEnergy CC Iberia (2012)

CC Iberia offers the Iberian innovation community access to six different sustainable energy topics, which are addressed by KIC InnoEnergy. At the same time, it coordinates KIC InnoEnergy's expertise in the field of Renewable Energies. Currently, CC Iberia manages seven innovation projects (other five projects finished by December 2014). Besides, CC Iberia delivers European educational offers in Spain and Portugal related to four Master Programs and the PhD Program in Renewable Energy. Finally CC Iberia also serves as the Iberian entry point to the KIC InnoEnergy Highway, a European incubator specialised in sustainable energy. At present, twenty ventures are being nurtured in Renewable Energies.

The organogram of CC Iberia is presented in Figure 20. The CC Manager, the Portugal Office Manager, the Finance Officer, the Education Director, the Business Creation Director, the Industry Director and the Chief Technology Officer of Renewable energies are responsible for the management of the CC. The Project Managers of each Innovation Projects are under the supervision of the CC Manager. The Education Program Managers are under the supervision of the Education Director, while coaches and other consultants in activities related to business creation services are under the supervision of the Business Creation Director. The Project Managers, the Education Program Managers, coaches and other consultants are responsible for the operations of CC Iberia.

Fig. 20: KIC InnoEnergy CC Iberia Organogram



Source: KIC InnoEnergy CC Iberia (2012)

Within CC Iberia, the unit of analysis selected for this study is one of it Innovation Projects. This decision was based on its interdisciplinary, with the presence of different actors of the innovation chain jointly collaborating in these projects. For KIC InnoEnergy, innovation projects are the vehicles to transform available marketable products and services related to the field of sustainable energy that create positive impact on market and society by (KIC InnoEnergy, 2015b):

- Decreasing energy cost,
- Increasing security vis-à-vis resources holders,

- Increasing intrinsic operational safety or reliability, and /or
- Reducing Green House Gas emissions.

Such projects should normally present (KIC InnoEnergy, 2015b):

- A time to market shorter than five years from the beginning of the project,
- A maximum project duration of three years,
- The majority of the functionality of the system and/or its component has to be already proven at least at laboratory level (with proof of concept).

In order to be created, innovation projects need to be organised in a project consortium, with three to seven European companies and research organisations. After the consortium is created, a project proposal has to be submitted to KIC InnoEnergy. The evaluation process occur in two levels; at thematic field level (where an assessment committee check both admissibility and eligibility criteria in relation the a specific thematic field and rank all the proposals) and at KIC level (where a committee with representative from industry and academia review and rank all eligible proposal evaluations performed a thematic level using the same assessment criteria. The KIC level assessment committee then submit a ranked list to the KIC Executive Board for final decision). If accepted, a project agreement between KIC InnoEnergy and the consortium is signed, which includes details about the project scope, budget and work plan. It also includes a grant from KIC InnoEnergy to help co-finance the development of the product. This stage marks the formal start of the project.

The consortium then produces a feasibility study funded by KIC InnoEnergy, which includes a return on investment proposal (that covers all relevant dimensions of the business: technology, IP, market regulation, manufacturing, sales and finance) in case the product is successful in the market. If KIC InnoEnergy accepts the feasibility study and the return on investment (ROI), a preliminary ROI agreement is signed. During the development of the project, several assessment meetings take place, where the project manager has to report to the corresponding CC the project's evolution and correct any deviation. At the end of the project, KIC InnoEnergy and the consortium sign a ROI final agreement. A product/service is launched to the market through a commercialising party (who has to be a member of the project consortium). KIC InnoEnergy receives the agreed percentage on sales. The amount of revenues received by KIC InnoEnergy is proportional to the amount of sales. The profits are reinvested in new innovation projects.

The innovation project investigated as the unit of analysis in this study was the Offshore Test Station-Cross Fertilization of Offshore Renewable Energy (OTS).

b.1) Co-location Centre Iberia – OTS

OTS was designed with the purpose of developing new products and services related to the offshore renewable energy sector in the short term. With duration of four years (2011 to 2014), the project was initially aimed at promoting linkages among the three offshore renewable energy test sites in two different areas in Europe. This would yield the following results (KIC InnoEnergy, 2015c):

- Innovative components and systems
- New instrumentation, monitoring, simulation and controlling tolls,

- Recommendations and best practices,
- Training.

To achieve this, two sub-projects were designed with specific missions. These were (KIC InnoEnergy, 2015c):

a. Acoustic underwater environmental modelling and monitoring tool: develop cost-effective environmental monitoring and long-term analysis tools for disturbance (due to sound propagation in water) and impact on marine life adapted for offshore plant requirements. These are issues of great societal concerns and can be seen as non-technical hinders/barriers for the development of offshore installations in general, and renewable conversion in particular. By developing reliable models and techniques for passive and/or remote monitoring for real offshore locations, not suitable for longer human presence, the objective is to produce products that can mitigate such circumstances and thus reduce the efforts needed through safe, reliable and cost effective equipment and methodologies. Two products/services were produced: buoy with hydrophone and other environmental sensors and data transmission system, and 3D sound propagation tool (for mapping sound propagation from a given point).
b. Software for operations and maintenance planning: holistic integrated software for support operation and maintenance activities with appropriate computational tools (with features not existent in the market) in order to reduce capital and operational costs, environmental impacts, and increase safety in offshore renewable energy farms. Such software has three modules: offshore energy production forecast, integration of data from different operation and

maintenance sources and risk assessment tools, recommendations for operations and maintenance cost reduction and risk minimisation strategies.

Nine partners from three European countries formed OTS: one business school, one research centre, three universities, and four were from business partners. Throughout the project, four partners left the project (two research centre and two companies). The project management structure consisted of two bodies (KIC InnoEnergy, 2011b):

a. Project Management Board (PMB): which included the Project Manager (who was a member of a business partner, as required by KIC InnoEnergy), the Associated Project Manager (who was also a member of a business partner), and the Project Coordinator (who was a member of a research centre). During the development of the project, the Associated Project Manager became the Project Manager.
b. Project Steering Board (PSB): this board included one representative from each partner, the Project Coordinator, the Associated Project Manager (who later withdraw from the project) and the Project Manager.

The Project Coordinator was responsible for the overall coordination of the project and headed both the PMB and PSB. He was also responsible for preparing the initial proposal of OTS. The PMB met monthly (at least once each trimester in a physical meeting) in order to monitor the project and take the necessary steps to ensure a smooth project progress according to PSB decisions. The PSB met every month (either through telecom or face-to-face) to monitor the project and provide the necessary guidance for the next month of the projects, including funding reallocations and new partners acceptance.

The Project Manager was responsible for running the project on a day-to-day basis and establishing smooth links to CC Iberia, KIC InnoEnergy, project partners and the wider industry. He was responsible for the reporting of the project, both to the KIC structure and internally. Additionally, the Project Manager visited all the partners in a regular basis (at least once every six months). He was also responsible for identifying and promoting innovation and funding opportunities and routes to commercialisation and assuring project dissemination. OTS members developed individually their tasks, at their home institutions, and had regular meeting, through telecom conference or physically at least twice per year.

The total funding of the project was € 600 thousand per year, KIC InnoEnergy funded more than 70% of this amount (KIC InnoEnergy, 2011b).

1.2. ATLAS Experiment at CERN

1.2.1. European Organisation for Nuclear Research (CERN) and Its Experiments

The European Organisation for Nuclear Research (CERN) is a European research organisation that operates the largest particle physics laboratory in the world. Established in 1954, the organisation is based in the Franco-Swiss border (as represented in photo 1) and has 22 member states. The term CERN is also used to refer to the laboratory that provides the particle accelerators and other infrastructure needed for high-energy particle physics research. Most of the activities at CERN currently involve operating the Large Hadron Collider (LHC), and the experiments for it. The LHC represents a large-scale, worldwide scientific cooperation project.

The LHC tunnel is located 100 metres underground, in the region between the Geneva International Airport and the nearby Jura Mountains. It uses the 27 km circumference circular tunnel previously occupied by the Large Electron-Positron Collider (LEP), which was shut down in November 2000. The four main LHC experiments (ATLAS - A Toroidal Large Hadron Collider Apparatus, CMS – Compact Muon Solenoid, ALICE – A Large Ion Collider Experiment, and LHCb – Large Hadron Collider Beauty) are expected to contribute to the study of particle collisions from a different aspect, and with different technologies. This study will further investigate ATLAS Experiment at CERN.

Photo 1: Visual Representation of the LHC and its Four Detectors

Source: Caryl (2015)

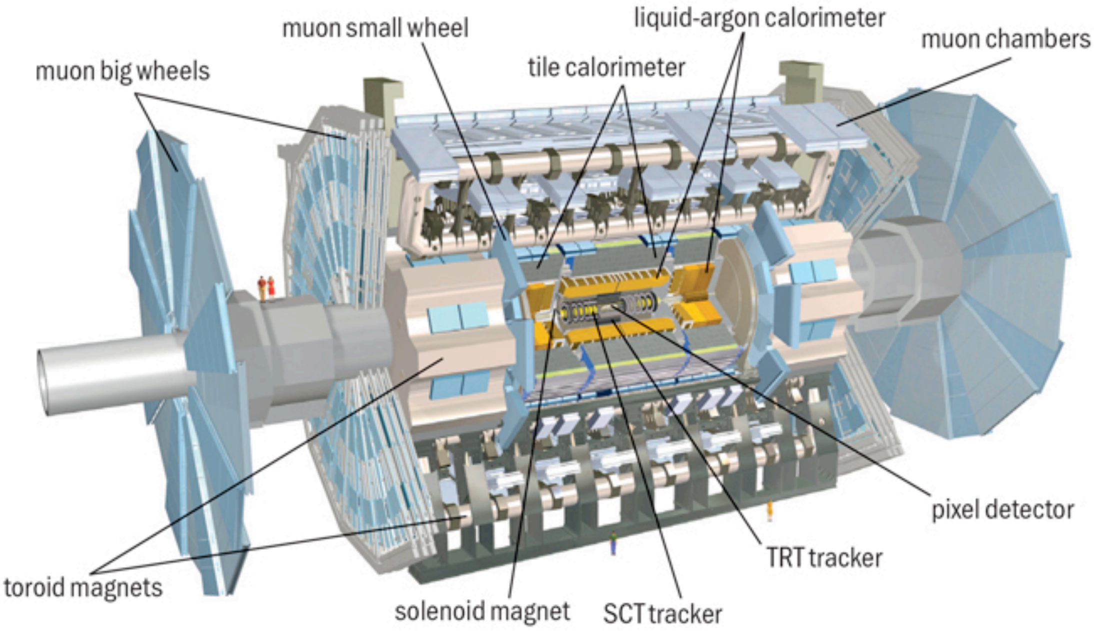
1.2.2. The ATLAS Experiment

ATLAS is a high-energy physics detector built by an international community of researchers and CERN (The European Organisation for Nuclear Research) in the border of Switzerland and France. The ATLAS detector is 45 metres in length, 22 metres in diameter, and weights about 7,000 tones. It is built to register particle collisions at the LHC and to analyse the products of such collisions. In effect, the LHC accelerates particles – protons – in opposite directions at speeds very close to that of light before smashing them together. The colliding protons produce new, elementary particles that allow researchers to probe deep into the structure of matter and help them reconstruct the state of the early universe just fractions of second after the Big Bang, some fourteen billion years ago. In layman's terms, the detector can be thought of as a giant microscope that is coupled to a digital camera. It zooms in on the collisions taking place in the LHC at a scale way below what can be seen by the naked eye and tries to make sense of them. To capture one billion collision events a second, the ATLAS detector has to take about 40 million snapshots a second, each with an image resolution of about 100 megapixels. Only 200 of these snapshots end up being stored every second to be made available for further analysis (ATLAS, 2011).

Because of the much higher particle-collisions energies and production rates it achieves compared to existing accelerators, it might shed light on new theories of particle physics beyond the Standard Model. The detector was designed to maximise the potential for new physic discoveries, without sacrificing the ability to perform high-accuracy measurements of known objects. For instance, in July 2012, ATLAS was one of the two LHC experiments involved in the discovery of a particle consistent with the Higgs boson.

The detector is probably one of the most complex pieces of machinery ever built. Its design is the fruit of a slow process of scientific and technological evolution that was marked by many trials and error. Sophisticated software engineering tools were used to produce over 3,700 engineering assemblies and 10 million functional elements. The overall ATLAS detector layout is shown in the figure bellow (fig. 21), which indicates the different areas of ATLAS.

Fig. 21: The ATLAS Experiment Layout



Source: ATLAS (2015a)

In brief, the ATLAS detector can be divided into five major parts, each of these is in turn made of multiple layers:

- The **inner detector** tracks the trajectories of particles precisely,
- The **calorimeters** measure the energy of easily stopped particles,
- The **muon spectrometer** makes additional measurements of highly penetrating muons,
- The two **magnet systems** bend the trajectories of charged particles in the Inner Detector and the Muon Spectrometer, allowing to identify and measure them, and,
- The **trigger and data-acquisition system** collects, transfers, and stores the digitised collision-event data for later physics analysis.

The ATLAS collaboration, the group of physicists who built and now run the detector, was formed in 1992 when the proposed EAGLE (Experiment for Accurate Gamma, Lepton and Energy Measurements) and ASCOT (Apparatus with Super Conducting Toroids) collaborations merged their efforts to build a single, general-purpose particle detector for the Large Hadron Collider. The design was a combination of the two previous experiments, and also benefitted from the detector research and development that had been done for the Superconducting Supercollider. The ATLAS experiment was proposed in its current form in 1994, and officially funded by the CERN member countries[36] in 1995. Additional countries, universities, and laboratories joined in subsequent years, and further institutions and physicists continue to join the collaboration even today. Construction work began at individual institutions, with detector components then being shipped to CERN and assembled in the ATLAS experiment pit from 2003 (ATLAS, 2015a).

The material costs were 540 million Swiss Francs (over 495 million Euros) – CERN as a member of the experiment contributed with 14% - and it was completed in 2008 and the experiment detected its first single beam events on 10 September of that year (Giudice, 2012). Data taking was then interrupted for over a year due to an LHC magnet quench incident[37]. On 23 November 2009, the first proton-proton collisions

[36] CERN has 22 member states: Austria, Belgium, Bulgaria, Czech Republic, Denmark, France, Germany, Greece, Hungary, Italy, Israel, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Spain, Sweden, Switzerland, United Kingdom.

[37] On 19 September 2008, a magnet quench occurred. It occurs when one of the superconducting magnets that steer and focus the particle beams warms above a critical temperature and the magnet quench. During a quench, the wire becomes resistive and therefore generates heat. The magnetic field is lost, leading to a loss of liquid helium and bringing operations to an abrupt halt. In the LHC, a loss of approximately two tones of liquid helium was vented into the tunnel before detectors triggered an emergency stop. The escaping vapour expanded with explosive force, damaging over 50 superconducting magnets and their mountings, and contaminating the vacuum pipe, which also lost vacuum conditions. The cause of the problem was a faulty electrical connection between two magnets.

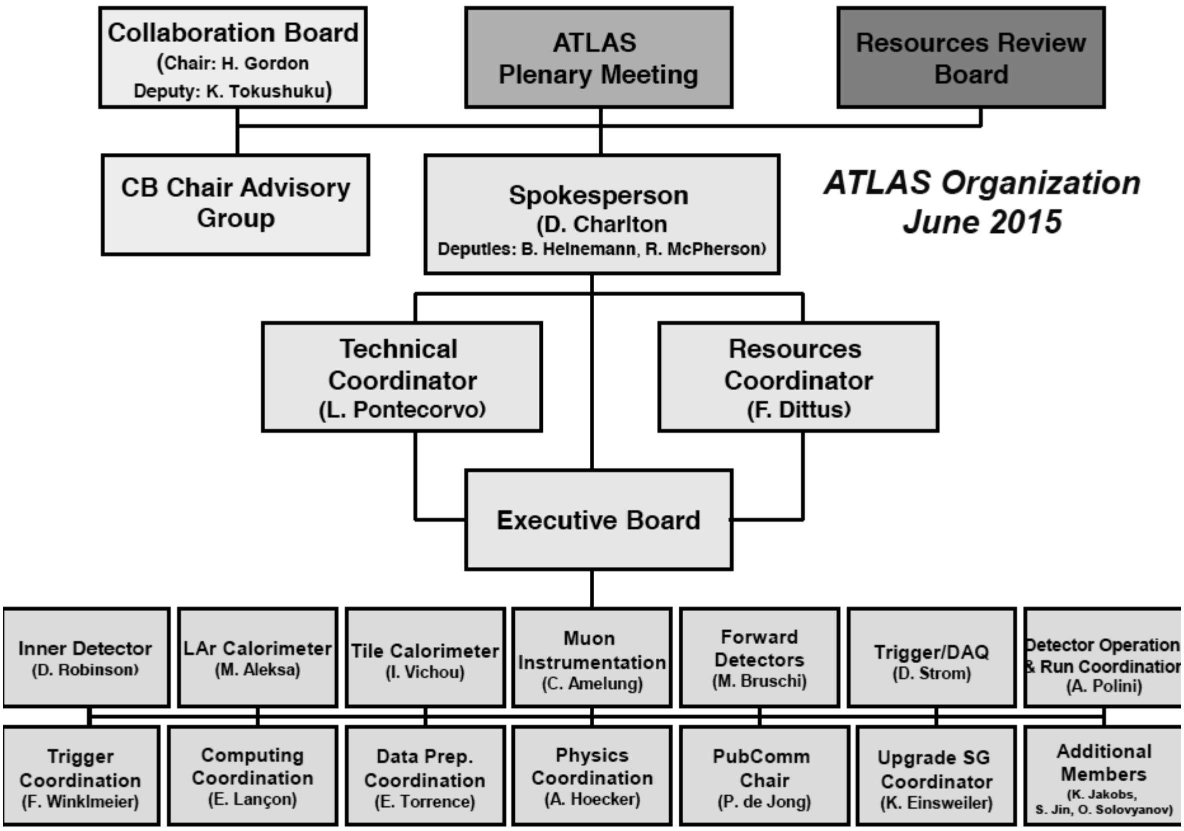
occurred at the LHC, at relatively low injection energy of 450 GeV per beam. These collisions were successfully registered in ATLAS, which has been logging data ever since. All the while LHC energy has been increasing: 900 GeV per beam at the end of 2009, 3,500 GeV for the whole of 2010 and 2011, then 4,000 GeV per beam in 2012 and finally 6,500 GeV per beam after a long shutdown in 2013 and 2014 (ATLAS, 2015a).

The sharing of construction rights and responsibilities, its objectives and related financial costs were described in a formal agreement entitled Memorandum of Understanding (MoU) for Collaboration in the Construction of the ATLAS Detector. In 1998 it was signed by both CERN, as the host laboratory for the LHC, and the ATLAS funding agencies (in 2015, it was composed by 77 agencies from 40 countries) (ATLASb, 2015). Responsibilities for maintenance and operation procedures, monitoring its functioning, annual maintenance and operation budgets of the ATLAS detector are established in a separate Memorandum of Understanding on Maintenance and Operation Procedures (M&O MoU). The host laboratory provides the high-energy beams and related infrastructure for scientists to use, but responsibility for the design, construction, and operation of a given detector resides with the community that sponsors and undertakes a particular type of experiment. Although the MoU is not legally binding, the Institutes and Funding Agencies recognise that the success of the Collaboration depends on all its members adhering to its provisions.

a) The ATLAS Experiment – Structure

With 3,000 scientists (around 1,000 graduate students), ATLAS detector is a big and global experiment. The collaboration's organisational structure is depicted in the figure 22 (ATLAS, 2015a).

Fig. 22: The ATLAS Experiment Organogram



Source: ATLAS (2015a)

The Plenary Meeting is the forum of the all-hands discussions. All major ATLAS decisions concerning physics objectives and results, hardware and software design, and organisational matters must be discussed in the Plenary Meetings and, if appropriate, in subdetector Working Group meetings.

The Collaboration Board is the policy and decision-making body of the ATLAS Collaboration. Each participating institution in the ATLAS detector has in general one representative (some may have up to two) in the Board, which is also composed by the members of the Executive Board (ex officio). All participating institution has equal rights on the Collaboration Board and only one vote. The Chairperson of the Collaboration Board is elected ad personam. The term of office is two years and is not renewable. After the first year of office, a deputy is elected who will become the chairperson's successor. After the end of the chairperson's term of office, the chairperson will serve for yet another year as deputy. The chairperson may nominate an advisory group, the members of which will be elected by the Collaboration Board upon proposal of the chairperson for the duration of the chairperson's term. Typical tasks of the Board are: decisions on global detector design, policy matters, financial and human resources, elections, ATLAS organisation and membership. This Board has weeklong meetings (ATLAS week) three times a year to agree and decide upon ATLAS's global science policies, such as, how scientific papers are going to be produced and published (ATLAS, 2015a).

As defined in the MoU, the overall execution of ATLAS is the responsibility of the ATLAS Management led by the Spokesperson. The Management is a team of five people: Spokesperson, two Deputy Spokespersons, Technical Coordinator, and Resources Coordinator. Their mandate lasts for two years, after this period members return to their activities in the experiment. The Spokesperson and Deputy Spokespersons have the responsibility to globally overview all aspects of the ATLAS project, and to react appropriately. The Spokesperson represents ATLAS with respect to CERN, funding agencies and other outside bodies, to delegate gently to guide and, when requested to do so, to arbitrate. He has no direct hierarchical power over the scientists working on the project, they report back to their respective home institution (ATLAS, 2015a).

The Technical Coordinator is responsible for the common projects (that are those ATLAS components to which individual institutes either do not wish, or are technically unable, to commit) and the technical integration of all ATLAS components. He should also overview the implementation of ATLAS engineering standards and procedures, and monitors the detector construction. Activity managers assist the Technical Coordinator. The Resources Coordinator is responsible for the overall resource planning, and to ensure that the ATLAS resource needs are consistent with the different local national planning. The Resources Coordinator is also directly responsible for the administration of the ATLAS common fund (CERN, 2015).

The Spokesperson, Deputy Spokespersons, the Technical and Resource Coordinators and the coordinators of the subdetector systems or other major activities all form the Executive Board. Such composition will be adapted to the needs of the experiment. The members of the Executive Board are elected for a term of office of two years, renewable with a 2/3 majority. It is chaired by the Spokesperson, with the Technical Coordinator as deputy chairperson. This Board directs the execution of the ATLAS project in line with policies set by the Collaboration Board. The Executive Board is responsible for the design, construction and operation of ATLAS within the available resources (CERN, 2015).

All matters related to the use of resources and requiring interactions between the ATLAS Collaboration and the funding agencies are dealt within the Resources Review Board. This Board meets twice a year and is chaired by CERN's Director of Research. In these meetings, the ATLAS Management provides a status report on the progress of ATLAS, on the use of funds provided by the funding agencies, and seeks endorsement for both its annual construction budgets and its subsequent operating ones (Jenni et al., 2011).

In addition, ATLAS bodies include 13 subdetector systems, which are responsible for maintaining and operating specific parts of the ATLAS detector (inner detector, calorimeters, muon detector, trigger /data acquisition, and forward detectors) and groups responsible for overall coordination tasks (computing, commissioning, operation and run, trigger, data preparation, physics, public communication, upgrade and additional members). The representatives of member Institutions of a Subsystem constitute the Institution Board of that Subsystem. All major project management positions are elective, and appointments to them require a majority vote. The voting system is designed to encourage rotation in these positions. Project managers help to foster horizontal coordination across the collaboration's numerous institutions and activities, rather than to establish some kind of supervisory relationship with their colleagues (ATLAS, 2015a).

Within the immense universe of ATLAS experiment, the unit of analysis of this study is the subdetector system Tile Calorimeter. It will be discussed in the following section.

b) Tile Calorimeter

ATLAS calorimeters (electromagnetic and hadron) are situated outside the magnet that surrounds the inner detector (as shown in figure 22). Their purpose is to measure the energy from particles by absorbing it in high-density metal and periodically sample the shape of the resulting particle shower, thus inferring the energy of the original particle from this measurement. The hadron calorimeter (or Tile Calorimeter –

TileCal) absorbs energy from primarily hadron particles. The main part of the calorimeter – the tile calorimeter – is 8 metres in diameter and covers 12 metres along the beam axis. 600,000 steel plates are interleaved with 408,000 plastic scintillating tiles. Incoming particles interact with the steel, creating a shower of other particles. This shower goes on to interact with the plastic tiles where its energy is transformed into tiny flashes of light, called scintillations. All this light is then carefully collected in optical fibres and transferred out of the detector. Its total intensity reveals the energy of the original particle (TileCal, 2015). Photo 2 shows the assembly of the optical fibres for the Tile Calorimeter.

Photo 2: Assembly of the Tile Calorimeter

Source: ATLAS (2015a)

The TileCal was constructed in three sections, one barrel and two extended barrel calorimeters, comprising 64 units (termed modules), which were assembled on each other to form cylinders. A key design constraint was to have a minimum gap between modules and the fabrication and assembly tolerances provide for a design of 1.5mm (TileCal, 2015). The TileCal is now twenty-three years old, dating back to the first R&D Program in 1992. In 1995, the Technical Design Report was completed. Final module production began in 1998. And in 2006 happened the installation of the final module in the ATLAS Cavern. Module construction was carried out at three collaborating institutions (Argonne National Laboratory in the USA, JINR Dubna in Russia, and IFAE – Institute of High Physics in Spain) where appropriate facilities for handling and storage were available. Each of these institutions was assigned the task of construction of one of the major sections of the full calorimeter plus a spare one (TileCal, 2013).

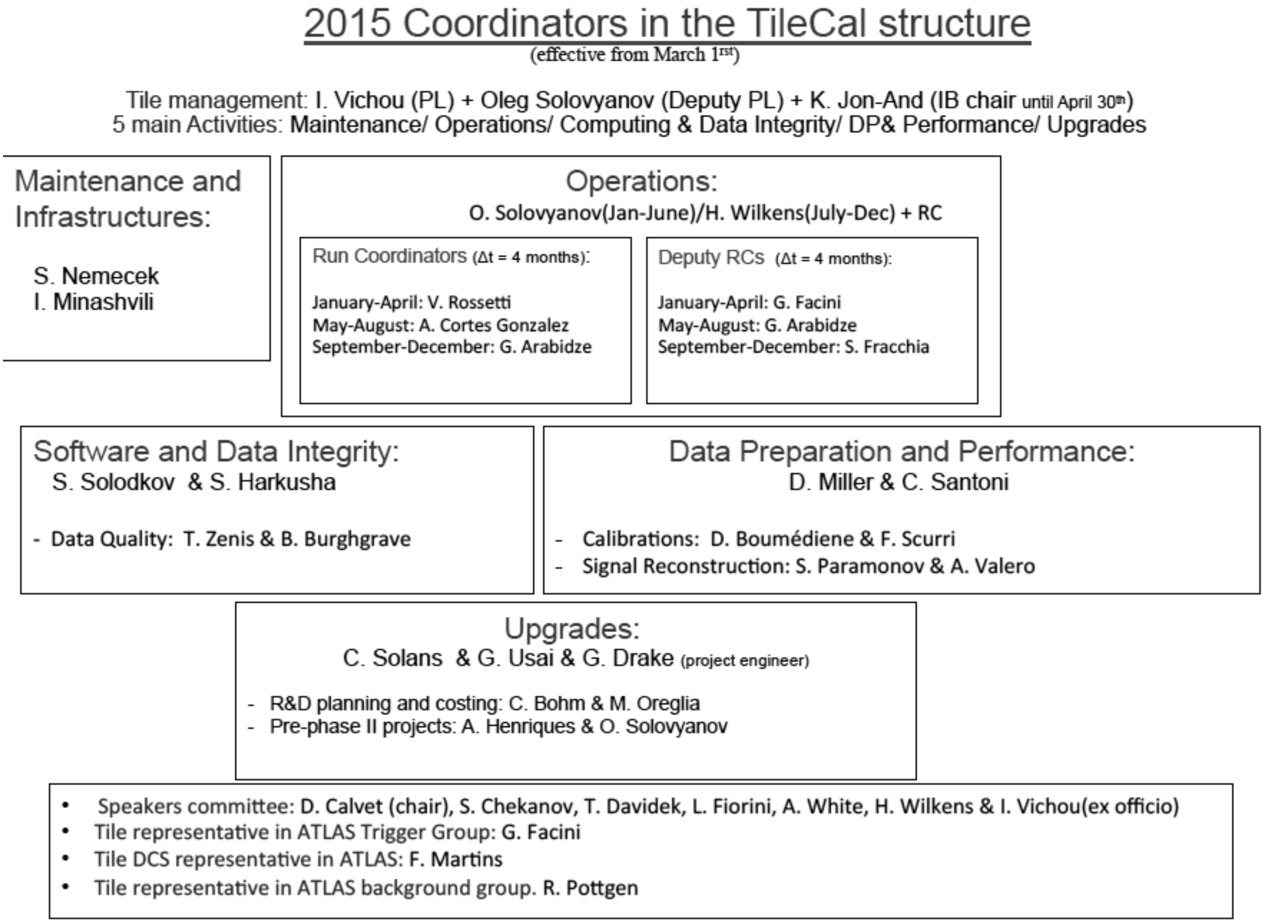
Submodules were constructed at seven institutions (Argonne National Laboratory at the University of Chicago, IFAE, the University of Valencia, Pisa University, Charles University in Prague, JINR Dubna and IHEP in Russia). Submodule construction was subject to a detailed quality control, which was developed during design and submodule prototyping, to insure uniform production throughout the submodule construction sites. In conclusion, following an odyssey of over 12 years, the ATLAS Tile Calorimeter was designed, constructed, and installed to specifications in the ATLAS cavern (TileCal, 2015) as shown in photo 3.

Photo 3: The Tile Calorimeter Goes Down in The ATLAS Experiment Cavern

Source: ATLAS (2015a)

The TileCal structure is organised in two axes: Tile management and its activities, as represented in Figure 23. A project leader (PL), a deputy project leader and internal board (IB) chair form the Tile Management. The five main activities of TileCal are maintenance and infrastructures, operations, software and data integrity, data preparation and performance, upgrades. A coordinator and a deputy manage these activities. TileCal has also a speakers committee, with a chair and six other elected members, a representative in ATLAS trigger, Detector Control Web System (DCS) and background group (TileCal, 2015).

Fig. 23: The Tile Calorimeter Coordination Structure



Source: ATLAS (2015a)

TileCal community is formed of around 150 authors and 250 collaborators including the engineers and the technicians from 26 different institutes around the world. Within these institutions, this study had the opportunity to visit the facilities and interview members of the IFAE, which also designed, fabricated and run extensive tests of the electronic readout and of the calibration systems of the TileCal. IFAE is a public consortium between the Government of the Autonomous Community of Catalonia and the Universitat Autònoma de Barcelona (UAB). Even though, it is an independent organisation, ruled by its own statutes and governed by a Governing Board. It is located on the campus of UAB in Bellaterra, Barcelona (Spain). Created in 1991, it has its own personnel as well as associated personnel consisting of members of the Physics

Department of UAB working on Particle Physics. The institute is dedicated to forefront experimental and theoretical research in the fields of high-energy physics and high-energy astrophysics as well as related technologies. Among its current projects, IFAE had and still has a major role in ATLAS Experiment (IFAE, 2015).

1.3. Brief Comparison Between the Two Cases

KIC InnoEnergy and ATLAS Experiment are both examples of innovation networks as their primary focus is on fostering an environment where collaboration among diverse members is promoted with the goal of enabling innovation (Dhanaraj & Parkhe, 2006; Hoberecht et al., 2011). To do so, these networks have created innovative elements so collaboration could take place. In the case of KIC InnoEnergy, innovation lies on the application of previously developed research into commercial product /services. In the case of ATLAS Experiment, new technologies (such as the components of the detector and the GRID computing technology) and the architecture for them had to be developed so that physicists could conduct basic research on particle physics. In addition, these two cases are also considered as innovation networks as in fulfilling their goals, they are also bringing organisational innovation.

Aside from these similarities, these networks were conceived based on different purposes and, as so, have different organisational structures and characteristics. KIC InnoEnergy was established in 2010 from a call of the European Commission to create the Knowledge and Innovation Communities (KICs) to address Europe's innovation gaps and shortcoming. Legally established as commercial company, KIC InnoEnergy aims at creating value by bringing technology to the market, while supporting entrepreneurship. Hence, its focus is on exploitation of previously developed research into commercial product /services.

To accomplish such aim, 27 shareholders (formal partners) and more than 150 additional partners (including associate and network partners) form KIC InnoEnergy. Although the majority of partners are engineers, working in fields related to sustainable energy – with the exception of the business schools –, diversity among them is high not only because of the large number of participants in the network but also as they belong to industry (large corporations as well as SMEs), research centres and universities from nine countries. In order to manage this diversity, KIC InnoEnergy has a formal structure of management, with an elected body of leadership devoted to manage, coordinate and support the efforts of the network. Such structure is output-oriented, with performance measured through specific indicators. Decision-making process is mainly done at the top-level of the network, where authority is exercised through formal positions.

On other side, ATLAS Experiment was formed in 1992 when other two collaborations decided to merge their efforts to build a single, general-purpose particle detector. Influenced by these previous experiment and the idiosyncratic characteristics of the field of High Energy Physics (HEP), both have largely influenced how the ATLAS Experiment is structured and functions. Driven by its exploration goals on conducting basic research to observe phenomena that involve highly massive particles that were not observable before, ATLAS was constituted as a loosely coupled collaboration of 3,000 independent scientists from 174 universities and laboratories located in 40 countries. Although there is a large number of collaborators participating in ATLAS Experiment, they are more homogenous since the majority are physicists (with the exception of engineers) working with related fields to high-energy particle. This allows a horizontal structure characterised by a much more flexible and fluid set of arrangements, embedded on high levels of trust, complementary expertise and ready to respond to changing environmental conditions. Besides, the decision-making process follows a bottom-up approach, where knowledge can be located anywhere in the network and (technical) decisions are taken at group level based on consensus.

This brief comparison of the main characteristics of the two cases is summarised in the table 17 that follows.

Table 17: Basic Comparison Between KIC InnoEnergy and ATLAS Experiment

Innovation Network	Establishment	Members	Typology of Partners	Mission	Focus	Organisational Form	Decision-making	Authority
KIC InnoEnergy	2010 – early stage of development	27 shareholders +150 partners	More Heterogeneous: industrial partners (large corporations, SMEs), business schools, engineering universities, research centres	To build a sustainable long-lasting operational framework in the energy sector involving industry, research and higher education; and ensure that this integration is more efficient and has a higher impact on innovation than the three standing alone	Exploitation	Company	Mainly top-down, centralised	Formal positions
ATLAS Experiment	1992 – advanced stage of development	3,000 scientists from 174 universities and laboratories located in 40 countries	More Homogeneous: physicists, engineers	To search for new discoveries in the head-on collisions of protons of extraordinarily high energy. To learn about the basic forces that have shaped the Universe since the beginning of time and that will determine its fate	Exploration	Project within a community (Memorandum of Understanding)	Horizontally distributed / collegiate, consensus-based	Expertise and years participating in the collaboration

Source: own author

Chapter 5

ANALYSIS AND RESULTS

In this chapter the empirical findings of this research are discussed and explained in detail. First, it is presented the findings and analysis of case 1 (KIC InnoEnergy and OTS Project), followed by case 2 (ATLAS Experiment at CERN and Tile Calorimeter).

In order to better understand the different innovation networks and to present authentic parts some direct quotes by interviewees were included. It is believed that this give the reader a better idea of the rich material that was gained with the interviews. The interviews are referred by its ordinal number and the position of the interviewee in the innovation networks. As we were interested in the information and not on the discourse, the quotes include mainly the message, not the way it was spoken. In this study we also dismissed the sex of the interviewees and therefore the informants are referred here only as persons. Some interviews have been translated into English by the researchers as they were originally conducted in Spanish, in Catalan and in Portuguese. Yet, special emphasis has been put to capture the essence of original data to avoid possible biases.

1. Findings and Analysis from Case 1 - KIC InnoEnergy and OTS Project

Embedded in an environment of change in the perception of how innovation should be fostered and developed in Europe, KIC InnoEnergy was created. Besides the overall European context, KIC InnoEnergy is also embedded in the very specific context of the energy sector, characterised by a highly regulated market, with many powerful and experienced competitors (mainly industry and universities), which requires heavy investments (also in technology) and that has certain constraints. Such contextual embeddedness surely had an impact on the way KIC InnoEnergy was organised, adjusting its structure and goals in order to comply with this changing context.

KIC InnoEnergy was established as a private company, driven by applied research with actions oriented toward launching innovative sustainable energy products and services.

Vignette 26: "KIC InnoEnergy is a product oriented company. We deliver things. And our product has three things: talents (specialised and new), innovation to change the current processes of sustainable energy and to change it for better (more secure, less costly, more operational and less contaminate) and to create use for it. We need to understand what KIC is doing to people contribute, to understand, to respect, to work together, to add. KIC needs to be converted completely into an output-driven company, close to the market and to the industry" (Source: KIC Family Day - CEO, 2011)

When joining KIC InnoEnergy partners have to sign a formal contract, where entry and leave conditions are stated as well as partners' rights and obligations. To manage and coordinate its activities, KIC InnoEnergy has got a tight management structure. Following Provan and Kenis (2008) study on the forms of network governance, KIC InnoEnergy has a network administrative organisation (NAO), where network members established a separate administrative entity to govern the network and its activities. A formal organisation, consisting of a CEO, CFO, Directors, different board structures and staff (for detailed explanation please see figure 19) operates out of a physically distinct office (McEvily & Zaheer, 2004). Partners are represented in the General Assembly and Supervisory Board, where they set objectives, strategic goals and supervise the executive team, but they are not involved in the management of the network. In this way, partners go on with their business as usual and delegate part of their power and resources to a parallel independent organisation with clear objectives, and with distinctive features like stability, leanness and highly result-oriented.

Coordination is done hierarchically through formal coordinating mechanisms and clear roles. These include a top-down organisational decision-making process, many structural coordination bodies (as mentioned in the previous paragraph), planning and the control of results and behaviours through budgets, technical reports, performance indicators, evaluations and feedbacks (Reger & Gerybadze, 1997). Information diffusion is limited and under central hierarchical control (Boisot, 2011), being distributed through a vertical channel of communication. In other words, it is a management that wants to be noticed.

As previously mentioned, 27 full partners and around 150 additional partners compose KIC InnoEnergy. Partners affiliation depends not only in terms of type of membership (for detailed explanation, please see figures 15, 16 and 17), but also in terms of dedication to KIC InnoEnergy (there are members who are paid employees by KIC InnoEnergy, while there are others who are paid by their home institutions and therefore they work part-time at KIC; and there are also PhD students doing research or enrolled in one of educational courses promoted by KIC InnoEnergy). Although members have different reasons to join KIC InnoEnergy (mainly due to the reputation of participating in a EU project or to get access to funding), they do not need to share values and beliefs, as they are submitted to superordinate goals.

Vignette 27: Partner 1 (CFO/economist): "Our priorities are different because of the person, the institution, the partner. So, this is a new dimension making interesting constellations and we need to work within it and this is a great challenge, but we share the same enthusiasm […] Partners may have different objectives to participate in this beautiful endeavour."
Partner 2 (social scientist): "But there is a common vision. It's written and official."
Partner 3 (engineer): "Ok, one thing is that it is published other that it is shared. So we now need to internalise it […]"
(Source: In-Company Training, 2012)

Aside from the large size of participants, heterogeneity of partners is reflected on different levels of proximity. The fact that partners belong to different European countries makes the level of geographical proximity among network partners to be low. However, this is not an issue to KIC InnoEnergy as different mechanisms (such as the co-location centres, face-to-face meetings, conferences, and annual events) are employed to create a temporary geographical proximity, thus promoting and facilitating interactions between partners (Torre, 2008). Such temporary proximity also helps on promoting trust, and consequently, increases the degree of social proximity between partners, as only some few had prior relations (ECORYS, 2012).

Vignette 28: "More than being from different countries, the main difficulty is the scope of KIC and to cope with the existing mindsets that the different partners have, normally from universities and other institutions. Universities are very technological driven […]" (Source: OTS Interview project manager)

Vignette 29: Partner 1 (engineer): "We are different because of

geographical distance. Diversity from Spain, Portugal, Poland […]"
Partner 2 (social scientist): " Yes, but we are talking about differences. We are different because of our nature. Our countries do not affect our collaboration"
(Source: In-Company Training, 2012)

Vignette 30: "Cultural diversity has less importance each day… People are diverse but they share a nucleus, especially if they work together... besides, there is an internal culture of a business company in KIC InnoEnergy […]" (Source: OTS interview project participant 5 – social scientist)

Cognitive proximity between partners is moderate-high because the majority of partners are engineers working on fields related to sustainable energy, what creates similarities in the way they perceive, interpret, understand and evaluate the world (Nooteboom, 2000). However, as partners belong to different institutional spheres (large industrial partners, SMEs, universities and research centres), they have different habits, rules and routines, affecting the sharing of knowledge (Boschma, 2005). Caniëls et al. (2014) suggest that institutional proximity can be stimulated by organisational and social proximity through the development of common codes of conduct. However, since KIC InnoEnergy is at its early stage of development, organisational proximity within its partners is still being created.

Vignette 31: "KIC InnoEnergy is about creating an engine for innovation and entrepreneurship. And you have seen that we have got different interpretations. But all of them add together. It would be quite disturbing to run a company without everybody being on the same page […]" (Source: KIC Family Day - CEO, 2011).

Vignette 32: "We have got teams from many origins and from different institutions […] They have to change the way they view things and this is hard for them as they have been their whole lives working like this We are changing the mindset of people through meetings, guidelines, reviews of projects. We are working on the diversity so as people who come from different institutions can work together in a better way. We are launching a project to train project leaders. So, these are some of the things that we are currently doing in order to change the mindset of people, but it will take some time. We have many things to fix and many organisational problems to still consider" (Source: OTS interview CC manager)

At KIC InnoEnergy level, it was possible to notice during data collection (through participant and direct observation) that such diversity of partners led to moments of internal conflicts. For instance, it was possible to observe goal conflicts between partners and KIC InnoEnergy. In KIC InnoEnergy, partners had to achieve certain goals that were very different or inconsistent with those settled in their home organisations.

Vignette 33: Partner 1 (social scientist): "We have got different expectations from KIC InnoEnergy because we are measured in a different way in our institutions".
Partner 2 (engineer): "The dean at the end of the year will ask me [university professor] about articles and not number of products released and start-ups. So, I am embedded in an institution that measures my performance differently from KIC"
(Source: In-company training, 2012)

Vignette 34: "[…] But, how to convince a university professor that the goal is not to write a good article but to create a product or service? KIC is not only a source of funding. We need to find a long-term solution otherwise we won't make it. And we won't achieve our objectives" (Source: In-company training – university professor/social scientist, 2012)

Besides, it was also possible to notice moments of administrative conflict between partners and the way that KIC InnoEnergy was developing procedures, policies and strategies. However, at that moment, partners did not see that those formal procedures that were being created would help them to diminish or overcome this type of conflict through the process of organisational integration, nor increasing collaboration and knowledge sharing and, as a consequence, organisational proximity (Boschma & Martin, 2010; Cassi & Plunket, 2014).

Vignette 35: "The KIC is a new way of doing things. It is new to many partners. And the processes internal to the partners have not been established. There is a huge work to be done. We still have not established the proper way to manage the network..." (Source: Family Day A - CEO, 2011)

Vignette 36: "The very undefined rules along the way and the changes along time… I am not referring to an event or to a moment, but during 2011 for instance many things changed and it was changing at the beginning almost monthly and that can be very bad for partners to understand how the rules work… if everything is not established it is very difficult…" (Source: OTS interview project manager)

Vignette 37: "We are doing things as we move forward. We do not have time to stop. We have got a certain pressure from shareholders, from the EIT. So we cannot stop for two weeks to plan how to do things better. Perhaps we would need to do this, but we have decided to move forward. And we will fix things as we move forward. Of course this has positive and negative effects, but it is the way it has been decided […]" (Source: OTS interview CC manager)

And finally, partners had difficulties in understanding the new way of collaboration in KIC InnoEnergy. During these moments of cognitive conflict, partners used to resort to the concept of the knowledge triangle, which was presented to them as one of the backbones of the creation of the KICs by the EIT. The concept of knowledge triangle refers to the interaction between research, education and innovation, which are key drivers of a knowledge-based society. In the European Union, it also refers to an attempt to better link together these key concepts with research, innovation, and entrepreneurial actions being one of the pillars of the creation of the European Institute of Technology (EIT) (European Commission, 2015). Although the concept of the knowledge triangle was introduced to KIC partners through a top-down orientation, by incorporating this concept into their practices, partners were sharing a common communication code and building a common knowledge base that would allow them to communicate effectively as to transfer or create knowledge (Balland et al., 2015; Carlile, 2004).

Vignette 38: "I will present some of the results of KIC InnoEnergy so far. To those who are not in the education side [of the knowledge triangle] please look at the numbers because they show a good success reached by those who are doing education […] Regarding 2012 business plan, one of the areas to be develop is to integrate the three sides of the knowledge triangle as they will reduce deficiency and it is the beauty of KIC InnoEnergy […]" (Source: KIC Family Day - CEO, 2011).

When it comes to lower level of activities in KIC InnoEnergy, innovation projects have a different operating structure. They have more horizontal hierarchical structures, with decision-making being done though a bottom-up approach. Partners have more flexibility to develop these projects based on their capabilities, but always with a focus on launching products into the market within KIC InnoEnergy eight thematic fields. Following, it will be investigated in detail the findings obtained from one of these innovation projects: Offshore Test Station (OTS).

An engineer from a private institution (non-profit centre that conducts research and consultancy in renewable area), with large experience in the field and with previous European Projects, prepared OTS proposal. At that time, eight partners were invited to participate. With exception of a business school, all partners were engineers working in related areas at universities (3), industry (1), SME (1) and research centres (3) in three European countries. They were informally invited to join in the project based on prior working relations and acquaintance, thus with high social proximity and trust among partners (Bruneel et al., 2007).

Vignette 39: "I've been in the project since the beginning as I was the person who proposed it. This project started in a very anarchic way. I went to Barcelona to present the work that we were doing in wave energy in Portugal... So, I went to this conference in Barcelona and there it was present one participant of KIC InnoEnergy. For my surprise, I was asked to immediately prepare a draft of the project proposal. Therefore, from one day to the other I had to think about a project plan in offshore energy in no time. Because of this, I had to prepared the proposal all by myself. I did it based on my experience and knowledge. I though about the five different test sites that were already operating or that would start to operate in the future (two in Portugal, two in Spain and one in Sweden) and if we could create a partnership between them it would be amazing. I invited some partners whom I had previously worked with and that I had a good relationship. This was the strategy that we thought that could make sense [...]" (Source: OTS interview project coordinator)

Vignette 40: "When company X joined the project, OTS consortium was already constituted. Member X invited us to participate in the project. I think it was in 2010. He was the one who designated and structured the project at the beginning. He was the one who invited partners to join in the project. Things were constituted this way. During this period, Company X was invited to participate and later on we were invited to be the project leaders. We accepted due to our involvement with KIC InnoEnergy. And during 2011, maybe from February onwards, with member X as general coordinator, our coordination was officialised and we started to work, to manage the team, and to develop the project's activities. The project was structured based on member X's knowledge and experience [...]" (Source: OTS interview former project manager)

Cognitive proximity was also high, as all engineers had a background and /or worked with renewable energy. The only exception was the business school partner, who was invited to help partners on developing an initial benchmarking, market analysis and business opportunity study to better identify the products, services and opportunities that would be later fostered by KIC InnoEnergy.

Vignette 41: "All partners were engineers, with the exception of the business school. Company X was working together with us on this area, so I thought we could carry on working on it. And I thought also that as Spain has a long tradition on Eolic energy perhaps it could be interesting to have some Spanish institution working on offshore wave energy. Besides, I thought that the business school could be interested in participate in the project as we needed an institution more related to business to develop these aspects in the project. As research centre X was also interested on developing something on this area they commented that they would consider their participation […]" (Source: OTS interview project coordinator)

Vignette 42: "I think it is very easy to work with partners because we speak the same language as we are engineers from the same technical field. We are very technical people. We know very much about the subject of our work package, so collaboration was very easy. We are specialised on what we are developing for OTS, so I think it made things much easier. Our meetings are quite straightforward. We were all engineers and so we spoke the same language, which made things easier. We discuss about simulation and prediction of waves in the ocean and we use experimental data to demonstrate that we are going on the right direction. When we face a doubt on which approach is better to follow we write down some equations to decide the direction to follow or the technique to be used. Plus, our experience help us a lot to discuss things and understand it through those equations. As we are experts in our fields, we do not question the decisions of others, as it is very difficult for me to discuss the results of a colleague when he is the expert on that area. Even when results are not as accurate or as good as expected probably there is a reason for that, and we don't question it. We are not working with people who are doing things in this field for the first time, so it is difficult to discuss or disagree with them. We are in a research world, among our peers." (Source: OTS interview project participant 1)

Although partners belonged to different institutional frameworks (universities, research centres, industry and SMEs), such institutional distance was compensated by social and cognitive proximity (Van Widen et al., 2014) as indicated by interviews. Besides, only one partner from industry participated in OTS (and they had large experience in working with research centres and universities), other partners who belonged to SMEs have a different way of developing its activities. Not to mention their participation was reduced, since university partners were responsible for developing the main activities of the project.

Vignette 43: "I think that collaboration is as good as it can be despite the geographical distance between us and the fact that we belong to different institutions. These have not affected the way we worked think that work package 2 with the ROV we have very good collaboration. I knew some of them before the project started; for example, I knew them 4 or 5 years before. It is easier to overcome these differences when you know someone already. You trust the person more. And I also know what they are good at. I feel more confortable working with them" (Source: OTS interview work package 2 leader)

Vignette 44: "[…] the researchers from university A are used to work in European projects. They have experience on it. So, for them is not a new scenario to work with companies and in different countries. Besides, research nowadays is all about collaboration and this implies to collaborate with other research groups or with companies outside Spain. As so, I believe they understand each other well. For me this is not weakness but strength" (Source: OTS interview project participant 3)

Vignette 45: "In fact what I miss in KIC innovation projects is the participation of industry partners. As promised by KIC InnoEnergy, I think that innovation projects should be industry-led, have a clear goal and that academic partners would be more available to develop the project activities. The innovation projects that I know in KIC, all are academic initiatives and led by university partners and the industry has a shy participation. The objective of KIC InnoEnergy's innovation project is beautiful but it is missing the real participation of industry. The industry goes on its own, when they have an interesting project it is not developed with KIC because of issues of confidentiality [...]" (Source: OTS interview project participant 4).

Moreover, geographical distance was not an issue in OTS, even with partners in Portugal, Spain and Sweden, as their activities had a high division of labour among participants. Tasks were broken up and distributed across members of the project, who would develop them individually at their home institutions (Foley & Smeaton, 2010) with very few interactions to build on collective knowledge (coordinated action). The project coordinator and manager were responsible of sharing the knowledge across partners mainly through e-mails and Skype calls, what affected partners' communication and the level of trust between them. Such way of organising activities prevented partners to engage in collaborative problem solving (creative abrasion) and reach integrative decisions that combine disparate or even opposing ideas (creative resolution) (Hill et al., 2015). Not to mention that it would go against the modus operandi of KIC InnoEnergy.

Vignette 46: " In my work package, we are from three different institutions (one technical university, one university and one research centre) and from three different countries (Portugal, Spain and Sweden) […] but the thing is we never met physically, and this is a bit odd. We have not done anything together as each of us is minding their own business by independently developing their tasks. I think that this generates distrust between us because we do not know or hear about the development of others… this is a problem not only for us but also for the whole project. Our task will be done using other partners' data. They will finish their part and send it to us, so we can carry on with out tasks. However, we do not know how it will be done. We still have not met since the December workshop. We finished to define the products; objectives and work plan through e-mails and Skype, what shows that there is little integration between us! The truth is collaboration is very sporadic to say it in a soft way. Perhaps it is caused by the way the project was structured. Our idea, aside from funding, when we joined OTS was to identify partners that would need our tool to develop their own research or products. A collaboration where they would give us their knowledge and know-how on a certain area, for instance in offshore energy, and we would add our expertise and know-how on numerical applications. So, this was our objective. Until now it has not been like this.

In fact we are developing our product independently from our partners and even inside our work package there are two separate parts [...]" (Source: OTS interview project participant 2)

Vignette 47: "[…] There had been coordination meetings to show results but never ever for developing and coordinating activities. I do not think anyone will tell you that there has been coordination to activity because it is impossible, it has not occurred. In the other work packages I do not know, but certainly not in ours, and I think that it did not occur also in relation to global-level project coordination between work packages. That is to say, we had meetings to present ourselves to others but to not produce collaboratively. I wanted to start developing my activities as soon as possible and that is my impression of how they're doing that […]" (Source: OTS interview number project participant 4)

OTS proposal was initially oriented toward developing a strategic vision for the offshore energy field. Based on partners' previous experience with previous European Projects, such as Framework Projects, the project plan was focused on applied research, without reflecting the demands of KIC InnoEnergy in terms of business plans, products and IP issues. On that time, OTS had nine work packages (WP) divided in three areas: (a) project management and coordination (WP1), (b) R&D activities at test sites and educational activities (WP 2: environmental monitoring; WP3: performance monitoring; WP4 ocean energy offshore operations; WP5: legislation and regulations; WP6: power quality and electrical grid; WP 7: offshore energy economy; WP8: education), (c) innovation activities (WP 9: initial benchmarking, initial market analysis and business opportunities study).

Vignette 48: "The explanations we received from KIC InnoEnergy were not clear at the beginning. There was a chain of communication that did not work during the elaboration phase. Some e-mails were not received or got lost or the addressee did not notice that it was an urgent matter. The idea was to orientate OTS towards developing a strategic vision for the offshore energy field. We organised the project in the format that we are used to: each partner will do his work separately and once and a while they would meet. Besides, since research projects are always very flexible, I thought that we would have freedom to do what we believe it would be the best for us. Because OTS was elaborated in an urgent way, I was not able to reflect on the requirements of KIC InnoEnergy… I knew that the proposal was weak, but even tough, I though that its value lied on the conceptual part…" (Source: OTS interview project coordinator)

Vignette 49: "When I joined OTS there was already a first proposal consortium, which did not change significantly. What we can say is that on those moments were the first innovation projects were launched within the framework Energy KIC, its conceptions were somehow different from the present scheme of work, due to ignorance of all partners. What was proposed was similar to other European projects, like the Framework Projects. So, the intended project development was, more or less, a nuclear consortium with minimum and sufficient partner countries, in our case Iberia, with participation of Sweden. From there, it is determined the objectives, the structure in work packages, tasks in each of these work packages, some results, and a distribution of efforts; so not very different from a project proposal within a call of a Framework Project […]" (Source: OTS interview work package 3 leader)

However concomitantly to the beginning of OTS, KIC InnoEnergy was still developing and refining its internal policies and requirements in accordance to the EIT. At the end of 2010, after receiving a feedback from the EIT, the CEO of KIC InnoEnergy submitted the revised business plan for 2011 – 2013. On that document it was stated for the first time that all innovation projects had to have a work package dedicated to develop a market analysis, and that it should be done at the beginning of each innovation project.

On the occasion of the first review meeting of the innovation projects, at CC Iberia level, such decision was informed to OTS coordination that the project plan had to be revised and reformulated, what affected greatly the development of OTS in many aspects. Partners had to change their mindset in terms of orientation of their work, being compelled to shift from an applied research projects with greater flexibility in the development of the activities and decision-making to a market oriented approach. Instead of work packages of activities, OTS had to have work package of products. Their way of developing activities would also need to change, from a high division of labour to a more collaborative orientation. Besides, partners were not used to the tool that they were being told to use (business plan) nor the control they were being submitted (tighter reports and reviews) in order to continue receiving funds, that differently from other European projects was yearly based and subjected to the accomplishment of previously established objectives. As an immediate consequence, one partner (an SME company) left the project due to intellectual property issues.

Vignette 50: "Basically what we did was to incorporate a package that would take into account the development of the market analysis, looking for opportunities in products or services within the lines that were being proposed by project. On that moment it was still not so clear for us the objectives of KIC InnoEnergy' s innovation projects. Because of this, our work packages had a research orientation, without proposing the specific developments or products or services. In the first moment, partners saw the market analysis as an instrument that could help them on identifying market opportunities that would allow suggesting post-project products or services […]" (Source: OTS interview work package 3 leader)

Vignette 51: "People were collaborating, but to change this mindset was the difficult thing. For instance, the first project proposal submitted was very research driven, made in the frames of Framework Project. The review we got from KIC was "interesting project but you need to focus because it is a very wide project and so on". This was true and we admitted that it was made as the partners felt more confortable, so following a framework that they are used to. This is a new type of funding from the European Union but no one knew the rules or what to do or what was the difference here. So, then we had to shit completely what we were proposing to do and the whole scope of the project from March 2011 until now. Some people drop from the project, other stayed. But even who has dropped did because they understood the shift and they considered that it was not possible for them to go on with the scope and schedule. And who stayed on-board was very driven to start a much more product approach, market oriented approach […] What I sensed from the partners is that we are trying to explain it but they are a bit lost because they don't know how to proceed […]" (Source: OTS interview project manager)

Vignette 52: "[…] On the initial proposal it was not reflected the requirement of the business plan. KIC InnoEnergy requested this latter on. It was when I figured out for the first time what was being asked for the innovation projects to include products and business plan. At first partners reacted in a positive way. I think that we all thought that it was a good path to follow. But there were doubts on how to do a business plan of a field, which there was still no business. In this decision it was implied that KIC InnoEnergy was interested on products and not on applied research. We needed to re-orientate the project because OTS was not designed to develop products but to develop a field that companies would later on invest. The project was a collection of working packages that would develop a strategic view of all areas (including economic, legal, etc.). Our products would be the results of these activities. So, the decision of designing a business plan to OTS caused a huge impact on the project. It naturally created difficulties to partners used to work on framework projects and in a different way from the one that KIC InnoEnergy was proposing and definitely not used to work under such tight control. We, in the project coordination, decided then to reformulate the whole project […]" (Source: OTS interview project coordinator)

Within it, although KIC InnoEnergy was setting the tone of changes and repositioning the project in accordance to its internal objectives, the approach to problem solving shifted from a "command and control" to "coordinate and cultivate" (Malone, 2004). It caused another impact on the collaboration, as participants are not used to take the leading role in selecting tasks and roles based on their skills and interests under this new frame. They were expecting to receive orders in order to execute them, and not having such strategic autonomy (Ancona et al., 2015). Partners were showing to be very uncomfortable and reactive to change.

Vignette 53: "[…] the project objectives required actions and things and that these would need partners who would develop the needed tools and activities for the project. The truth is that as the project was born two years ago with a bottom-up approach, people gathered together and the work package were designed more independently, you build the objectives from the bottom, what for me does not look good. From what I know and from what I have participated, all research projects have a script, the start here and at this point you have these subtasks or these work packages. In OTS, in contrast, it was the opposite. I expected that project coordinators could guide us to what was intended and for example the work we have done with the requirements of what types of frequencies are relevant, I expected that we should receive this from the other partners, and not that in the end we had to develop ourselves. You see, we had this servile manner in the sense that you tell us what you need and we will do it. At the beginning when I saw that the project would require numerical modelling I thought that someone knew what he or she wanted to do, and so he or she would tell us. And my disappointment and surprise was when I saw that no one had thought about it, they had decided to do numerical simulation without really knowing why. But then, as I said, the process was to find something genuinely useful, sealable, and we did that from the beginning [...]" (Source: OTS interview project participant 4)

In line with that, OTS partners had to develop a business plan for defining what products could be proposed, develop and deliver by the end of the project. This was something that they had never done before in their academic/professional life. To accomplish such requirement, it brought to the fore the participation of the business school. A meeting was scheduled for April 2011, where a participant from the business school (member A) presented a market plan for OTS based on the information provided by the partners. His presentation did not pleased all members and it was a great source of cognitive conflict, because aside from planning products for an inexistent market, partners did not understand the presentation – they had to get used to management terms. Besides, partners were considering that member A was not getting involved in

OTS activities, and the market analysis in particular, as it should.

Vignette 54: "Partners did not have a clear idea of how to deal with this demand. One of the things that were done was to include the business school to help us to give this market vision to the project. It was difficult because OTS partners did not have a fully knowledge of what a market analysis implied as they are mainly engineers! This task would require much more effort and dedication. And I believe that the budgets of these projects are not big enough for allowing them to have a market analysis as it had to be done. First because the institutions that participate in OTS do not have fully knowledge of what a market analysis implies and, second, although the business school has the knowledge to do a market analysis, it does not know enough about the technical world in which the market analysis had to be done. So, this was a job that required much more effort and dedication than the business school had done. Ok, the budget was what it was and it could not be changed but perhaps they should have dedicated more hours to the market analysis due to the allocated budget. So I think it was not very well developed probably because it is a complex theme to do a market analysis, the project is very big and finally because we were doing a market analysis for the first time [...]" (Source: OTS interview project manager)

Vignette 55: "We have done by now, all work packages, a market analysis. But, this is nothing that we'd heard from the beginning. And I have never dealt with something like this before. Despite the fact that I have been involved in businesses for many years, it was the first time that I had to do something like this. In our division here we have started more than 10 companies, and all of them are active with people employed. This requirement by KIC was thrown at us in a way that was not very constructive. I felt no support from KIC management. We were obliged to do something that I had no idea about by a simple change of the rules of the game" (Source: OTS interview work package 1 leader)

Vignette 56: "[…] To be more concrete, partners from university B did not understand the participation of the business school in developing the market analysis as they had internally the expertise to develop it and they are much closer to the project. And there was also from our side a misunderstanding with respect to the perception that business school was not behaving as a partner but they were having a consultant role in the project. A partner is not a consultant, it is someone who gets involved in the project, which participates in the meetings and contributes with something.

I do not know, we though that member A acted like this because he belonged to a private institution, although we have other partners from private institutions and they have a different attitude. I do not know this is a common behaviour in his institution, but we thought that the business school acted as an external consultant, as a service provider. I believe that this complicated things a bit. If it was to be like this, then the business school should not be in the consortium. The coordination of the project has been trying to manage this situation trying to make this organisation engage more in the project and to participate more on the Steering Board of OTS. It seems that the business school has a different view from other institutions that are more universities than companies. However, this situation is yet not clear or fully managed. Despite all, I believe member A did a good job… but on that time we were expecting more from him, like telling us the areas where we should invest our efforts, but this did not happen… He only delivered a report with a general analysis of the state-of-the-art of the offshore energy field [...]" (Source: OTS interview project coordinator)

Vignette 57: "Member A's presentation was nice to hear. The feeling I had is different from other partners. For me his presentation was ok, perhaps it is due to the fact that I do not know the technical aspects of the project, but the general comment was that a student could have done the same presentation as member A did. Perhaps it was because he did not know enough about offshore energy […] People started to complain about it during coffee time. For them it was good that the task was done, but there was a certain feeling of disappointment because there were expectations that were not fulfilled with his presentation. Partners from university thought that they could have done the task in a much proper way, especially because they had internally the expertise required to develop a market analysis" (Source: OTS interview project participant 3)

Discontentment turned into personal disagreements and incompatibilities, reaching the ears of the CC manager (member B), who was sought not only due to his position but also mainly because of his legitimacy and persuasiveness. Interested that partners could reach an agreement as soon as possible so that OTS could continue with its development and evolution, member B mediated in some occasions the affective conflicts between engineers and member A by promoting informal gatherings, developing trust, and looking for facts in the case in question (Das & Teng, 2002; Mooney, et al., 2007):

Vignette 58: "[…] Member B had an important participation after that first presentation. He helped a lot, talking informally to OTS partners during coffee time to cool things a bit because member A's part was at that moment the most important for the development of the project. So he was trying to help on the backstage of the project" (Source: OTS interview project participant 3)

Vignette 59: "After results were presented from member A, partners started to comment their opinion with me [member B] and, in general, they were not very positive. From there, I had a series of meetings with some partners. I also met member A separately for a couple of times and we discussed what was going on. I explained him a bit the perspective of partners and what they had told me. I think everyone had their share of reason, things are neither white nor black, and based on that I was able to convince partners to give member A another opportunity. He was going to further develop the market analysis and present it in a new workshop. We worked this relationship in a quite natural way; there has also been the willingness by the parties. For example, there was a meeting of an informal nature between the project coordinator and member A because they had more serious misunderstandings. They had lunch together to talk about their issues. I was not present because although I was invited I was on vacation. I tried to have a mediating role to put the two parts closer, but really all merit was theirs, I know a little both of them and they are good people and people of good will. From there it has established a good relationship and mutual respect" (Source: OTS interview CC manager)

OTS partners changed the way they behave in relation to member A, so that they settled a new meeting in June 2011 so member A could help them with his knowledge of market analysis to choose what best technical solutions to employ. On that occasion, member A conducted a brainstorm session in order to help partner come up with a new project plan organised in accordance to the products that they wanted to develop. By doing so, member A was brokering partners' knowledge on renewable energy to his expertise and knowledge in business management (Obstfeld, 2005).

Vignette 60: "In the second workshop unlike the previous one, there was dialogue, people locked themselves in a room for eight hours and somehow talked and discussed things. It was a different way of working. This second workshop was very different in comparison to the first. In the first work was done by member A and other business school partners unilaterally and the results were presented. To my judgment there was little interaction with them and other OTS partners. In the second workshop member A made everyone participate, give their opinion, there were a lot of questions. There was much more interaction" (Source: OTS interview CC manager)

Vignette 61: "We did a brainstorm session to look for products. I cannot remember well but we gathered together in June (we looked for a favourable date for all partners) to have our first brainstorm session, which was extremely well conducted by member A. It was a session that we thought that all the money that we had paid to the business school was worthy… The workshop in June was completely different. Member A brilliantly conducted the brainstorm session that would help us to initially define our ten products. His work was very important at this transition phase of OTS. He orientated us not only to define our products, but he also shed light on a vision that would guide us on how to develop these products based on the market analysis. I will not only say that in this stage the business school worked as they should have done but it also did an important job. He had an important role for the development of the project" (Source: OTS interview project coordinator)

Vignette 62: "Member A had an important role in brokering his knowledge in market analysis so we could understand a bit what we had to do, with this new mindset. After the second workshop then we squeezed the participants to move into this new direction… He helped us making bridges between old and new mindsets and implementing the seeds of this change […]" (Source: OTS interview project manager)

After this second meeting, partners came to a list of ten products for further developments. Another partner (a research centre) left the project due to disagreements with the orientation that was being given to the project. These ten products were later reduced to five. From these five, one product was left aside because, among other issues, the company that would develop the project did not have a profile that could fit into KIC InnoEnergy. In July 2012, the list of four products that would finally be developed were presented at OTS annual meeting:

- New air turbine for oscillating water column technologies,
- Underwater cable installations with ROV (remotely operated vehicle) technology,
- Software for operations and maintenance planning,
- Acoustic underwater environmental modelling and monitoring tool.

In this annual meeting, it was the first time that all OTS members were meeting face-to-face, with some new participants also being introduced. In this meeting a follow-up of the four products was done, with discussions on the future steps of the project. What became apparent on this meeting were the different objectives between some partners, who saw this project as a source for funding and an opportunity for developing their research, and for KIC InnoEnergy, that was interested on the generation of innovative products to be commercialised in the market. Funding was not guarantee for the whole duration of the project. It was given on a yearly basis in accordance to the accomplishment of previously established objectives. This together with a lack of resources to develop internal activities (e.g. PhD students were not allowed to work on it as wished by partners) was creating a great level of discontentment among partners.

Vignette 63: "[…] We've got a problem here that as the funding is not so substantial, people need to start to realise that the value lies on the products and not on the funding. Funding is a way to help to develop the product, which is our final added value. We need to focus then on the products. KIC InnoEnergy must know that this creates certain reluctance from people to realise the added value of being part of KIC. Partners are wondering why they should be in KIC when they have other European projects that would fund their research and the bureaucracy is much less. The objectives of KIC InnoEnergy and of the partners are not aligned. KIC wants to develop products to the market while partners expect to receive funding for developing their research and products. OTS partners need to look more at products, which should be the objectives of both. Universities can make money from products if they are good enough and fulfil the objectives of KIC. I have been trying to talk with partners about this, but it is not easy, especially with those that are far from us like Swedish partners. They are upset and they complain a lot. However, we must be patient and try to explain things for them. No one is forced to be here and if they believe that it is not worthy to carry on being part of KIC InnoEnergy, they should leave. Partners must want to be here to develop products. Then we must try to manage these frustrations as much as possible. We must try to make partners reply once a month, because so far it has simply not worked" (Source: OTS interview project manager)

Vignette 64: "The reason that I was interested in participating in OTS was that I thought that this project would play a good and important part in speeding up the development of ocean energy and technology. I never anticipated this to be something that would be great product or that could be sold. Even if it could be, I would not be the person who would do that. There reason for that is I have a full employment at the university, my salary is ok and I would never get the same salary for trying to sell this. So, that was never a driver for me. Still, if I had the products that I had anticipated, then OTS would be much more attractive. My goals were others, such as many others with scientific background, such as funding our research, answering environmental questions, developing good technologies and equipment, etc. For me to develop a large commercial product is just a fantasy. We are never going to take patents on this" (Source: OTS interview work package 1 leader)

Concomitantly to this goal conflict, new orientations were been given from KIC InnoEnergy through CC level. As a result of OTS project review, partners were advised to develop a new round of market analysis for the four products and to think on the possibility of the joining together two of these four products. Such demands, together with the new rules and norms being established, were causing administrative conflicts. At the same time that these formal coordination mechanisms (e.g. documents, project reviews, etc.) were negatively impacting partners, it was helping them to get going through the project development.

Vignette 65: "Well, I think that apart from documents that have emerged to help project partners understand and effectively target the project objectives, I believe that the feedbacks that have been receiving and the periodic project reports have helped us to go modulating the how, what and where to put an emphasis within the project activities. In fact, the decision to refocus OTS into a bundle of much more concrete actions happened due to some of the past reviews, and based on its recommendations […]" (Source: OTS interview work package 3 leader)

However, at project level, partners were asking for higher formal managerial coordination (coordination by commanding) from the project coordinator and manager. The perception of the low involvement from project coordination together with an environment of high uncertainty due operational conditions of OTS (internal rules being formed and incipient offshore energy market) led to a decrease of the organisational proximity among project partners (Bruneel et al., 2007). According to Boschma (2005) such level of proximity is associated with network coordination. It is regarded as essential for local systems with high division of labour because it tends to lower transaction costs, facilitate the transfer of knowledge and thus, learning and innovation, and encourage cooperation between partners. But with lower levels of organisation proximity, coordination in OTS at this stage was a difficult process, contrary to what is stated in the literature of small groups coordination (e.g. Peski, 2004; van Huyck et al., 1990; Weber, 2006) which suggests that coordination is easy in a small group that know each other well and trust each other's competencies.

Vignette 66: "Maybe OTS project is more participative as we take more into consideration the comments and opinions of different participants. The initial stage of OTS was less managed, what implied a bit of chaos and some coordination problems later on. In other project I don't see this happening. OTS is more participative but it is less controlled. It is more complicated to have all parts of the machine working properly. In this sense, it is complicated to make the willingness from different partners to come together in only one recommended objective. It is more complicated, although I would not say that OTS partners are not doing a great job, on the contrary. [But] there is a lack of management; people don't know what to do. We have researchers who don't know what will be their budget in the next year for developing their tasks. Because of this, they don't work with the same dedication. Of course this from the university point of view is very complicated as we are used to work in a different way. Here things are different, the scope of the project can change as it develops or as a market analysis is published. And it is not advancing because all the promises are not being fulfilled. And all this makes that people are not committed as they should be. I hope this can be overcome with time, not only for OTS but also for all KIC InnoEnergy" (Source: OTS interview project participant 3)

Vignette 67: "I would change the coordination of the project, which, on my point of view, is too loose. We still have not met since the December workshop. We finished to define the products; objectives and work plan through e-mails and Skype... what shows that there is little integration between us! The truth is collaboration is very sporadic to say it in a soft way. Perhaps it is caused by the way the project was structured. At least, in our work package, it is missing a closer and continuous follow-up and I think that at project level as well. For example, the September meeting was proposed for July and they announced it just one week before. That just can't be like this, things can't be done like this" (Source: OTS interview project participant 2)

Although data from this research was gathered until January 2013, in 2014 the demands from KIC InnoEnergy were followed by OTS partners and the list of products were finally reduced to two. They were:

- *Product 1 - offshore monitoring buoy*: after two years of research, design and implementation, the buoy, together with a 3D sound-mapping tool, was tested in July 29th, 2014. Six partners participated in the development of this product (three universities, one research centre, two SMEs and one company), which will be commercialised in 2016. Photo 4 shows the deployment of the buoy in the port of Lisbon.

Photo 4: Deployment of the Buoy in the Port of Lisbon

Source: Wavec (2014)

- *Product 2 – software for operation and maintenance of offshore test stations*. Three partners (two universities and a research centre) participated in the development of this product. Currently, partners are looking for funding (around € 1million) to finish product development.

With this decision, two other partners (a research centre and a SME) left the project since the work packages that they were participating were not continued, they were: air turbine (that was not developed due to its costs and time to market), and the underwater cable installations with ROV (due to a lack of market opportunity and time frame). The OTS project finished in the end of 2014.

2. Findings and Analysis from Case 2 – ATLAS Experiment and TileCal

The idiosyncratic characteristics of the field of High Energy Physics (HEP) have largely influenced how the ATLAS Experiment is structured and functions. HEP, also known as high-energy particle physics, exists to investigate the early Universe and its basic building blocks, namely matter. For that, researchers need to reproduce the conditions (e.g. energy, temperature, etc.) of the Universe on that time that would allow understanding its current form. Compared to many other fields of science, the HEP community is small (more than 11,000 researchers), oriented to basic research in two branches: theorists and experimentalists. The theorists work mainly at blackboards and computers in small groups whereas experimentalists design, build, operate and exploit gigantic devices (such as accelerators and detectors) in large collaborations that last for years.

In HEP, collaborations are strongly based on personal relations between the researchers. Being a relatively small group and with frequent interactions, it is not surprising that most people know each other at least by names or by having common acquaintances. As a consequence, social proximity is high as well as the level of trust between scientists. Knowing each other, the personal relations and high interpersonal trust are essential elements in order to the cooperation goes on smoothly, information sharing continues effective and the work progresses favourably (Provan & Kenis, 2008). Consensus needs not to be perfect, however everybody must accept the common goal, the means the collaboration adopts to attain that goal and the assumptions or theories that shape the collaborative activities (Knorr-Cetina, 1999). Different from traditional structure, collaboration in HEP is settled by a bunch of equal partners with emphasis on collective work. The administrative and scientific managements are usually interwove, with democratic decision-making, flat and highly egalitarian structures, and based more likely on mutually recognised memoranda than legally binding documents (Hyppöla, 2008).

ATLAS, being a HEP experiment, is oriented towards developing basic research in high-energy physics. It is not aimed at moneymaking or providing any goods or services but to fulfil its scientific mission. Marketable products and technological innovation are spin-offs of the research being conducted. Thus, reasons to join ATLAS lay solely on the opportunity and prestige of conducting research on (new) elementary particles in its unique research site. When joining ATLAS, participating institutes and universities do not sign any legally binding contract. Institutes signed memorandum of understandings (MoUs) for collaboration in the construction of the ATLAS detector and on its maintenance and operation procedures. Resembling more a gentlemen's agreement, it establishes a general understanding, and an underlying agreement, among the project stakeholders concerning how construction, function, annual maintenance responsibilities and operation budgets were to be shared across institutes.

The ATLAS organisation can be considered as loosely coupled network of independent research institutions bounded by common values and beliefs, where power is distributed (Boisot, 2011; Tuertscher et al., 2008) and management structures are semiformal. Many people throughout the organisation perform leadership functions, though they temporarily occupy these functions and return to work on the experiment when their mandate is over. Coordinators (as they call managers and leaders) are in these positions as they are recognised physicists, because of years of participation in the experiment and also due to personal capabilities. They can command but not control; they can tell the other specialists what they want to achieve, but not how to achieve it

(Spinuzzi, 2015). As Malone (2004) put it, they no longer respond to command and control, but to coordinate-and-cultivate.

Vignette 68: "[…] on the Executive Board, everyone sits around the table to discuss things; everyone listens to the others. For example, N. has served as technical coordinator for years; he helped to build it all. He has knowledge and authority, and, so, deciding something against him, I've never seen it […]" (Source: ATLAS interview subdetector system participant 6)

Vignette 69: " It is very good for you curriculum to have a position as a coordinator of something in ATLAS. It is good because it forces you to see things from a broader level. You need to be a good physicist so you can be a coordinator or supervise the work of others, but it has to be done in a proper time. A coordinator does not decide alone because people who are developing the activities know more than him or her. The coordinator facilitates, mediates collaboration. Besides, there are good and bad coordinators. The good thing is that they have mandates. You bare that coordinator for two years; ignore him or her. To go to the management level to complain is something that we see as very violent. We are not used to do something like this…" (Source: ATLAS interview technical coordinator).

Vignette 70: "[...] When there are discussions about physics, there is a consensus to reach the best solution. If decisions are more political, for instance decide on a certain 3d technology that was being proposed by one group formed by the Germans against another formed by Italians and Spanish. Although they had more money, support, and internal persuasion, we had the support from ATLAS management because it was a newer technology. So it was a decision done with a helping hand from the management. It was not so democratic or reached through a consensus, but it was something better for the experiment […] the technical coordinator talked at backstage with people to support this technology […]" (Source: ATLAS interview subdetector system participant 7)

Since there are many institutes and universities involved in the collaboration, decisions are decentralised to the appropriate level in question (where technical expertise resides) and taken collectively based on technical aspects. In this way, coordination is done via mutual adjustment, with no need to manage directly or monitor the process of individual developers as long as their tasks conform to standardise interface specifications previously defined and agreed.

Vignette 71: "Decisions were very collegiate, though someone had to make the final decision. At that time M. made the final decisions because he was the group leader. But the discussion of everything, the problems, the options, etc., everyone discussed it. Even the students were there, listening […] There are subgroups that are organised a bit differently. For example, there is a task force to decide on electronic issues. This group discusses questions with external specialists who supervise what's being done with TileCal on the electronics side. The head of electronics at ATLAS is there when an important decision has to be made. Now, in terms of ATLAS, there's an entire process. There is a design proposal for each important element. There's a letter of intent, which is a first draft of what that component is. It is then approved and presented to collaborators as well. Then there is the technical design report, explaining everything that has to be done in great detail. It also has to be approved at various levels. There is also a production review before entering into production. This review details the production process for scintillators in participating companies. I also took part in some visits to Russia, to see what firms were producing them, how they did it, who worked for them. But each step has to be approved in the review" (Source: ATLAS interview subdetector system participant 6)

For this reason, a huge number of meetings have been needed in the course of past years. Meetings have had not only a social function of gathering people, but it has been an essential place for partners discussed upon different matters, present reasoning and evidence to justify their claims and make decisions (Knorr-Cetina, 1999). For example, if a group want to change a technological path, they have to mobilise the support of other groups throughout the collaboration. Interestingly, some mentioned that consensus must be reached prior to meetings in order to minimise further questionings. Of course such collective decision-making takes time but, on the other hand, the problems are solved immediately being perceived as a collective choice and everyone is kept informed due to the openness of ATLAS collaboration.

Vignette 72: "[…] there are many meetings to discuss things. Sometimes discussions are infinite. Sometimes there are different groups proposing different ways to follow and then discussions become a bit tuff. So there are always meetings and discussions on how to develop activities. In ATLAS if five universities want to develop similar or the same activities in terms of physics, they will be obliged to sit down together and coordinate their work to speak as one unison voice. So this is done to avoid having "winner and losers", but everyone collaborating together […]" (Source: ATLAS interview subdetector system participant 2)

In the same way as decisions, activities in ATLAS are organised in accordance to the phase of development of the experiment in coordinated actions, being broken up and distributed across the different groups – those related to the building and maintenance of the detector, and those related to data analysis – and in accordance to the phase of the experiment. Notwithstanding, ATLAS collaborators work with high collaborative orientation to build on interlaced knowledge (Tuertscher et al., 2008). For the most part, members are autonomous, able to exercise their own freedom, flexibility, and creativity as long as they can produce results (Castells, 2010).

Vignette 73: "[…] How did we work? Well, in part, locally. We created groups that met weekly reviewing all of our progress on different components. Everyone listened to each other." (Source: ATLAS interview subdetector system participant 6)

Vignette 74: "The reason that everything works is that we have a common denominator, which is the detector. The detector is one and the same for all. I am responsible for one part of the detector, and that part work well, but if the part of someone else is not working properly then it will affect me as well… so, it is fundamental that each part works well and that all parts together work well also…So, it needs to be a cohesive work that later one will be seen as one, for instance, in an article.

So in the end there is a common product which is the article […]" (Source: ATLAS interview subdetector system participant 2)

Lately, some internal guidelines are being written in shared data repositories to formally orient and organise in a certain stance ATLAS activities, especially for first comers. Among data repository, there are ATLAS Wikipedia, mailing lists, files, and tutorials, among others. ATLAS Wikipedia, for example, is a web-based software that allows all viewers of a page to change the content by editing the page online. This makes the wiki a simple and easy-to-use platform for cooperative work on texts and hypertexts (Ebersbach et al., 2006). One of these wikis is about how to publish an article with ATLAS experiment data. Publications in ATLAS are done collectively, with the list of authors presented in alphabetical order and, perhaps, also ordered by institute. Although there is an established practice that publications are made in the name of the whole collaboration, there are some requirements to be considered as an author of a published paper. On the TWiki is presented a summary of these guidelines and also the access to the full document of the ATLAS Publications Committee (ATLAS TWiki, 2010).

Vignette 75: "Well, normally there are usually instructions on Wikipedia, which are instructions for users that work a bit like the first guide to them so that they know how these things are organised. There are also mailing lists that you use when you do not know what to do and want to make questions to others. In the mailing lists there are many people writing and collaborating so you expect someone to contact you and tell you what you must do. There are other tools that are a little more detailed, for example, there are tools to find the data grid and make lists from data, including how to download data and take it to your institute so you can process it there. There are many different types of tools. In ATLAS there is a structure, an internal organisation of things, you have meetings, and this at first is quite complicated to learn because there are rules, in the sense that if you want to analyse data, you can take the data as you want and do whatever you want, you have to follow some rules and instructions. It is very bureaucratic in a way because, for example, when writing a paper, which ultimately is a product of physics and that is important as a result of our collaboration, you have to follow some scrupulous rules about how you have to do analysis, how you have to write the paper, the phases of approval and then preparing the manuscript to send to the magazine, is all well documented but also very complicated [...] (Source: ATLAS interview subdetector system participant 4)

Vignette 76: "We always have to give examples in the meetings showing how important the work that people are doing is and if it is not done, showing them with examples the difficulties to retrieve the information, to pass it to another person when they leave our when they go to something else. Yes, we always need to keep a watch on that. And then, as ATLAS is a very big collaboration, there are rules that are very important to follow, and new people sometimes break the rules or they do not follow the rules, not because they don't want to, it's just because to learn all the procedures takes time and it´s difficult. So we should keep watching this aspect through the coordinators, as I said […]" (Source: ATLAS interview subdetector system project leader)

Another recent formal mechanism of coordination added to the collaboration is the OTP (Operational Task Planner), a tool used to account for all the non-physics work in the ATLAS experiment. The same tool is used to subscribe to shifts and on-call duties. Data from the OTP is used to generate a number of reports for the users, management and the ATLAS funding agencies.

Vignette 77: "Well, the first pressure it creates at the present is that it's extremely difficult to conciliate the time that physicists spend to do physics and the time that physicists spend to maintain and operate the detector. And this is a big difficulty. And it's difficult also to pass this message to the Institutes, because although the Institutes have to keep part of the manpower, keeping the detector running correctly, they want to be very visible in the physics analysis they are doing. And this is a difficult process because the physicists cannot have good data for good results if the detector isn't running well, so they need to do service work. So, for

> example, ATLAS has a tool which is called OTP, […] this is a monitoring tool where each service task to operate and maintain the detector for physics correctly, defined by the project leaders and the technical coordination, is stated. We enter into this tool the percentage of the time that each member of the community has spent in this task or on that task, and at the end ATLAS retrieves all this information and theoretically, in principle, if everyone makes a good share of the service task, they should spend at least 30% of the time in helping operating the detail. You can be a software task; it can be a hardware task and so on. And then ATLAS collects all this information and twice per year there it is a report that all the founding agencies showing if the Institute is above or below the so-called quota that they should provide to the collaboration. All these reports are available; everyone can consult them, with names, with the tasks. So OTP is a tool which monitors the performance in terms of tasks, but also put some pressure in some institutes which are very much below the quota that they should provide in terms of technical help for two to three consecutive years. Never in ATLAS has anyone been put in the situation where they do not become authors or were not allowed on signing papers. But, I mean, this is a way of pressure. Frequently we had Institutes coming saying, "what can I help you more?" Because the report is in red. Another tool that ATLAS has put in place that helps the technical work to be done is the qualification task. A person coming to ATLAS becomes an author after passing a so-called qualification. And qualification means that during one year for 50% of the time that person has to a certain task. These tasks are technical activities defined by the project leaders, by the activity coordinators. And after this one year the person becomes an author, and they start signing the papers. So this is, for example, another tool that ATLAS has, CMS has the same, to help the collaboration to fulfil the tasks that are less fun during data taking period. So at the end these results, people have to work in a very, very organised way, if not entropy is there to destroy it" (Source: ATLAS interview subdetector system project leader)

Similar way of operating can be observed in groups, which decide the best way to organise their activities, thus functioning as "sub experiments". The TileCal, for instance, which was initiated by a group of friends, is composed nowadays of around 150 authors and 250 collaborators, including physicists, engineers and technicians from

26 different institutes from around the globe. The project is structured in five main areas: operations, maintenance, upgrades, performance and data analysis; and each area has a coordinator responsible for supervising the development of activities and organising the internal structure that makes TileCal work. They meet three or four times a year for one week in ATLAS facilities to discuss a specific and previously defined subject. There are also the weekly meetings done through videoconference with collaborators in their home institutes to cover the operational aspects and on performance. Coordinators meet separately once a week or once every fifteen days. And finally, there is also the Institute Board meeting attended by a representative from each of the 26 institutes, the project leader and the Institute Board Chair.

Vignette 78: "In principle groups can manage their internal organisation as how they see it best, how they make their selections at that level. There are guidelines in ATLAS for systems, so there are some differences. But the general organisation groups, let's say, is more or less the same. But, in practice, within the group, each one does what is practical for solving their problem, let's say" (Source: ATLAS interview subdetector system participant 6)

Smaller and more specific groups of participating institutions like IFAE, one of the research institutes responsible for conducting research in the TileCal, follows the same principle and heavily rely on meetings for information sharing, decision-making, distribution of activities and feedback on results. Aside from their internal meetings in their headquarters in Barcelona with 30 people with different affiliations, they also have virtual meetings between the group in Barcelona and the other part of the group that is in CERN and they also participate in some physical meetings at CERN facilities.

Vignette 79: "In IFAE there is a kind of informal petit committee formed by three senior physicists with large experience in ATLAS and in physics, with very important positions in ATLAS and within our group, in which we always consult ourselves, irrespective of the meetings, about things in relation to our group, decision from ATLAS that will affect us directly, for instance to accept a certain management position or not. Besides, this petit committee we gather also in the weekly meetings of one hour and a half. They are executive in the sense that we follow an agenda where it is previously defined each subgroup will make a presentation updating on their activities, followed by discussions. So every week a group will be invited to make a presentation […] And then we have virtual meetings with the group that is currently developing research in ATLAS and the meetings that you do physically in CERN" (Source: ATLAS interview subdetector system participant 1)

Regarding diversity within ATLAS, its members are mainly experimental physicists, engineers and technical staff from a variety of cultures, language and nationalities; thus being a community without unit (Knorr-Cetina, 1999; Hyppöla, 2008). Although members of ATLAS collaboration are from different countries, geographical distance is not seen as a problem as participants mentioned the use of information and communication technology to help on generating, absorbing, storing and diffusing information and knowledge. Besides this virtual proximity, participants are also able to spend some time in ATLAS facilities to develop collective localised action, promoting temporal geographical proximity (Torre & Rallet, 2005). However, what different participants from ATLAS experiment is that this geographical distance do impact on a cultural distances among them, not in terms of physics, but on the different personalities, ways of thinking, and communicating. However, it was not perceived as disturbing element since these issues are solved through communication and mutual understanding (Spencer-Oatey, 2015).

Vignette 80: "There's a difference in general between Europeans and North Americans. American students have learned to be more assertive, to talk a lot more, while the Europeans learn after a while, saying, "If we don't start talking like them, we're not going to make it." But that's how they come here. I don't know if their educational system is like that, in high schools or wherever, but they are less shy than Europeans. There are also other communities for whom it's harder to show themselves and let others get to know them, like the Japanese. There are a lot of them, but they have problems with the language, in general. Of course this makes it more difficult. We don't know Japanese. They have to show much more merit, but it's an obstacle, which is more difficult for them. But, I also see some Japanese that are a little different, they make more contacts and when, for example, on the committees, they look for people from everywhere a bit […]" (Source: ATLAS interview subdetector system participant 6)

Vignette 81: "Of course you have to work harder because you have to understand that not all people think or reason in the same way, you have to be a little more tolerant. There are many differences, obviously, because we are talking about an experiment has physicists from Japan, United States, Europe, with all kinds of mentalities and ways of working and talking too, then you must understand and learn to work in this environment" (Source: ATLAS interview subdetector system participant 4)

Vignette 82: "The key thing to work in a community like this is to communicate. It is one of your main tools. You need to talk to people, you need to communicate, you need to understand what they say, it's true that for Americans in particular is easier, because it is their native language, and perhaps they do a small effort to communicate with others. I think it's sometimes a great problem for people who do not know English well. For example people coming from Brazil, there are many times they do not to come with an acceptable level of English and demands from them an extra effort. I learned a bit of Portuguese but this applies to me, they cannot expect to go a meeting and without speaking English. And I think you can amend this a bit by communicating through e-mails, so at least there is some communication and if they cannot overcome the failure because of the language, the end result is that just leave. So I believe it is essential to be able to communicate not only in physics" (Source: ATLAS interview subdetector system participant 5)

Cognitive distance between physicist and engineers, and between physicists from different parts of the experiment, was small but it was mentioned in the interviews. To overcome cognitive difficulties, they have relied on boundary objects such as the detector (in the construction phase of the experiment) and its representation through simulations (in the current phase to organise activities), which acts as a common reference point that allows different actors to coordinate their actions (Canals et al., 2011). Through the construction phase, the simulated detector became a quite faithful representation of the real object, which is used later in the operation phase to interpret data obtained. In this way, they act as supplementary evolving boundary objects that contribute to the coordination of collaboration (Canals, 2013).

Vignette 83: "The reason that everything works is that we have a common denominator, which is the detector. The detector is one and the same for all. I am responsible for one part of the detector, and that part work well, but if the part of someone else is not working properly then it will affect me as well… so, it is fundamental that each part works well and that all parts together work well also […]" (Source: ATLAS interview subdetector system participant 1)

Vignette 84: "Well, simulation is important because when you have such a complicated thing as ATLAS experiment, you have to do an estimative or understand what one can expect of a measure that you get from the experiment. Monte Carlo is so important because the type of structure is so complex that it not possible to do a estimation on a piece of paper, to have an idea of what will happen is necessary to do it with Monte Carlo. Then for physics analysis Monte Carlo is almost always necessary because when one wants to compare what you see with what is expected, the expected part is almost always predicted with Monte Carlo. We physicists prefer to get our explanation of the data itself, but sometimes it's not possible. Then you have to use the Monte Carlo simulation to know that we can wait from what you have observed. When for example the experiment was questioned, even now when there are studies being made for the upgrade of the experiment, you always do it through the simulation to know a little more how it will work, what are its possible characteristics and which are also the limits of a solution rather than another. So the simulation concentrates the knowledge on physics and of the experiment, so that people who do not know the experiment in depth can use simulation

Monte Carlo. This simulation is used in almost every aspect of the experiment […]" (Source: ATLAS interview subdetector system participant 4)

Vignette 85: "One thing that worried us was the physicist, because among the engineers we understood ourselves. But we found in common that we all liked to drink beer with an understandable English to communicate. We had a clear and common objective, which was to build the detector together. We knew that there would be conflicts, but we would solve it as they appeared. I have always had it clear that the physicists have to say what they want to, it is their obligation. And we have to do what they ask. I have always had this in mind when working with them. You have to delineate your territory with them. Besides, you have to know a bit about their world, about physics so you do not say stupid things, so you can communicate with them and they can understand you. You do this so you can be integrated and work together. The Monte Carlo simulation also helped. Because in experiments like ATLAS sometimes you have only one single shot. You have to do it from the engineering side and from the physics side with prototypes and tests. The simulation is fundamental when you are working on something never done before. If you cannot simulate, you cannot see if you are going in the right direction. You cannot test all the parts of the detector because it is not viable, but you can get a good representative sample and from there simulate it. And with the simulation you have a clear idea where to go, points to take into consideration and care, what were strengths and weaknesses […] The simulation is a useful tool to link different, independent or isolated parts of knowledge into a common view that would not be possible otherwise. It allows the integration of knowledge from different interrelated physicists without having to know all the expertise of others… And later on, thanks to the data we gathered from simulations, it was possible to see how the detector would function, the research lines to follow to find Higgs, etc." (Source: ATLAS interview subdetector system participant 8 - engineer)

Institutional, organisational and social proximity are high in ATLAS as members belong to universities and research institutes that conduct research in particle physics, with friendship bonds (or previously acquainted) and that are aware of how ATLAS operates when they join in the experiment. These three types of proximity rest upon the same mechanism, named shared rules and habits (Caniëls et al., 2014). Trust can be either generated by common institutional frameworks or by shared social community norms, including the same organisational arrangement (Broekel & Boschma, 2012). As a consequence, it facilitates interactive learning because common representations, norms, and rules eases the exchange of knowledge from one agent to another and thereby facilitates coordination by reducing transaction-costs (Boschma, 2005).

Since ATLAS members are mostly employed by the different institutes and get their salaries from various sources, competition occurs at group level, between institutes, and mainly because of distribution of resources (e.g. funding, number of PhD students, etc.) or because of technical aspects (e.g. trying to get their components or appliances approved into the final detector). However, this issue does not affect the experiment probably due to close personal relations and mutual trust. Besides, a task force is settled to gather more diagnostic information on issue-related differences and consensus can be reached at group level (DuBrin, 2011). It was also mentioned the "competition" with CMS experiment, though the competition is not very serious, as one experiment must validate the results of other.

Vignette 86: "[…] Of course, within groups is where conflicts are most evident at times. Different people compete for different resources, who has a post-doc student working with them, who has the money to do what. We can't do everything, so we have to limit things within groups. Then, when we get to the detector level, if there are too many groups, we also have to decide […]" (Source: ATLAS interview subdetector system participant 6)

Vignette 87: "The cultures are very different. And we have really to create a mechanism of respecting everybody. It's a competitive environment where each institute has its own ideas, for example TileCal for the electronics or for the optics; the final choices were not there from the very beginning […] we chose different technologies and sometimes one Institute was the driving force from one option and another one was for another option and we basically, I mean the way it worked was that a mechanism of choosing different technologies based on results. So we go to the test beam, we have the Monte Carlo simulations, and it's based on the results on which you take decisions so. Of course we have stronger groups and we have richer institutes, but we try to take decisions based on performance and of course also based on costs. So it's an optimisation between cost and performance. This is a process that needs careful coordination and sharing of responsibilities among all the institutes. As I was saying, each one brings something. Even being poor or less powerful institutes, we tried, at least at the coordination level, to give room to each Institute to participate and be involved in the construction by bringing pieces of iron or pieces of electronics or pieces of optics and developing the mechanism that each Institute could bring their expertise and we have wonderful engineers, technicians from all over the world […]" (Source: ATLAS interview subdetector system project leader)

Vignette 88: "It is a usual technique that you've probably heard that we never make decisions, actually we do make all the decisions, but we do it in such a way that there is no decision made, so you work by consensus. You make sure that everybody at the end gives up or is convinced. One has to work in a certain way, but you never force anybody to go in a different way, being on the other side of the barrier. So if you find yourself in this situation, you enlarge the barrier in order to have always everybody inside. And you don't force a decision when you see that there are people that do not agree, so you try to work more, to find reasons. If somebody does not agree, normally there is a good reason for it, so you better listen to him. I have learnt that the best way to collaborate with people who have different opinions is to bring them in, to force them in. Right now, for example, if I have a problem and I see there is a decision to be made and there is somebody that does not want or is very critical I create a task force and I put this person in the task force. Because then this guy knows he has to do something, he is obliged to be part of the solution process. When he is there, he cannot have an opinion that is 90 degree from everybody else because there will be no solution, and his mandate is to find a solution. In that way you build consensus but in a clever way, without breaking legs […]" (Source: ATLAS interview technical coordinator)

Less discussed was the presence of affective conflicts at group level. When problems due to personal disagreements and incompatibilities arise, it is solved through face-to-face encounters and informal conversations at group level. It was also commented the importance of some senior physicists in the experiment, with experience and expertise but also leadership skills and commitment in helping to mediate these situations (Mooney et al., 2007):

Vignette 89: "There are conversations that are not constructive. That happened to me many times, I came to a meeting, present some results and I got some comments that were totally negative. What I usually do is go for a coffee with someone senior (in my case is the project leader) and tell her what happened. Well, in this particular case she told me to not pay attention to that guy because he was rude and there is nothing else to do. So, I took a deep breath, revised some of my results so this guy could be satisfied, I sent it to him, approval was given and there was no more problem. Besides, there are also other types of situation that you go for her for mediation. When someone is not doing his or her job. You talk to the person but still there is no solution… Then you talk to her [the project leader] and explain to her the situation. So she tries to talk to the institute, with the person, she tries to understand the situation" (Source: ATLAS interview subdetector system participant 5)

Chapter 6

DISCUSSION

This chapter presents a discussion of the results obtained from data collection in KIC InnoEnergy and ATLAS Experiment. From this discussion, some propositions are stated.

1. Discussion

This study was conducted with the aim of shedding light on how does diversity and conflicts in innovation networks affect the coordination mechanisms employed. Although prior researches show that coordinating innovation networks is of considerable importance (Gardet & Mothe, 2011), the form that coordination takes is still seen as paradoxical in the literature (Jarzabkowski et al., 2012). This relates to the issue of whether innovation networks can be deliberately coordinated or as they exhibit rather self-organising features different coordination mechanisms may be needed (Ritala et al., 2012; Hurmelinna-Laukkanen et al., 2014). As Rampersad (2008) praised, deeper understanding supported by empirical evidence of the different ways of coordinating innovation networks is welcome.

The empirical analyses of the two cases of this study illustrate very interesting considerations. Although KIC InnoEnergy and ATLAS Experiment are distinct cases, with differences mostly evolving from their environments (the context in which they are embedded), network purposes, characteristics and stage of development, these networks have also some similarities that allow to make a presumption that the comparison of these cases can make interesting contributions into the debate on coordination mechanisms in innovation networks.

First, it is important to mention that KIC InnoEnergy and ATLAS Experiment are both examples of innovation networks as their primary focus is on fostering an environment where collaboration among diverse members is promoted with the goal of enabling innovation (Dhanaraj & Parkhe, 2006; Hoberecht et al., 2011). To do so, these networks have created innovative elements so collaboration could take place. In the case of KIC InnoEnergy, innovation lies on the application of previously developed research into commercial product /services. In the case of ATLAS Experiment, new technologies (such as the components of the detector and the GRID computing technology) and architecture for them had to be developed so that physicists could conduct basic research on particle physics. In addition, these two cases are also considered as innovation networks as in fulfilling their goals, they are also bringing organisational innovation.

Aside from these similarities, KIC InnoEnergy and ATLAS Experiment are settled in different contexts, were conceived based on different purpose and, as so, have different organisational structures thus affecting the coordination mechanisms employed. Table 18 summarises these differences, which will be discussed in detail as follows.

Table 18: Differences Observed Between KIC InnoEnergy and ATLAS Experiment

	KIC InnoEnergy	ATLAS Experiment
Network Purpose and Evolution	Commercial Company (exploitation) Early stage of development (2010)	Basic Research (exploration) More advanced stage of development (1992)
Degree of Formality	Societas Europea	MoU
Characteristics of Network Members	• More Heterogeneous: industrial partners (large corporations, SMEs), business schools, engineering universities, research centres • Cognitive proximity • Limited social proximity • Geographical, institutional and organisational distance	• More Homogeneous: physicists, engineers • Social, institutional and organisational proximity • Limited cognitive distance • Geographical distance
Prior Exchange Relations	Mainly no	Yes
Conflict Type	Cognitive, affective, goal and administrative conflicts	Cognitive, affective and administrative conflict

On one side, for achieving its exploitation goals, KIC InnoEnergy was established as an innovation-oriented company focused in creating value by bringing technology to the market, while supporting entrepreneurship. Its structure resembles a mechanistic organisation, as it is characterised by a formal structure, which means that there are ordered levels of management where lower levels are answerable to higher levels. There is a formal body of leadership, which rely on more traditional forms of management for supervision and control of outputs, behaviours, lower levels of trust and rivalry expertise (Lam, 2004). This is done through standardisation of work processes and outputs (Mintzberg, 1980). In standardisation of work processes, KIC InnoEnergy has been providing innovation project participants guidelines and procedures that must be fulfilled in order to be considered as an eligible consortium. KIC InnoEnergy Highway, a business accelerator programme, can also be cited as an example of standardisation of work processes. Through a sequence of steps from the submission of a business idea to finding a first customer, KIC InnoEnergy Highway assesses and leads start-ups to be developed following certain business creation criteria. The process is the same regardless where the proposal is submitted (KIC InnoEnergy, 2014). Regarding standards of performance, KIC InnoEnergy has been relying on reports at different levels and key performance indicators (KPIs) to follow-up and control results of KIC InnoEnergy's activities (EIT, 2015b).

Authority is exercised through formal positions, with the centralisation of the decision-making process and the overall knowledge generated in the network mainly at top-level. Even tough KIC InnoEnergy is under a fixed form of coordination, it has not compromised or limited the innovative capacity of the network nor its potential outcomes as praised by some researchers (Hurmelinna-Laukkanen & Nätti, 2012; Ritter et al., 2004; Wilkinson & Young, 2002). Instead such formal structure of coordination has helped to overcome geographical distance, manage lower levels of trust among network members, and reconcile broken and individualised tasks (Burns & Stalker, 1994).

On other side, ATLAS Experiment, driven by its exploration goals, was constituted as a loosely coupled collaboration of independent research institutions (Tuertscher et al., 2011) focused on conducting basic research to observe phenomena that involve highly massive particles that were not observable using previous lower-energy accelerators. The nature of the experiment itself, an emergent and one-of-a-kind technological system, influenced this organisational structure to resembles more an organic organisation, in which does not comply with traditional management approach (Hurmelinna-Laukkanen et al., 2014). Through a commonly held and broadly internalised set of goals, the reputational effects of a clan culture, the ATLAS detector itself and the geographical reach of a grid infrastructure, all imposes a horizontal coordination constraints on those who work with it (Hoffmann et al., 2011). As mentioned in the literature, under such conditions, informal coordination mechanisms (such as boundary objects) help on the reconciliation and transformation of knowledge (Gal, 2008; Ramaligan & Mahalingam, 2013), thus replacing hierarchy as a mechanism of coordination (Kleinbaum et al., 2008; Hurmelinna-Laukkanen et al., 2014).

Besides, this horizontal structure is characterised by a much more flexible and fluid set of arrangements, embedded on high levels of trust, complementary expertise and ready to respond to changing environmental conditions that require emergent and innovative responses (Burn & Stalker, 1994). Individual tasks are developed based on expertise and it is constantly redefined through interaction with others as all systems must fit and work together. Each participant contributes to the common task of the organisation, in a web of complementary expertise. The decision-making process follows a bottom-up approach, where knowledge can be located anywhere in the network and (technical) decisions are taken at group level based on consensus (Knorr-Cetina, 1999).

Of course hierarchy still exists, tough in a soft terms, to communicate and to coordinate but formal authority relations do not drive it. Some members possess capabilities (such as management and communication skills, aside from experience and expertise) that make other members see them as their representative (Ihrig & MacMillan, 2015). Moreover, the superordinate goals (e.g. discovering the Higgs or suppersymetry) and the constraining power of the scientific ethos, allowed ATLAS to avoid much of the silo thinking and many of the turf battles that typically occur in other organisations (Santalainen et al., 2011).

Differences between the two cases in relation to coordination mechanisms were not only observed due to different networks characteristics, as previously discussed, but it was also observed due to the characteristics of network members. Such diversity of members was expressed using the concept of proximity, which can be perceived as a degree of closeness between two individuals' attributes (including geographical location, knowledge field, affiliation, professional experience/expertise, character traits, and rules and regulations that one is subject to) (Caniëls et al., 2014). And such proximity between actors is said to have an impact on the collaboration of network members and on the coordination of their actions (Whittington et al., 2009). In the case of negative effects, it can create conflicts that may hamper effective collaboration to take place (Boschma & Frenken, 2010).

It was possible to observe in the findings that, although innovation needs elements of distance among collaborating network members, in some occasions such distance was a source of conflict of different nature and intensity in the two innovation networks studied (Parjanen, 2008). In the particular case of KIC InnoEnergy and OTS project, members were very heterogeneous. It was observed geographical, institutional and organisational distance within this network. Geographical distance refers to the spatial of physical distance between network actors (Boschma, 2005). Although it is mainly said in the literature that geographical proximity is important for the sharing of knowledge and innovation (Doloreux, 2002; Knoben & Oerlemans, 2006), this distance was not perceived as a source of conflict. The way that KIC InnoEnergy is organised in co-location centres creates temporary geographical proximity as it enables physical spaces that ensure the interface between different partners (Rychen & Zimmermann, 2008). Besides, the mentioned occasional meetings, that required business travels, is also seen as a form of transitory geographical proximity, fulfilling the occasional needs for physical interactions expressed at different times (Carrincazeaux & Coris, 2011). Moreover, the use of ICTs (e.g. Skype, video conferences) also helped to overcome such distance by creating virtual proximity (Torre, 2008) and reducing the need of face-to-face interactions (Boisot, 2011).

Institutional and organisational proximity rest upon the same mechanism, namely shared rules and habits. It can be either generated by common institutional frameworks on regional, national or supra-national level, or by shared social community norms, including the same organisational arrangement (Broekel & Boschma, 2012; Caniëls et al., 2014). Institutional distance refers to the fact that actors operate in different institutional regimes (Etzkowitz & Leydesdorff, 2000). This means that they do not share the same institutional rules and legal norms, as well as habits and values (Boschma, 2005). Such distance creates conflicts because they have incentive incompatibilities (Hardeman et al., 2015; Parjanen, 2008). For example, firms have an incentive to appropriate knowledge, while universities have an incentive to publish research instantaneously. According to Caniëls et al. (2014), it can be stimulated by organisational and social proximity by developing common codes of conduct which may even turn into formal regulations and law.

However, by the time of data collection social proximity was still limited, as it develops in the course of overlapping relationships (Caniëls et al., 2014). Besides, it was possible to observe organisational distance within KIC InnoEnergy members, the same happening in OTS Project. Organisational distance relates to the difficulty in coordinating transactions and exchanging information within and between network members (Parjanen, 2008). Since at that time KIC InnoEnergy was starting to develop its internal norms and regulations, although partners were working in the same organisation, they had different goals and objectives. The organisational arrangement was not succeeding in aligning their aims and interests in shared activities (Broekel & Boschma, 2012).

These distances among partners led to the observation of internal conflicts such as cognitive, affective, administrative and goal conflicts. As previously discussed, cognitive conflict takes place when partners disagree about a task or what is the best technical solution to be employed (Mooney et al., 2007). It was observed in two situations, one at KIC-level due to the difficulties of parties in understanding the new way of collaboration being praised within KIC InnoEnergy. In this occasion, partners relied on the abstract concept of the knowledge triangle to create a common reference point for creating a common ground, integrating their knowledge and allowing them to work together (Michalski, 2006). This concept worked as a boundary object to provide coherence across intersecting social groups and help informally on their coordination (Bechky, 2006; Canals et al., 2011). Although this boundary object followed a top-down order, as such concept was developed by the EIT and applied by KIC InnoEnergy top-level management; and it was not fully understood by partners still it served as a common point of reference and a mean of alignment (Marick, 2015; Zdunczyk, 2006) about the rationale of KIC InnoEnergy.

This consideration leads to the following proposition:

Proposition number 1: In innovation networks characterised by more heterogeneous members and at early stage of development, cognitive conflicts could be informally solved through boundary objects.

In another situation of cognitive conflict, now at innovation project level, engineers were facing difficulties to understand how to develop a market analysis in OTS Project. In order to help them to provide focus, recruit the necessary expertise, and ensure the project's accountability, partners relied on the expertise of the marketing expert. He orchestrated this conflictual situation by guiding them to build bridges between these two separated knowledge bases (business and engineering) (Turnhout et al., 2013). At first, the marketing expert took benefit from his brokerage position (tertius gaudens) as he kept apart OTS partners and the business students who prepared the market analysis, bridging minimal information between them. He kept control of what went through between them (Vernet, 2012). In a second moment, he changed his brokerage orientation into a more reconciliation attitude to help partners foster new collaboration and ease coordination and consensus (Lingo & O'Mahony, 2010). Under such perspective, brokers (tertius iungens) integrate different ideas and contributions and synthesise them into a coherent whole (Obstfeld, 2005).

Thus, the consideration above leads to the following proposition:

Proposition number 2: In innovation networks characterised by more heterogeneous members and at early stage of development, cognitive conflicts could be informally solved through an orchestrator in brokerage function.

Other conflict that was observed from data collection in the OTS Project was the affective conflict between engineers and the marketing expert due to his behaviour on the occasion of the first iteration for developing the market analysis. Partners went to seek help from a member of KIC InnoEnergy to mediate this conflict that existed because of an apparent incompatibility of parties' need and interests (Moore, 2003). The decision of partners to seek help from this member went beyond the fact that his occupied an important position within KIC InnoEnergy. It was also because of this person was high regarded by partners as he displayed interpersonal oriented skills (e.g. good listening skills, empathy, trust, ability to reorient partners' efforts toward their long-term goals), and also because of his expertise in the field (Gray, 2008). The mediator normally assesses the conflict between parties and assists them in defining their differences in terms of a problem to obtain a settlement that would allow partners to collaborate (Spangler, 2013). In order to do so, the mediator listened to both sides; gave participants insights into their own behaviours and of others; encouraged and improved communicate among them in an attempt to rebuild trust and relationships (Ansell & Gash, 2012; Podro & Suff, 2013).

Based on this consideration, the proposition that follows is:

Proposition number 3: In innovation networks characterised by more heterogeneous members and low level of trust between them, affective conflicts could be informally solved through an orchestrator in mediation function.

Regarding goal and administrative conflicts, the first was caused by the different objectives between KIC InnoEnergy and network members, and the latter was due to the new rules and policies being applied in KIC InnoEnergy at time of data collection. Goal conflict occurred because of the presence of incompatible goals, objectives or about preferred outcomes among network members (Borkowski, 2011). Administrative conflicts were observed because of disagreements about the procedures to be followed in accomplishing tasks (Ongori, 2009). These conflicts could be minimised by adopting formal coordinating mechanisms (e.g. standard procedures, manuals, written policies) that would specify goals, decisional processes and responsibilities (Houle, 1989). Besides solving these conflicts, these formal coordination mechanisms would also increase organisational proximity (Parjanen, 2008), which can be intentionally developed (Knoben, 2008) and it is a powerful mechanism for coordination, particularly for big organisations (Torre & Rallet, 2005). According to Boschma (2005) strong coordination mechanisms are required to provide solutions to conflicts like these and increase organisational proximity.

This consideration leads to the following proposition:

Proposition number 4: In innovation networks characterised by more heterogeneous members and at early stage of development, administrative and goal conflicts could be solved through the use of formal coordination mechanisms, and that by the way might increase organisational proximity.

In the case of ATLAS Experiment, although members were more homogeneous in comparison to KIC InnoEnergy members, institutional, organisational, and social proximity was high as members belong to universities and research institutes that conduct research in particle physics, with friendship bonds (or previously acquainted) and that are aware of how ATLAS operate when they join in the experiment. Although geographical distance was present, as members of ATLAS collaboration are from different countries, it was not seen as an issue due to the important enabling role played by information and communication technologies (ICT) in the development and operation of ATLAS detector (Boisot & Nordberg, 2011a). Besides this virtual proximity, there was also a temporary geographical proximity (as members spent time in CERN facilities developing localised actions or as they met occasionally in conferences or meetings) that diminished the impact of little geographical proximity (Torre & Rallet, 2005).

It was observed tough cognitive, affective, and administrative conflicts. Regarding cognitive conflicts, research findings showed that it occurred in two situations. First, it was mentioned in the interviews that a small cognitive distance was observed between physicists and engineers during the phase of construction of the ATLAS detector. Although these engineers were used to work with physicists, they had an engineering ethos. In contrast to the scientific ethos, the engineering ethos aims to reduce uncertainty by moving as fast as possible towards higher levels of knowledge codification. This means clearly state the objectives and the means of realising them readily identified. Any residual uncertainty can often be reduced by managerial fiat.

However, for the scientific ethos uncertainty has to be absorbed through clan-like interactions that facilitate exploratory behaviour – through minor tests and experiments –, generate consensus, and foster a sense of collective responsibility (Hoffmann et al., 2011). A scientific culture adopts an exploratory stance towards knowledge, whereas an engineering culture adopts an exploitative one (March, 1991). Although both ethoses are complementary and essential to the creation of knowledge, finding the balance between them is the tricky point. Engineers and physicists found a way to overcome this setback and collaborate by resorting to the physical aspects of the detector. The ATLAS detector served as a boundary object since it was used as a basis for meaningful conversations across groups negotiating design matters (Tuertscher et al., 2011) and informally coordinating their activities (Hoffmann et al., 2011).

The use of boundary objects to solve cognitive conflicts was also mentioned in the interviews to be important during the first and second phase of the experiment (operation and maintenance of the ATLAS detector) with the use of simulations to serve as a boundary object, or an interface, between different groups of scientists participating in the experiment. ATLAS involves many specialised scientist from a variety of background, such as high-energy physics (HEP), semi-conductor technology, cryogenics, electronics, and computer science just to name some few. In this context, such simulations acted as a representation of the physical detector when it was being built, and later on, to interpret data obtained from the experiment (Canals, 2013). In a variety of domains, especially in open innovation settings (Chesbrough, 2006), modelling has been shown to be able to support situation where disparate stakeholders need to create new knowledge, allow groups to engage with innovation projects and contribute to potential solutions to problems (Dodgson et al., 2007).

Taking these issues into consideration, the following argument is proposed:

Proposition number 5: In innovation networks characterised by more homogenous members and at more advanced stage of developments, cognitive conflicts could be informally solved through boundary objects.

Another type of conflict that was also mentioned in the interviews, tough in lesser extent, was of affective background. This occurs when two interacting partners, while trying to solve a problem together, become aware that their feeling and emotions regarding some or all the issues are incompatible (Amason, 1996). Interviewees mentioned that it was manifested in interpersonal clashes characterised by negative reactions (Das & Teng, 2002). If not solved, such conflict is nearly always disruptive to group performance and collaborative decision-making (Mooney et al., 2007) by limiting information-processing ability and cognitive functioning of group members and antagonistic attributions of group members' behaviour (Amason, 1996). Due to the fact that ATLAS Experiment is structured as an agglomeration of collaborating clans and is itself driven by a clan culture (Boisot & Nordberg, 2011b), interviews mentioned that when affective conflict did happened they tended to solve it at group level and through informal help of another member of the collaboration. Usually, a senior physicist with expertise, experience and leadership skills was informally consulted to help mediating the conflict and overcoming the issue without disturbing the functioning of the experiment.

This consideration leads to the following proposition:

Proposition number 6: In innovation networks characterised by more homogeneous members and occasionally lower level of trust between some members, affective conflicts could be informally solved through an orchestrator in mediation function.

Another finding from data collection in ATLAS Experiment was that interviewees mentioned the recent use of formal coordination mechanisms to solve some administrative issues. Now that ATLAS has reached a second phase in its development and activities are being individually developed (e.g. analysis of data gathered), other non-physics tasks were being left behind. So through the use of formal tools, for example OTP (Operational Task Planner) and the rules for becoming an author in ATLAS, ATLAS ensures that everyone is committed to work for the experiment and develop the required tasks even if they are not so glamour and fulfilling such as finding Higgs or conducting an statistical analysis. This finding was interesting to be observed in ATLAS Experiment, as coordination is tacit, horizontal and accomplished through a process of negotiation (Hoffmann et al., 2011; Tuertscher et al., 2008). However, ATLAS has entered in a phase that maintenance and operation procedures of the detector need to be established and broken down into tasks according to one or more logical hierarchies. And the management team has identified the need for a new system to document, orchestrate and monitor the maintenance and operation of the ATLAS detector (Copy & Tsikanin, 2007).

Therefore, the consideration above leads to the final proposition:

Proposition number 7: In innovation networks characterised by more homogeneous members and at advanced stage of development, formal coordination mechanisms could be used to solve administrative conflicts.

Chapter 7

CONCLUSION

In this concluding chapter, the results obtained in this study are summarised. And finally, the limitations faced by this research are addressed as well as the subjects to be tackled by future research in order to fill some of the gaps that exist in our present knowledge and understanding.

1. Conclusions

The objective of this study was to identify and characterise the coordination mechanisms in their different forms in innovation networks. Innovation networks are characterised by the diversity of actors composing it. Such diversity is not only relevant for generation of innovation, but it is also very challenging as it turns collaborating for innovation full of barriers, paradoxes and contradictions. Coordinating these networks then becomes of utterly importance because many interorganisational networks have failed due to poor management (Howells, 2006). However, the form that coordination takes is still seen in the literature as paradoxical (Hurmelinna-Laukkanen et al. (2014). Some authors have defended that management-like control is possible (Ritter et al., 2004), while other have suggested that innovation networks cannot be centrally directed (Ojasalo, 2004). Perhaps this debate is due to few empirical studies conducted on the subject (Dhanaraj & Parkhe, 2006). Besides, the existing literature has not explicitly stated in which situations different forms of coordination would function best (Lèven et al., 2014). Not to mention that research on coordination mechanisms have addressed them individually (Gardet & Mothe, 2011).

This study attempted to address this gap by investigating the coordination process in two innovation networks: KIC InnoEnergy and ATLAS Experiment. These two cases were selected as their primary focus is on fostering an environment where collaboration among diverse members is promoted with the goal of enabling innovation. To do so, these networks have created innovative elements so collaboration could take place. Despite that, KIC InnoEnergy and ATLAS Experiment are distinct cases, with differences mostly evolving from their environments, network purposes, characteristics and stage of development.

KIC InnoEnergy was founded as a commercial company in 2010, what implies that this network is more formalised with defined strategy, objectives, business plan, rules and procedures. To comply with it, KIC InnoEnergy created a result-oriented structure, with an executive team formally appointed for managing, coordinating and supporting the efforts of the network. Authority was exercised through formal positions, with the centralisation of the decision-making process and the overall knowledge generated in the network mainly at top-level. To manage the heterogeneity of its members and the early stage of development of the network, it was observed that KIC InnoEnergy relied more on formal mechanisms (standardisation of work processes and outputs) as its main source of coordination. Such observation goes in lie with what Provan and Kenis (2008) suggested as required for an interorganisational network that has an internal need of managing distributed resources, enhancing network legitimacy, dealing with unique and complex network-level problems and issues, reducing the complexity of self-governance and bridging borders between network actors.

ATLAS collaboration, on the other hand, was formed in 1992 when two previous experiments merged their efforts to build the ATLAS detector. Influenced by the nature of the experiment itself, ATLAS organisational structure was constituted as something similar to an adhocracy due to its size and complexity, bounded by common values and beliefs, where power is horizontally distributed across the network. The decision-making process followed a bottom-up approach, where knowledge could be located anywhere in the network and (technical) decisions were taken at group level based on consensus. Influenced by these characteristics, the more homogenous aspects of ATLAS members, the detector itself and the geographical reach of the grid infrastructure, all imposed a horizontal coordination constraint on those who work with it. Hence, it was observed that informal mechanisms (boundary objects) were used as its main source of coordination since the management of the network depends exclusive on the involvement and commitment of the organisations that comprise it (Provan & Kenis, 2008).

Hence, differences between the two cases in relation to the use of coordination mechanisms were observed due to the different characteristics of the innovation networks studied (including its stage of development) and its members. Aside from these coordination mechanisms, findings showed the use of complementary coordination mechanisms in both innovation networks to further help on their collaborative processes. These mechanisms were also influenced by the different characteristics of the innovation networks studied (including its stage of development) and its members, alongside the conflicts caused due to the diversity (or differences) of network members. Irrespective of the characteristics of the network and the diversity of its members, both innovation networks have relied on virtual proximity (through the use of ICTs) and temporary proximity (through co-locations centres, CERN facilities, and meetings) to overcome issues related to geographical distance.

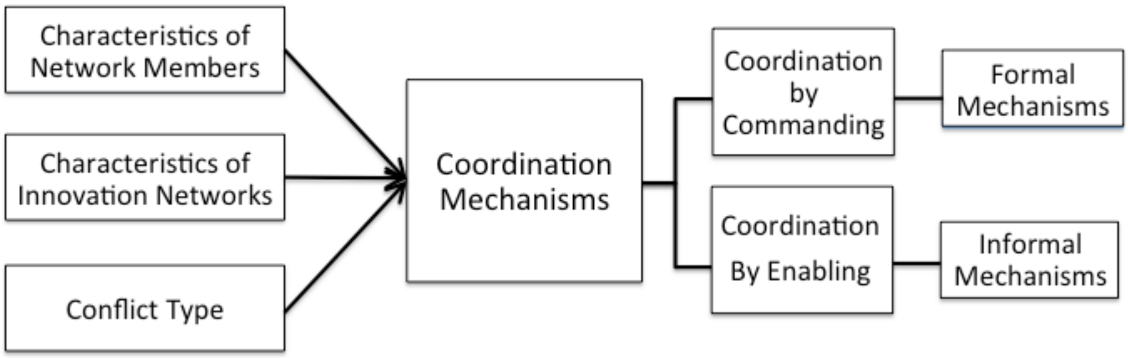
Other common observation to both cases was that, independent of the diversity of members and the stage of development of the network, findings indicated that cognitive conflicts could be informally solved through the use of boundary objects. In both cases, boundary objects (such as a concept or a physical apparatus) were employed to provide coherence across intersecting social groups, serve as a common point of reference and a mean of alignment. However, in the case of KIC InnoEnergy, probably influenced by the more heterogeneous aspects of its members and its early stage of development, a third-party acting on a brokerage function was also observed when solving cognitive conflicts. He guided members to build bridges between two separated knowledge bases, integrate different ideas and contributions and synthesise them into a coherent whole that may ease consensus and coordination.

Findings also seemed to indicate that in both cases, irrespectively of the characteristics of the innovation network and its stage of development, in situations of lower levels of trust and where affective conflicts took place, the help of a third-party acting on a mediation function could informally solve these conflictual situations. Even in ATLAS Experiment, where members had higher social proximity (due to friendship bonds or acquaintances) in comparison to KIC InnoEnergy, members relied on a party highly regarded to assess the conflict and assist them in defining their differences in terms of a problem to obtain a settlement that would allow partners to collaborate. In both innovation networks, this person was selected based on his interpersonal oriented skills and expertise in the field.

Formal mechanisms of coordination (such as written policies, rules, and standard procedures) were observed in the two innovation networks studied when solving administrative conflicts. These conflicts were observed because of disagreements about the procedures to be followed in accomplishing tasks or a further need to specify goals, decisional processes and responsibilities. In the case of KIC InnoEnergy, findings indicate that these formal coordination mechanisms were also employed to solve goal conflicts. These conflicts take place when members have incompatible goals, objectives or preferred outcomes. Findings make one considers that, in case of innovation networks characterised by more heterogeneous members and at early stage of development, formal mechanisms of coordination could not only solve administrative and goal conflict, but also increase organisational proximity as stated in the literature (Knoben, 2008; Parjanen, 2008; Torre & Rallet, 2005). Organisational proximity is a relevant mechanism for coordination and can be intentionally developed, for instance, through the integration of network partners to the organisational structure, the definition of guidelines and the development of an organisational framework for collaboration, by the exchange of knowledge (Menzel, 2008).

Therefore, the findings of this study illustrated that three different aspects had an effect on the type of coordination mechanisms employed in innovation networks: characteristics of innovation network, characteristics of its members, and types of conflict. The manner through which coordination mechanisms were implemented evolved accordingly to the structure of the network, the type of interactions between partners and the emergence (or not) of conflict. Different coordination mechanisms were employed in an attempt to overcome difficulties and ensure effective collaboration for innovation. The figure bellow (fig. 24) represents graphically this consideration.

Fig. 24: A Proposed Model for Innovation Network Coordination



In this way, and contrary to what most studies on innovation network coordination says (e.g. Dhanaraj & Parkhe, 2006; Hurmelinna-Laukkanen & Nätti, 2010; Ojasalo, 2008; Powell et al., 1996; Ritter & Gemünden, 2003; Ritala et al., 2012; Ritter et al., 2004), research findings indicate that **both** formal and informal coordination mechanisms, that is to say coordination by commanding and by enabling, could be seen as complementary forms of coordinating innovation networks. The focus of attention should be not on whether innovation networks can or cannot be coordinated, but what kind of solution is most suitable for different types of innovation networks. Some networks may be more manageable, while others are fuzzier and call for discrete orchestration rather than formal coordination. Thus, aligning and matching innovation network type and coordination type seems to be relevant so as to not sacrifice the independence of network members and the flexibility that are needed for innovation.

2. Limitations and Suggestions for Future Research

The main limitations of this study were related to time and scope issues. Both KIC InnoEnergy and ATLAS Experiment organisational structures are complex and multileveled. Moreover, it involves a great number of partners. Even tough it was conducted twenty-three interviews, it gave us the possibility to meet only with a small part of these networks, thus a wider study might enrich understanding of interorganisational networks like these two. On the other hand, there was a time constrain to collect data. Having the possibility to spend more time in the study sites, observe more collaborative activities and for a longer period would enable the proposition of a deeper picture.

Another limitation of this study rests on its cases. These two interorganisational networks could be considered as outlier organisations, deeply influenced by the context in which they rest, what could affect the replication of the findings in other innovation network. Nonetheless, it does not diminish the relevance of analysing two organisations that have been perceived as the frontrunners of innovations, by developing new approaches to cooperation and catalysing positive societal changes.

On that account, a possible avenue for future research is to extend the analysis to others innovative networks with different characteristics and settled at different environments, so as to have comparative patterns and, consequently, analyse the different coordination mechanisms employed and their complementary aspects. Other issues call for further investigation and research. For instance, there is a need to better understand the possible effects of network structure as a mechanism for promoting proximity between network participants. A detailed understanding of this relationship seems to be essential if future innovation networks are to be designed properly. Besides, there is also room for a more in-depth analysis of the orchestrating function of intermediaries since the notions of mediation and transformational leaders have been little addressed in the network literature. If such functions are to be found relevant for coordination of different innovation networks, it could be thought instead as a role with permanent positions within these networks. Moreover, deeper studies are needed to better understand the effect that different forms of proximity (or distance) have on the different types of conflict.

Finally, it is important to extend this analysis to other innovative networks at different stages of development, and even in a longitudinal study, in order to obtain comparative patterns and, consequently, investigate the dynamic aspect of coordination in the development of networks. Innovation networks at different stages of development may need different coordination mechanisms as repeated interactions give rise to trust, interpersonal routines and common language, which altogether enhance the efficacy of mutual adjustment between them, and the very task of coordination may become easier. Therefore, over time, perhaps an innovation network would rely more on coordination by enabling (through informal mechanisms) and less on the need of coordination by commanding (through formal mechanisms).

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Annex 1

LITERATURE REVIEW OF SELECTED RESEARCHES ON INNOVATION NETWORKS

Study	Research Focus	Methodology	Objective	Key Findings
Ahuja (2000)	Structure of Innovation Networks	Longitudinal study (patent analysis) in the chemical industry	To study how relationship structures impact innovation networks	In this research, the author relates three aspects of a firm's ego network (direct ties, indirect ties and structural holes) to innovation output. Each of them plays a distinct role in the innovation process. Direct and indirect ties have both a positive impact on innovation, but the impact of indirect ties is moderated by the number of a firm's direct ties. Structural holes have negative effect on innovation
Baba & Walsh (2010)	Structure of Innovation Networks	Archival and secondary data on a specific drug to lowering blood cholesterol levels	To assess key factors that enable firms to make proactive decisions about high-risk innovation	They found that dense networks with strong ties are key for the successful introduction of breakthrough innovation in companies and a source of competitive strength
Baum et al. (2009)	Formation of Innovation Networks	Conceptual paper (quantitative simulation)	To investigate the role of complementary knowledge stocks on network formation	Relying on a conceptual model, the authors showed that firms ' knowledge bases must "fit" in order for joint innovation be possible in innovation networks
Boschma & Frenken (2010)	Formation of Innovation Networks	Conceptual paper	To propose that various forms of proximity are responsible for the formation of innovation networks	While a high degree of proximity is considered a prerequisite to make actors connected, the authors expected the effects of network relations on innovation to be rather ambiguous. Proximity between actors does not necessarily translate into higher innovative performance, because excess of proximity may be harmful for learning. In terms of network formation, the forms of proximity positively affect the establishment of networks

Study	Research Focus	Methodology	Objective	Key Findings
Cantner & Graf (2006)	Performance of Innovation Networks	Longitudinal analysis (1995 - 2001) of patents in the region of Jena - Germany	To describe the evolution of the innovation network and its impact on R&D collaborations	In this research, the authors study the growth and the structural changes of innovation networks as a result of job mobility of scientists and the technological overlap between the actors. Questions like how new relationships come into existence and existing ties are cut, how new actors join in the innovation system while others leave it, are used to guide the analyses
Chang et al. (2008)	Performance of Innovation Networks	Survey of 75 firms in the Hsinchu Science Park (Taiwan)	To analyse the impact of innovation networks on a firm's performance	Findings suggest that participating in innovation networks positively impacts a firm's capability to introduce new products and receive new awards. However, it has no significant effect on the firm's capability to receive patents and adopt new technology
Cowan et al. (2007)	Formation of Innovation Networks	Conceptual paper	To identify effective factors for joining in innovation networks	The authors develop the idea that innovation in these networks will result from the recombination of knowledge held by each network partner and its success is determined, in part, by the extent to which firms' knowledge complement each other.
Cowan & Jonard (2008)	Formation of Innovation Networks	Conceptual paper (Digression)	To develop and analyse a model of joint innovation to investigate that successful partnerships demands some similarity between partners	The authors suggested that complementary knowledge assets not only determine innovation network formation and partner selection, but also could be used to explain resultant network structures
Dhanaraj & Parkhe (2006)	Management of Innovation Networks	Conceptual Paper	To examine how a hub firm manages and coordinates other members in an innovation network.	This theoretical research suggests that in the presence of hub firms "orchestrating" network activities, there is no need of a hierarchical authority for managing innovation networks. Hub firms shall focus on knowledge mobility, innovation appropriability and network stability to foster value creation in innovation networks
Gilsing & Nooteboom (2010)	Structure of Innovation Networks	Archival data and unstructured interviews on four innovation networks in multimedia industry and biotechnology	To provide an empirical illustration concerning the fact that density and strengths of ties vary for innovation networks of exploration and exploitation	Findings showed that innovation network effects depend on the industry and on whether the focus of a network is on exploration or on exploitation. Besides, next to density and strength of ties one should also look at their content, for example in terms of types of knowledge, technology and of competence for innovation
Granovetter (1983)	Structure of Innovation Networks	Conceptual paper	To further study the importance of weak ties with organisations outside the network for access to information and innovation	The author proposed that weak ties enable fast access to information and adaptation to change. Furthermore, organisations with a lot of weak ties outside the network will have great advantage in terms of spreading innovation

Study	Research Focus	Methodology	Objective	Key Findings
Hagedoorn & Duysters (2002)	Performance of Innovation Networks	Structural equation based on 88 companies operating in the international computer industry	To examine the relevance of both efficiency-based and learning-based network behaviour in the context of inter-firm partnering	The authors found that learning through exploratory networks is better for innovative performance than learning through exploitation networks
Heidenreich et al. (2014)	Management of Innovation Networks	Structural equation modelling of the German mechanical engineering industry	To examine the influence of networks managers on core management functions and performance outcomes in low and high complexity settings	Results confirmed that employing a network manager significantly improves core network management function and relational as well as structural network performance, which in turn enhance goal achievement performance and network retention. Such contribution is even greater in high complexity settings.
Hurmelinna-Laukkanen et al. (2009)	Management of Innovation Networks	Case study of a Finnish Mobile TV	To empirically illustrate how the characteristics of the network and its management can be aligned	The authors noted that aligning and matching network type and coordination type is relevant. Appropriate form of coordination for different kind of innovation networks can be found from the continuum formed between management and orchestration.
Levén et al. (2014)	Management of Innovation Networks	Longitudinal study of a research and innovation programme focused on Information Technology for process and manufacturing industries in North Sweden. Data was collected on multiple data sources (interviews, audio recordings of management meetings, archival data)	To investigate what are the challenges associated with managing innovation networks to improve firm competitiveness and stimulate growth	The authors provided a detailed analysis of the challenges related to configuration of the network, orchestration of partnerships between participants, and facilitations of innovation dedicated to development projects. Besides, they also proposed a model of managing research and innovation networks through fertilisations across industries and between firms and research institutions.
Mohannak (2007)	Performance of Innovation Networks	Survey and interviews of 44 biotechnology and information communication technology firms in Australia	To investigate how innovation networks promote learning and adaption in face of technological changes	Results indicate that competitiveness and organisational learning may be enhanced by the presence of collaborative institutions and innovation networks. Collaboration within university and training institutions often take place in closer vicinity, justified by the fact that face-to-face contacts are prerequisite for joint innovation projects

Study	Research Focus	Methodology	Objective	Key Findings
Obstfeld (2005)	Structure of Innovation Networks	Multimethod study (survey, ethnographic study and statistical tests) in an engineering division of an automotive manufacturer	To investigate the importance of dense networks to innovation	The author argued about the fact that open networks pose a fundamental problem for acting upon new ideas because the dispersed actors are more difficult to coordinate due to their opposing interests, unique perspectives and different languages. Conversely, dense networks have a structure conducive to collective action or coordination because they facilitate trust, shared interests, perspectives and language. Hence, results showed that a tertius iungens orientation (the third who join – someone with behavioural orientation toward connecting people in one's social network by either introducing disconnected individuals or facilitating new coordination between connected individuals), as well as dense social networks are positively related to involvement in innovation
Ojasalo (2008)	Management of Innovation Networks	Case Studies of 2 software firms in Finland	To map the characteristics of management approaches in innovation networks	The contribution of this study lies on the identification of various aspects that explain the nature of innovation network management (duration, primary reward, the fundamental meaning, nature of networked organisation, planning, control and trust, hierarchies, authority and coordination). By relying on these aspects, one could better understand how to manage innovation networks as it would enable a comparison of management approaches in different networks
Owen-Smith & Powell (2004)	Performance of Innovation Networks	Patents by dedicated human therapeutic and diagnostic biotechnology firms located in the Boston metropolitan area	To explain the innovation rates of biotechnology firms	Findings obtained from a quantitative study showed that networks function as pipelines through which information and knowledge flows between firms, allowing for organisational learning and, as a consequence, increasing the number of patents

Study	Research Focus	Methodology	Objective	Key Findings
Powell et al. (1996)	Formation of Innovation Networks / Performance of Innovation Networks	Longitudinal study (1990-1994) using secondary data of biotechnology firms	To understand why biotechnology firms engage in innovation networks	Results in this study show a linkage between networks of learning and firm performance. Firms need to learn to locate themselves in network positions that will allow them to access and transfer knowledge and to keep pace with scientific and technological developments. In relation to the performance of innovation networks, the authors stated that firms learn from exploration and synergies between different types of alliances. Collaboration between firms not only enhances learning about new development, but also strengths internal competencies
Powell et al. (2005)	Structure of Innovation Networks	Longitudinal study (1988 – 1999) of 428 American and European firms	To analyse the structure and dynamics of inter-organisational collaboration in the field of biotechnology	Findings highlight that different rules for affiliation are responsible for shaping innovation networks evolution. As organisations increase both the number of activities on which they collaborate and the diversity of organisations with which they are linked, they reach a cohesive, central and influential position within network
Pyka & Küppers (2002)	Performance of Innovation Networks	4 case studies of biotechnology, telecommunication, energy and e-commerce firms	To examine the mechanisms and circumstances which can contribute to the successful development and evaluation of innovation networks	This study proposes a dynamic and systemic computational model to simulate an innovation network. This dynamic model, applied to different industrial sectors, analyses the interdependencies of the factors compounding an innovation network, which are: a firm's own R&D efforts, the innovation partnerships and alliances, the resulting knowledge base, the resulting innovation and the market acceptance for the innovation
Rampersad et al. (2010)	Management of Innovation Networks	15 interviews with specialists on innovation and collaboration	To determine success factors for managing innovation networks	Despite all the difficulties and challenges, measuring the success of innovation networks is an important task for their endurance. As so, the authors propose the following success factors for further consideration: cognitive factors (i.e.: coordination and harmony), structural factors (i.e.: power distribution and density) and relational factors (i.e.: trust and commitment)
Ritala et al. (2009)	Management of Innovation Networks	Expert panel discussions and in-depth case study of an innovation network	To explore orchestration capability as a firm's ability to purposefully build and manage innovation networks	The authors showed that orchestration capability consists of both organisational (e.g. capabilities in operational and entrepreneurial issues) and individual level determinants (e.g. interpersonal communication and social skills). These two levels are interconnected in several ways and even can be seen as substitutes or complements

Study	Research Focus	Methodology	Objective	Key Findings
Ritala et al. (2012)	Management of Innovation Networks	In-depth case study	To discuss and empirically analyse coordination mechanisms in innovation-generating networks	The findings suggested that coordination of innovation-generating networks combines “management” and “orchestration”, both of which have their distinct roles throughout the development of the network. The latter is used throughout the case in question to communicate vision and build social capital, and the former to coordinate phases closer to commercialisation
Ritter et al. (2004)	Management of Innovation Networks	Conceptual paper	To inquire to what extent business networks are manageable and how management can be characterised and measured	One of their conclusions is that the challenge for managers is to develop a networking ability that enables them to connect their resources to those of other actors. The discussion lead to a set of propositions describing the abilities firms will need to have to successfully manage complex business networks
Rodan & Galunic (2004)	Structure of Innovation Networks	Survey with 106 middle managers in a medium-sized Scandinavian telecommunication company	To look at the relationship between network structure and knowledge heterogeneity on manager’s overall performance and innovativeness	They found that sparse networks are beneficial with regard to innovative performance when they are accompanied by heterogeneous knowledge
Rost (2011)	Structure of Innovation Networks	Survey data on networks among inventors in the German automobile industry	To investigate which type of network structure is more conductive to innovation	The author demonstrated that, in the presence of strong ties, weak network architectures (structural holes) leverage the strength of strong ties in the creation of innovation. This implies that weak network architectures have no value without strong ties, whereas strong ties have some value without weak network architectures but are leveraged by this type of structure. The findings indicate that innovation research tends to overestimate the impact of weak network architectures in the creation of innovation
Rycroft (2003)	Performance of Innovation Networks	Conceptual paper	To determine a new indicator to measure success in innovation networks	Based on the consideration that traditional technology-based indicators are limited because they exclusively focus on either innovation inputs (i.e.: R&D spending) or output (i.e.: patents), the author proposes another indicator to assess innovation network performance: stock of collective learning. This indicator focuses on the network key actors (firms, universities and government agencies), which are considered as the source of success of innovation networks

Study	Research Focus	Methodology	Objective	Key Findings
Schilling & Phelps (2007)	Structure of Innovation Networks	Longitudinal study of patent performance of 1,106 firms in 11 industry-level networks	To further study if the network structure enhance firm innovation	The authors showed that firms in networks with high clustering and high reach (short average path lengths to a wide range of firms) will have greater innovative output than firms in networks that do not exhibit these characteristics
Steward & Conway (2000)	Structure of Innovation Networks	Interviews with staff involved in the SPRINT Programme – Strategic Programme for Innovation Technology Transfer	To improve the understating of how innovation networks are structured in order to promote the diffusion of innovation	Findings suggest that there is no single best network structure for innovation diffusion. What an appropriate network configuration requires is a proactive network management, with a strong sense of purpose and direction
Tidd (2001)	Management of Innovation Networks	Conceptual paper	To shed light on innovation management	The author argued for the need to take a broader view on innovation management, taking into consideration the relationships between environmental contingencies, organisation configurations and performance. He identified uncertainty and complexity as key environmental contingencies that influence organisational structure and management processes for innovation.
Tiwana (2008)	Structure of Innovation Networks	42 innovation-seeking project alliances involving a major American conglomerate and its alliance partners	To explore tensions and complementarities between bridging and strong ties in innovation networks	While weak ties provide access to diverse, structural hole-spanning perspectives and capabilities, strong ties help integrate them to realise an innovation
Tortoriello and Krackhardt (2010)	Structure of Innovation Networks / Performance of Innovation Networks	Questionnaire and archival data on 276 R&D scientists and engineers	To investigate the conditions under which having ties that span organisational boundaries (bridging ties) are conducive to the generation of innovations	The authors found that two aspects of network structure are significant: the extent to which ties cross organisational boundaries ant the extent to which ties are surrounded by third party ties. Strong ties that are bridging and are surrounded by third party ties are positively related to creativity. In relation to performance of innovation networks, the authors pointed out that close ties in innovation networks facilitate knowledge transmission, what as a consequence facilitate common understanding and norms, reduce miscommunication and carry out coordinated action to tackle tasks. The open communication channels allow for the development of trust within such networks, making these ties very effective at knowledge transfer, boundary spanning, creativity, and innovation

Study	Research Focus	Methodology	Objective	Key Findings
Vasudeva et al. (2012)	Structure of Innovation Networks	Longitudinal study of cross-border fuel cell technology alliance networks involving 109 firms from nine countries between 1981 and 2001	To analyse how the institutional settings influence the effects of structural holes on firm innovativeness	The authors found that network positions will be influenced by institutional settings of high and low corporatism. Structural holes have a more positive impact on innovation when the brokering firm or its network partners are located in countries with higher levels of corporatism. This implies that firms must not only match their network structures to the outcomes they wish to obtain, but they must also consider whether their partners will behave collaboratively based on the institutional norms with which they have been imprinted
Zaheer & Bell (2005)	Structure of Innovation Networks	Quantitative study based on Canadian mutual fund companies	To investigate if firms with superior network structures may be better able to exploit their internal capabilities and thus enhance their innovative performance	The authors found that firms that span multiple structural holes are more likely to have superior innovation performance, suggesting that firms need to develop network-enabled capabilities—capabilities accruing to innovative firms that bridge structural holes
Wang et al. (2015)	Structure of Innovation Networks	Meta-analysis study based on samples from 40 studies encompassing 15,860 organisations	To examine how network centrality influences organisational innovation and performance	The study showed that network centrality positively influences both organisational innovation and performance. In addition, findings indicate that the impact of network centrality on organizational innovation is stronger for small organizations while that on organizational performance is stronger for large organizations. The influence of network centrality on overall organizational innovation/performance is stronger for organizations in developed institutional environments as well as in knowledge-intensive industries
Whittington et al. (2009)	Structure of Innovation Networks	Quantitative study (correlations) based on longitudinal study of 12-year period based on a sample of 371 dedicated biotech firms from the industry directory (BioScan)	To investigate how propinquity and network centrality might jointly and individually influence innovation	Based on the study, the authors concluded that proximity and network centrality exert complementary, but contingent, influences on organisational innovation. The density of ties inside a region may facilitate the development of relational governance mechanisms that increase the performance of proximate organisations. Such thick ties can render local alliances more efficacious

Annex 2

INTERVIEW COVER LETTER (KIC InnoEnergy)

Dear Recipient,

Within the Corporate Innovation Unit of KIC InnoEnergy (INDU) we are developing different actions to enhance the performance of its innovation projects. One of these actions is a study on how to promote more effective collaboration among the participants of the innovation projects of KIC InnoEnergy. This concern is also being further investigated in my PhD thesis, as part of the PhD Programme of ESADE Business School (University Ramón Llüll).

The context of innovation projects in KIC InnoEnergy is especially challenging because it requires dealing simultaneously with companies, universities and research centres, as well as promoting collaboration of all stakeholders - experts, teachers, scientists, managers - to achieve the common goals previously established. This diversity of network members may create many sorts of distance between them, making the process of collaboration likely to break down and, as a consequence, to jeopardise the success of the network.

In order to get an overview of the activities that are being developed in these projects as well as more detailed information about the current challenges that partners have been facing or may come to face in the near future, we are interviewing participants of innovation projects.

Your comments and considerations are particularly relevant to the research we are doing. In this sense, we would be grateful if we could interview you. We have already interviewed other partners from OTS project, including the project coordinator, the project manager and some project partners.

The interview can be conducted on the location, day and time of your choice. The length of the interview is approximately one hour. There is no need to prepare anything, as it would only be a dialogue.

If you agree with the interview, we would be happy if you could inform us the date and time you prefer to do it.

In case of having any question concerning the research, please do not hesitate to contact me.

Hoping to have your acceptance, we appreciate your attention and collaboration.

Yours sincerely,

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SEMI-STRUCTURED INTERVIEW GUIDE

Block 1 – Icebreaker: In this initial part of the interview, the aim was to explain to the interviewee the objectives of the research, make him/her confortable and clarifying any doubts. Confidentiality issues, permission for recording the interview and using data gathered were reinforced at this stage. Questions were related to the interviewee educational background, current occupation and involvement in the innovation network:

1. As we do not know each other, we would like you to first introduce yourself and tell us about you current occupation.
2. How did you become involve in the collaboration? How long have you been participating in it?
3. What is your position in the network? What are the main activities that you conduct?

Block 2 – Purpose of the Innovation Network: The objective at this second part of the interview was to have a general understanding of a particular project and/or the whole innovation network, focusing on the factors that contributed to its formation (including the role played by its founders/initiators), and its main characteristics. Questions were related to the early stage of the project/network:

4. Why was the project/network created?
5. How was it formed?
6. Who decided the aim and objectives of the project/network? How was partners selected? Was there someone important during this stage? What did he/she do?

Block 3 – Evolution of the Innovation Network: In this part, attention was drawn to the success in achieving the purpose initially settled for the network. The intention was to obtain a more detailed perception of the collaboration regarding its:

- Internal rules
- Decision-making process
- Shared aspects
- Type of support (coordination)
- Interactions and communication

Examples of question asked were:

7. How are activities developed in the project/network?
8. How do you make decisions?
9. How do you communicate with each other?
10. What do the project/network coordinators do? How are members supported?
11. In what do you believe that this Project/network is different compared to other collaborations that you have participated?

Block 4 – Triggers of Network Development: In this section, the intent was to obtain a clear perception on critical incidents that the collaboration faced alongside its working processes.

Examples of questions included:

12. Could you give an example of a difficult moment that the project/network had faced? How was it overcome?
13. Could you tell me about the mechanisms (or people) that were essential for the consolidation of the collaboration?

14. Please, could you give an example of a successful moment that the network has faced?

Block 5 – Identifying Unity and Diversity: The focus of this part was on the issues that could impact the collaboration in some extent due to the multidisciplinary of partners who come from different institutional spheres, as well as cultural issues that may rise due to the diverse nationality of the network's members. Questions made were:

15. How do you manage to collaborate with partners from different institutional spheres? How does it affect the day-to-day activities?
16. During this period that you have been participating in this collaboration, could you share with me a moment when the diversity (or differences) among project participants caused a problem to the collaboration? What did happen? How was this managed? Was there someone/something that helped overcoming this issue?

Block 6 – Envisioning the Innovation Network: This last part of the interview aimed at identifying perceptions of the innovation network members regarding the evolution and future of the network, its learning capacity and their desire to change something that they do not agree on.

17. After this period that you have been participating in this innovation network, what suggestions or changes would you propose to improve collaboration?
18. If the network would have to start all over again, what would you change?
19. What do you think are the challenges that the network will have to face in a forthcoming period?

Annex 3

DATA CODIFIED

1. The SUCCESS Project

Code	Themes	Categories	Innovation Network Studied
Organisation	Decision-making	Top-down	The SUCCESS Project

"Well, I would say that we should start with differentiating meetings that had vertical activities as the major focus and not horizontal activities. They were usually conducted with partners' locations, so the partners invited the participants to come to their place. And there were meetings that were word package related. In general, the meetings were pretty active from all the participants. It was not like in a classroom, where one person makes the speech and all the others would nod and listen. In general they were open discussions, […] where you were invited to discuss with the others and to give your feedback and comments, and in general I would say it was quite result-oriented and there were very little politics involved […] And usually it happened in the following way: there would be an introduction on the topic, and afterwards, those were occupied with the different themes, different aspects of this topic. They would give a short presentation, which then would afterwards be discussed […] The steering committee telephone conferences happened on a regular basis. They were structured on a way in which the agenda was suggested from the project coordinator. The participants were going through the agenda. These were quite effective when there was a high priority […] now there is a lot of wrap-up to be done after each steering committee telephone conferences, which was not necessary earlier, because not everything could be discussed in the steering committee telephone conferences […]" *(Source: interview OMB member – social scientist)*

"[…] I think that email was used for thinks like when everyone has to send a proposal about some certain item, and then this item was compiled by the coordinator, and then perhaps after some briefing this was discussed in a teleconference, for example […]" *(Source: interview WP leader - engineer)*

Code	Themes	Categories	Innovation Network Studied
Organisation	Degree of Formalisation	Formal Mechanisms	The SUCCESS Project

"[…] For the steering committee, the virtual communication has been working very well I think, since we have had more or less a teleconference every two weeks. So it's been working very nicely. And it's always been virtual, so it was not bad. For the activities of the work packages, the different work packages, I was telling you that at the very beginning a number of meetings, physical meetings, were held […] *(Source: interview WP leader – engineer)* "[…] I'm pretty sure that the people who were attending the meeting in Karlsruhe was understanding the presentation. But, the people not attending for any reasons the meeting in Karlsruhe, it was a bit more difficult to transmit to them the model until the report was done, and the report perhaps was finished – I don't know – at the end, since of course we needed some time to compile everything, to write everything and so perhaps this was, I don't know, at the beginning of January […]" *(Source: interview WP leader – engineer)* "[…] I think that pressure of having deliveries done has been important. Because we could be discussing a lot, but if we have to finish this work package or this delivery for that day, the need to have these objectives, it pressures you. You agree, or you agree, you have to […]"*(Source: interview SC member – social scientist)* "[…] The coordinator adopts a more administrative role in the sense that, okay, I send the agenda, I write the minutes and so on, which is something very, I mean, it is basic. To have someone that does this role is very important […] *(Source: interview SC member – social scientist)* "In the beginning of the project we didn't have a coordinator so it wasn't so good, but when someone was appointed it went rather good because he's a very practical person and he's a very good organiser, so that wasn't bad that there was a main person who did all the coordinating of the project. This was better than before" *(Source: interview partner – engineer)* "[…] A year ago we signed a piece of paper that we got into this project with a budget to do one thing […] For me his attitude is breach of contract [...]" *(Source: OTS interview project participant 4)*

Code	Themes	Categories	Innovation Network Studied
Organisation	Degree of Formalisation	Informal Mechanisms	The SUCCESS Project

"Well, I don't think that this diversity has been formally managed; I think that the process has been a little bit spontaneous. My feeling is some people like member A, member B, and I (member C) have taken special care of managing this. Perhaps we were more worried to reach the desired outcomes, so we helped others without thinking of doing it. In a sense we were trying to get over issues so we could develop our tasks" *(Source: interview WP leader – engineer).*

"[…] Well, I have to admit that… before I was saying that perhaps we have had too many meetings, but I have to say that having the number of meetings we have had, I think it made people feel closer to collaborate. So in the other side, the good point of having so many meetings is that the level of trust probably has increased" *(Source: interview WP leader – engineer)*

Code	Themes	Categories	Innovation Network Studied
Members	Prior Relations	Unfamiliar	The SUCCESS Project

"So at the beginning, it was quite frustrating… without knowing the partners […]" *(Source: SC member – social scientist)*
"[…] It was rather difficult because we were completely strange people for that […]"*(Source: SC member – social scientist)*

Code	Themes	Categories	Innovation Network Studied
Members	Prior Relations	Familiar	The SUCCESS Project

"In fact in this project I knew many of the people representing the partner institutions before starting the project, so I think this helps a lot, of course, and then later on, at the very beginning of the project there was like a number of meetings, personal meetings, and I feel this makes it quite simple to work with them" *(Source: WP leader – engineer)*

Code	Themes	Categories	Innovation Network Studied
Members	Diversity	Geographical Distance	The SUCCESS Project

"Well, people were coming from different countries, but I think that everybody was very committed to the collaboration, so this was not a significant barrier […] (*Source: interview WP leader – engineer) (Source: interview partner - engineer)* "But geographical distance was not a problem […]" *(Source: interview partner - engineer)* "I think that the geographical distance was not very important if there is a strong relationship with the other partner […]" *(Source: interview SC member – social scientist)*

Code	Themes	Categories	Innovation Network Studied
Members	Diversity	Temporal /virtual geographical proximity	The SUCCESS Project

"[…] Besides, the use of virtual communication helped to overcome geographical distance and enabled us to work together […] So there were regular face-to-face meetings, which was something very important. I found them very useful, mainly when the group was more reduced, and then you met these people from time to time. So you had more or less a continuous relationship with that person. I think that virtual communication is important since many times even a simple phone call can help to understand the people. Of course, I think that we have to distinguish two points: First, the email is not interactive, and with email sometimes one has to be carefully since an email is very practical, things can be sent and it's registered, the date, time when you send the email, the people you send it to. The problem is that it's not interactive, so sometimes you write in some words the concept you want to express and these words don't express what you want, so that is a problem, and sometimes it is important to have some dialogue interactively and this is difficult. So I think that email could be used for thinks like when everyone has to send a proposal about some certain item, I think this is excellent, and then this item can be compiled by the coordinator, and then perhaps after some briefing this could be discussed in a teleconference, for example. And then the phone calls, I mean person to person, I think they are very interesting many times to have feelings, detailed opinions about some specifications, so I think that really, if we use email to elaborate proposals and then we read the different proposals made by the different partners, and then we use teleconferences to use the interactivity in order to understand exactly what everybody is saying, and finally, of course, person to person phone calls can be used at any moment. That's for sure, I think this could be very helpful." (*Source: interview WP leader - engineer)*

"[…] From my personal experience, getting together with people, especially in socialising events on the evening before meeting was tremendously important, because you would have a face with the email, which you had formally, and the face to the phone number you'd been calling formerly, and you would get a discussion other than project-related, of course there were project-related discussions as well, but to get to know the person and not only the collaborator or the colleague. And I think this helped a lot to contact people on specific issues, it was less problematic for me to address people, when I knew them person to person, when compared to the point at when I did not know them personally, and I guess this was similar to all other participants as well." *(Source: interview OMB member – social scientist)*

"[…] But the truth is that in some aspects, not at the very first beginning but afterwards, the geographical proximity helped us to find moments to meet face to face and then to establish a relationship. We could say, for instance, with [University X], there is a relationship because after a time we have met together and then, I mean, geographical proximity has helped us, sometimes to meet here, and that has helped, but now there is the basis for a relationship, so I could imagine that if all of us would have been in the same city, of course, it would have been easier, but it's not…I'm saying that not because you are far away you cannot work together" *(Source: interview SC member – social scientist)*

"But geographical distance was not a problem. We had these travels where we visited each other and had our conferences and I think this was very fruitful to get to know each other and also to fulfil the tasks and talk about the issues which are necessary to bring the project forward, but of course, it needed a lot of travels […] We used e-mails and videoconference to develop our activities. This virtual communication was rather important. I think that physical meetings were rather important because working just by e-mails creates misunderstandings and misunderstandings are sorted out when you see each other. We had these travels where we visited each other and had our conferences and I think this was very fruitful to get to know each other and also to fulfil the tasks and talk about the issues that are necessary to bring the project forward. We had these face-to-face meetings where we also had a working dinner beforehand, so one gets to know people and gets to know them with time, also a little bit more private, which I think creates also trust as you don't know only the official side, and so it was really better at the end of the experiments*"(Source: interview partner - engineer)*

Code	Themes	Categories	Innovation Network Studied
Members	Diversity	Cognitive Distance	The SUCCESS Project

"We had three different kinds of people working in the project. Essentially, most of the people were, and I was included in this group, engineers specialised in sustainable energy, another group of engineers working on climate, there was a minor difference between these two tough, and then there was a third group of people related to social sciences, who were partners from the business groups. This last group had a great difference with other two." *(Source: interview WP leader - engineer)*
"[…] We had teleconferences and emails. I think that the geographical distance was not very important if there is a strong relationship with the other partner. For instance, partners from other business school and I, I consider that we work together, and they are in Denmark and I am in Barcelona, but the important thing is that previously, there was a strong link between us. I mean, there was a previous relationship, for a long time, and so in that sense, geographical distance was not important […] I'm saying that not because you are far away you cannot work together, and that is the example between Denmark and Barcelona [...]" *(Source: interview SC member - social scientist)*
"Well, it was difficult, in the sense that when you have to know that we were partners that we were coming from the social scientist side, and most of the other partners were coming from the technological or scientific part, related to energy. So at the beginning, it was quite frustrating […] For instance in a meeting in Barcelona one of the participants said, "well, what you are saying there is like, we could do it as a brainstorming session," so this means that even our methodology, our models, our way of understanding science was not understood by them. It was not legitimised. And I think that this provoked us also, like some kind of situation in which we…I don't know how to express it…but we felt like, "okay, they consider what I am doing as something that is not science; I am doing just brainstorming sessions, and this kind of silly things". So that provokes that the relationship is not as smooth as possible, so somehow there is a lack of respect in that sense... When we started to work in the project, it was rather difficult because we were completely strange people for them, we were coming from completely different worlds..." *(Source: interview SC member – social scientist)*
"[…] When we started to work in the project, it was rather difficult because even if were speaking in English, we thought that (and when I say "we" I mean the social scientists) we were not completely understood. [There were many] misunderstandings, in the sense that we didn't exactly understand the same things, I mean the interpretation was different. Finally, we had conflict here. Because I think that perhaps we were not completely aware of this situation […]"*(Source: interview SC member – social scientist)*
"[…] When we asked them about making an interview, following a semi-structured guideline, which is something that is very used in the social sciences in qualitative research side. And for us this implies no difficulty. But we realised it was difficult for them, because they didn't do it like a conversation, as a real interview, but they just sent the guidelines to the person who does the interview, which is something that is unacceptable in social sciences. So we had to take more time explaining them exactly what we were trying to do, and saying okay this is like a conversation, it is not really an interview, you should not have sent all this. And finally, they could see the first results" […] *(Source: interview SC member – social scientist)*
"It was a little bit difficult in the beginning because I had to adapt to the different ways people are and to the different knowledge and also to the fact that it's combined with management and this is my first pure management project. […] People use terms when speaking about the same matter, but they use different terms, and it wasn't easy to adapt, to understand perfectly what is wanted because when there are then tasks coming it's not easy to understand which tasks one has to fulfil. This of course creates a problem […] The different jobs people were having, so everyone was coming from a different side of physics or chemistry or process engineering or whatever, and then combined this with the issues brought forward by the social scientists. It was just to figure out what was really important in the combination of all " *(Source: interview partner - engineer)* "[…] Engineers and social scientists have different ways of doing things, but if you take it on a higher level, on one level above, they do have the same thinking, but they do it on different subjects. So, they have a little different view on things, and, like I said, there has to be mutual learning from each other about how the other "side" is thinking. They had to learn to understand each other, what the other part is thinking […]" *(Source: interview OMB – social scientist)*

Code	Themes	Categories	Innovation Network Studied
Members	Diversity	Organisational Distance	The SUCCESS Project

"I think what could have been improved was, for example, that people in the beginning tried to figure out what language they were really using, so what do terms really mean, and the agreement is settled in the beginning and not just by a kind of quarrelling each other together, but the amount of meetings was okay, and I think perhaps what also would have helped was if the discussions in the meeting would have been reported, the kind that there is a draft where you know who was talking what in the meetings, because then you don't forget what has been talked about. So, we needed more formal rules, more established procedures" *(Source: interview partner - engineer)*

"So you can take two different positions. The coordinator adopts a more administrative role in the sense that, okay, I send the agenda, I write the minutes and so on, which is something very, I mean, it is basic. To have someone that does this role is very important. But apart from that, I think that […] we would have needed a bit of order, modifying ideas. Yes, to try to unify the different perspectives, because the thing that all of us were equal, but that sometimes provokes that with so many people, a little bit of disorder is there. So, in order not to come to disunity, we would have needed to have a bit stronger role, and active role of the managerial side. But I think that both of the roles that I explained to you are very important to have in this type of project because if you don't have someone who really puts order in the more administrative side in the sense of which is the agenda, which is the point, etc. then it leads to disaster" (Source: interview SC member – social scientist)

"[…] The communications improved. The transparency improved, but there were not chain activity. I think that it impacted on the way that how the relationships evolved. I missed an integration phase between working together on some common aspect. So, more or less, work package 2 was doing the job and work package 3 was doing the job […]"*(Source: interview SC member – social scientist)*

"[…] But at the same time there was no attempt to come closer […]" *(Source: interview SC member – social scientist)*

"One partner however presented a drawing explained that he wanted to put a microphone and so, but he did nothing else [...] For me his attitude is breach of contract. The project leader and the project coordinator did nothing. […] It is true that in KIC InnoEnergy they pay less, but if you say that you will do it, you did compromise doing it" *(Source: OTS interview project participant 4)*

Code	Themes	Categories	Innovation Network Studied
Members	Diversity	Institutional Distance	The SUCCESS Project

"[…] Perhaps the barriers were more because of the type of institution that partners belonged to, than because of the country there were from. Perhaps it was a barrier that in some institutions the way to do the things is different in one and another, for example, I can say that essentially in the universities we have a common way to do things, I work at an university and sometimes the way institutions work are different, so then if you are used to do things in a way and for any reason this changes, it's a little bit stressful. I think that the companies or research centres or universities, it is more complex I think to manage this, than geographical distance. […] One of the most complex aspects in the project was probably that the engineers, scientists, and technicians could understand that the nature of this project wasn't technical. This was quite difficult from the beginning, essentially all the people were thinking about that we were going to do something technical, scientific or related to research, and in fact, this wasn't the case, it was related of course to research management, this was not something purely technical. So probably this was the main barrier […]" *(Source: interview WP leader - engineer)*

"[…] And the other thing is that, well, the only positive aspect was that there were other social scientists, and also we were friends with these social scientists before, so we were like a little island there in the middle of technical people and they were talking about how to make the energy sector sustainable or turbines or nuclear power and many other topics […]" *(Source: interview SC member – social scientist)*

Code	Themes	Categories	Innovation Network Studied
Members	Diversity	Social Distance	The SUCCESS Project

" […] When we started to work in the project, it was rather difficult because we were completely strange people for them, we were coming from completely different worlds..." *(Source: interview SC member – social scientist)*

Code	Themes	Categories	Innovation Network Studied
Members	Conflict	Cognitive	The SUCCESS Project

“[…] I was telling you that at the beginning that the project was not taken in its big nature by everybody, so that means that perhaps at the very beginning the role of the people from the social science field and the work they were doing wasn’t properly understood and accepted […] And then perhaps, in the meetings, perhaps this may be fault of the people of the university, I don’t know, but perhaps I feel that my colleagues from the industry have felt this, and they have told me, that our meetings were not effective enough and they did not agree on the way we were working […] We had to be more efficient and reach conclusions.”*(Source: interview WP leader - engineer)*

“[SUCCESS] was very different because partners from the technical field behaved quite differently than those from the social sciences and for me it was difficult because I am not a social scientist, and it is in part a social scientist’s project so for me it was difficult to move into the area of social scientists and I had to learn a lot. In WP3 we all tried to be social scientists and made our own errors, but we were also allowed to be not perfect, because we all knew that we hadn’t taken a social science degree, whereas when in WP2 I always had the feeling I had to perform best and I tried to understand what this really meant, because there was a certain type of terminology used which in some terms I didn’t understand, so I had to look it up in Wikipedia or in Google what it really meant, or in my books, to understand what is really dealt in work package 1 and 2. But the language was easier in WP3, where we all were kind of engineers and tried to do our best, whereas it was getting super professional in WP2, and I sometimes didn't know perfectly what the meaning was, so I had to read it two or three times to understand. For example, the model took me a certain while to understand, because I am not a modelling person, if you know what I mean. So the language was easier in WP3, where we all were kind of engineers and tried to do our best, whereas it was getting super professional in WP2, and I sometimes didn't know perfectly what the meaning was, so I had to read it two or three times to understand […] *(Source: interview partner – engineer)*

“Well, it was difficult, in the sense that when you have to know that we were partners that we were coming from the social scientist side, and most of the other partners were coming from the technological or scientific part, related to energy […] for instance in a meeting in Barcelona one of the participants said, “well, what you are saying there is like, we could do it as a brainstorming session,” so this means that even our methodology, our models, our way of understanding science was not understood by them. It was not legitimised. And I think that this provoked us also, like some kind of situation in which we…I don’t know how to express it…but we felt like, “okay, they consider what I am doing as something that is not science; I am doing just brainstorming sessions, and this kind of silly things". So that provokes that the relationship is not as smooth as possible, so somehow there is a lack of respect in that sense [...] When we started to work in the project, it was rather difficult because we were completely strange people for them, we were coming from completely different worlds [...]” *(Source: interview SC member – social scientist)*

“[…] Finally, we had conflict here. Because I think that perhaps we were not completely aware of this situation.... I said, okay these people are not following, they don't want to follow the steps, or they don't want to do it in a proper way, or even perhaps they cannot understand it, so this involved conflict and at the very beginning there was a huge gap in conflict terms. I mean, we didn’t quarrel, but we discussed a lot, so I think those are some of the consequences of working with the diversity, with a lot of partners” *(Source: interview SC member – social scientist)*

“[…] I mean taking into account that at the very first beginning we were very slow, because we were discussing all the time about the objectives about what this work means, about what we want to say about the other thing. […] So, we needed quite a lot of time to establish more or less common ground, or common objectives, or to say more exactly what were the steps that we were going to do. And also, I mean, other phases begun the phase of misunderstandings, in the sense that, even if the thing works, we didn’t exactly understand the same things, I mean the interpretation was different […]” *(Source: interview SC member – social scientist)*

“Well, when I was in work package 1 some guidelines for an interview were sent and apparently... I mean, the partners did their work to interview people, and then the first results were collected. And this was quite frustrating, because most of the results were not useful, they hadn’t been collected in a proper way, and then there was a reaction of the person who was in charge of this work package received a lot of criticisms about the guidelines, that it was not good, that there was a lot of overlapping, that they were the same questions, and at the same time this other person was saying that it wasn’t the problem of the guidelines, it was the problem of how they were contacting the interviewers, that they couldn’t be sent by email, that they could have enough time to ask these questions in person, that it was the same structure, so that was quite a frustrating... we had a conflict there, because indeed the problem was that we were not having the results... ok. And that had an impact on the objectives of the project, because the problem is that time was something important, so that was one of the moments that the distance was evident” *(Source: interview SC member – social scientist)*

Code	Themes	Categories	Innovation Network Studied
Members	Conflict	Affective	The SUCCESS Project

“I think what could have been improved was, for example, that people in the beginning tried to figure out what language they were really using, so what do terms really mean, and the agreement is settled in the beginning and not just by a kind of quarrelling each other together […]” *(Source: interview partner – engineer)*

“I don’t know what happened in the first year of the project, but I guess some learning had been going on, but I already heard it from anecdotes, how this process went, and there were still, to some extent, some tension between engineers and social scientists, when I came to approach them with what I think […]” *(Source: interview OMB member – social scientist)*

“[…] Finally, we have conflict here. Because I think that perhaps we were not completely aware of this situation. As I say, okay these people are not following, they don't want to follow the steps, or they don't want to do it in a proper way, or even perhaps they cannot understand it, so this involves conflict and at the very beginning there was a huge gap in conflict terms. I mean, we didn’t quarrel, but we discussed a lot […]”*(Source: interview SC member – social scientist)*

“[…] Even our methodology, our models, our way of understanding science was not understood by them. It was not legitimised. And I think that this provoked us also, like some kind of situation in which we…I don’t know how to express it…but we felt that feeling in that sense that, “okay, they consider what I am doing as something that is not science; I am doing just brainstorming sessions, and this kind of silly things". So that provokes that the relationship is not as smooth as possible, so somehow there is a lack of respect in that sense […]” *(Source: interview SC member – social scientist)*

“[…] At the very beginning, the thing is that the work package 2 was really belonging to the social sciences side. […] In terms of the feeling we had that if people had made it clear that what we were doing wasn’t called science, and that we were the strange people, that doesn’t motivate you to try to breach the gap. So, in terms of economy it was easier to work with people we usually work with and you usually understand each other, and the ones with the cognitive gap which is smaller, so that was a consequence... And so, I mean this was perceived by other members of the group like if we were very snobby people working alone just because we wanted it” *(Source: interview SC member – social scientist)*

“[…] People blaming each other, so I blame you, you blame me, in this kind of way […]” *(Source: interview SC member – social scientist)*

Code	Themes	Categories	Innovation Network Studied
Members	Conflict	Administrative	The SUCCESS Project

“ […] Let’s say that our usual way of doing business was influencing a little bit the way the people were working, what caused some differences with what the project was about and what we had to do […] It was quite difficult from the beginning to understand the nature of the project, essentially all the people were thinking about that we were going to do something technical, scientific or related to research, and in fact, this wasn’t the case, it was related of course to research management, but this was not something purely technical. So probably this was a main barrier. […] I think that the way the project was organised was not good. I would definitely change the sequence in time of work package 2 and 3. I think they were too overlapped. The general project management forced this, since we had 2 years to develop the project, so we had to do it in time. But definitely I think that it would have been better to finish work package 2, and when it was finished to then define the experiments […] It was very difficult to choose the experiments to be validated before, or more or less at the same time the was being done, so I think it was inconvenient, definitely I would change it. […] So it was complex to explain what was going to be done and then share results” *(Source: interview WP leader – engineer)*   “[…] The problem was to link WP2 and WP3 together. That was in the beginning a little bit of a problem because WP3 and WP2 worked each one their own way and then in the end we had to link those two work packages together, and the link wasn't too easy because it needed meetings and joint meetings and also virtual communication, and it did not take place as much as needed. […] So in the beginning of WP3 we had a little bit of chaos, I think we misunderstood slightly what we had to do, so it took us a certain while until this disagreement had been settled and overcome, and so it was a bit chaotic on the beginning. […] Because there was a set of time not perfectly coordinated by direct coordinator […]” *(Source: interview partner – engineer)*   “It was right when I came into the project. There was certain tension between the work package 2 and work package 3 because word package 3, according to the schedule, would have already required input from work package 2 on the model in order to proceed with the work, and the model simply was not ready, or it had not been published because one business school’s policy was to have the model fool proof without having it torn apart by presenting it too early, and this was happening simultaneously…both work packages had to be done at the same time, and the more information exchanged would have been required, and when I first came into the project I had the impression that this was still sort of a tension between engineers and social scientists’ way of doing the work” *(Source: interview OMB member – social scientist)*   “So at the beginning, it was quite frustrating… even without knowing the partners, but you have to know about the projects, about sustainability in energy, I mean I talked to the dean, "I think you have sent me to the wrong project, because this has nothing to do with us". And he said, "no, no, no. It is right". Our participation is going to be minor, and it’s not going to be very important, but this has to do with this type of innovation networks and so on. And then, after the kick-off meeting, my reaction was, we started in a such a huge room full of people, and all the people were explaining technical things about energy, and then I thought, and I told this to the dean, "what are we doing in this project?” I mean, I cannot even understand what they are talking about and I cannot see exactly what we have to do here”. Because at the very first beginning, apparently, the main objective of the project was technical-related. Then, suddenly, a person from the European Commission arrived. And he started saying, "No, no, this is not the objective. This project is not a technical project. It has to do about discovering new ways of collaboration" […] So afterwards, when we started the project, apparently at that moment the objective was much more clear, and then when we started working in the project, it was rather difficult […]”(Source: interview SC member – social scientist*)*   “[…] One of the problems of this project was the design phase. And I think that the objectives were not very clear for all the partners. I mean, there was a first distribution of who would participate on which phases, so, for instance in work package 1 some people who were not in the planning to work on that work package, they worked finally. And others who expected to work there they didn’t do as much work as they had planned. So this provoked a huge conflict, and it’s been the first time that I have seen it in a European project, that the budget was reallocated. So, in the work package 2, I assume that many people thought, based on what happened in work package 1, that if in work package 2 in the planning it is supposed that I have to collaborate with three man-hours or whatever, and I don’t do anything, then this funding is going to be reallocate and I’m

not going to receive this funding. It will probably go to the people who have done the work. So there was this type of pressure to say, so what is my work? What do I do? But at the same time there was no attempt to come closer […]" *(Source: interview SC member – social scientist*)

"At the very beginning, the thing is that the work package 2 was really belonging to the social sciences side. So, I mean, indeed the social science side did most of the work. And also, I should state that we didn't do a lot of effort to joint other perspectives. Why? Two reasons, because of time, I mean, for us we would have needed double the time to integrate people that had no idea in their professional careers about this topic, because they are experts on other fields, we would have needed a time of training in order to integrate to a team of social sciences. And there was no space, no proposal for that. And the other thing, in terms of the feeling we had that if people had made it clear that what we were doing wasn't called science, and that we were the strange people, that doesn't motivate you to try to breach the gap. So, in terms of economy it was easier to work with people we usually work with and you usually understand each other, and the ones with the cognitive gap which is smaller, so that was a consequence... And so, I mean other members of the group perceived this as if we were very snobby people working alone just because we wanted it" *(Source: interview SC member – social scientist*)

Code	Themes	Categories	Innovation Network Studied
Members	Conflict	Goal	The SUCCESS Project

"[…] We had different goals with industrial partners and perhaps it was a great misalignment as they were thinking about the future of the different sectors, they were not thinking about the SUCCESS Project […] Another conflict I think is that there was another external factor from the project that has been very important, which has been the preparation of the KIC proposals. I think that during the project the level of trust of the different partners was growing, I think, but for some reasons […] at the end, two KIC proposals have been growing from the partners of the Success Project. So then, I mean that for some reason, perhaps this is a big misalignment that I was trying to explain subtly before, perhaps at the end there are some conflicting interests that may arise not within the project [...] But anyway, the conflict of interest at the end is coming because the resources are limited, but partners of the Success project, some of them, about half of them are involved in one KIC proposal, and the other half in another one. So I think that essentially, the level of trust among the partners has increased, of course, having some misalignment, but I think this misalignment is more related to the strategic objective of some of the partners in the long term, than with the Success partners. So I mean that the Success Project cannot solve this misalignment for sure. For sure." *(Source: interview WP leader – engineer)*
"And the most complex thing, I suppose that we had different expectations of what we were trying to do. I mean, to coordinate such a group is quite a difficult task, and if you don't take into account these kinds of gaps in advance, previously, I mean, it is very difficult to solve them […]"*(Source: interview SC member – social scientist)*
"I think that there was a gap between objectives and how the project was design, we didn't have a common set of rules. We were a big group, and sometimes the objectives were not very clear. [So], to coordinate such a group is quite a difficult task, and if you don't take into account these kinds of gaps in advance, it is very difficult to solve them [...] As we were such a diverse group, everybody wanted to speak, everybody wanted to contribute. But, there was no consensus, there were different perspectives […]"*(Source: interview SC member – social scientist)*
"We were a big group, and sometimes the objectives were not very clear. […] Probably we didn't have a common set of rules" *(Source: interview SC member – social scientist)*

Code	Themes	Categories	Innovation Network Studied
Coordination	Commanding	Direct Supervision	The SUCCESS Project

"[…] Our meetings were not effective enough, so perhaps it's important to define very clearly the objectives of the meeting, they should be given to the participants with proper time in advance, and they think that should be important that the chairman of the meeting, probably stress a little bit, not being of course a dictator, but stress a little bit the way that we go through the different objectives of the meeting […] I am thinking that the project leader has been very important, perhaps he has not been the person sharing all the activities, since for any reasons in the physical meetings perhaps the chairman or chairwoman were someone else, and many times in teleconferences he was not there. I think it could have been better if he could have taken this role more extensively. I think he has been doing a very nice work coordinating everything, with the work, with emails, with the web server, with everything, and when it was necessary in the meetings and on the teleconferences, but perhaps I think that I am missing a little bit more. I think it could have been better, so from my view, the involvement of the project leader in this role could have been much deeper." *(Source: interview WP leader - engineer)*

"In the beginning of the project we didn't have a coordinator so it wasn't so good, but when someone was appointed it went rather good because he's a very practical person and he's a very good organiser, so that wasn't bad that there was a main person who did all the coordinating of the project. This was better than before" *(Source: interview partner – engineer)*

Code	Themes	Categories	Innovation Network Studied
Coordination	Commanding	Standardisation of Outputs	The SUCCESS Project

"[…] I think that pressure of having deliveries done has been important. Because we could be discussing a lot, but if we have to finish this work package or this delivery for that day, the need to have these objectives, it pressures you. You agree, or you agree, you have to […]" *(Source: interview WP leader - engineer)*

"[…] It was a bit more difficult to transmit to them the model until the report was done, and the report perhaps was finished - I don't know - at the end, since of course we needed some time to compile everything, to write everything and so perhaps this was, I don't know, at the beginning of January […]"*(Source: interview WP leader - engineer)*

Code	Themes	Categories	Innovation Network Studied
Coordination	Enabling	Broker	The SUCCESS Project

"Maybe the person who has been most relevant at the end was member A. Although the model has been designed by the group of member A, this member was who has been really involved in explaining the details of the model to everybody, trying her best so everybody could understand it, especially making engineers understand a model of collaboration framed in management terms, and I think that she has been extremely proactive, and this person has been member A […]" *(Source: interview WP leader - engineer)*

"Well, I think that member A's participation was quite helpful at some points in time because she had a way to structure thoughts and to guide everybody towards a common solution. I was not surprised when I heard that she has been doing work as a consultant, because when she is in the discussion, she can give a direction in a discussion and extract the results, and make them visible to all the others, so she has often been the one who was guiding discussions to a result. She didn't guide it to a result she wanted. But she was guiding them to any result" (*Source: interview OMB member – social scientist)*

Code	Themes	Categories	Innovation Network Studied
Coordination	Enabling	Mediator	The SUCCESS Project

" The way WP2 and WP3 were designed was very difficult. So member B was very helpful because he was in both WP, so he was like a bridge to connect us, making us talk, showing who was doing what and how business was being organises, calming us down […]" *(Source: interview partner – engineer)*

"Also, there are some people that help to do it [align diversity in the project]. For example, member B also helped. I mean it was a different role. I think that at least he was like the telephone between the social scientists at a certain moment that we didn't, we were like a little island, and the others, so sometimes he was participating in those capacities so he could see what work package 2 was doing, what work package 3 was doing, so he could keep some communication between one group and the other. But it was a different role. But finally I think that somehow he showed with the results that the social scientist part was doing a very good job on that, so that somehow he made them realise that they needed us. And then, we had to integrate some kind of map of knowledge, yes" *(Source: interview SC member – social scientist)*

Code	Themes	Categories	Innovation Network Studied
Coordination	Enabling	Transformational Leader	The SUCCESS Project

"I think in the beginning of WP3, we had a little bit of problems if we talked about topics to be developed and this made a little bit of chaos, and I think we also misunderstood slightly who in the beginning what we had to do, so this took us a certain while until this disagreement had been settled, and so it was a bit chaotic in the beginning. It was a bit easier afterwards. Member C encouraged us to get through things, to try our best to work with a terminology that was not ours [...] Because there was a time not perfectly coordinated by the direct coordinator, so we simply put together what everyone has done, and so there was a kind of degree of freedom for who could do what, but this was of course more chaotic, but on the other hand there was also more freedom about who could do what, so it wasn't too bad. It took a longer time to write it all together, because there were so mixed contributions. Yes, member C used a lot of patience with us. I personally got on very well with member C, …what I like more of people like him is those who display a certain calmness and comfort. I really don't like it when people are getting off in their despair and hectic and over productive and a little bit desperate, because that creates a climate which is bringing each other difficulties. Sometimes people are desperate to fulfil the needs that are all getting exaggerated and then the climate is very hectic, especially if you have several persons who are like that. So I get on very well with people who spread certain calm and are good at rhetoric to combine, to handle people's temperaments and emotions, and I think this is rather important" *(Source: interview partner – engineer)*

"[…] I think that member C also helped, probably because he was able to speak in the technical language, and he was able also to speak the social sciences, he was very respectful, I mean in the sense that he was very humble also when he was explaining what he thought, he didn't express any type of superiority, and sometimes he was looking for the team more than for his individual institution or his individual role. Well, I think that he did a very good job [...]" (*Source: interview SC member – social scientist)*

2. KIC InnoEnergy

Code	Themes	Categories	Innovation Network Studied
Organisation	Decision-making	Top-down	KIC InnoEnergy

"[…] During 2011 and after the first review in Barcelona, we were told that we needed to reformulate the organisation of the project and orientate it more to the market and based on the four products. With this new organisation, partner X [from a research centre] realised that they were no longer interested on the objectives of the project, so they asked to leave the project […]" *(Source: OTS interview former project manager)*

"The work package is managed by people in Lisbon. So, our main role is technical. We have somehow a management role but within our tasks. It means that we coordinate the activities of two or three groups involved in our tasks. The work package is led by people from Lisbon" *(Source: OTS interview project participant 1)*

"We had a new project with new calendar, new products, new participants as we are now organised around products and not work packages. Such decision of having products was, I think, not even clear for KIC. It is my opinion […]" *(Source: OTS interview project participant 2)*

"[…] There are two levels in KIC InnoEnergy, the project level and the top management level. There was a clash between these two levels […]" *(Source: OTS interview project participant 5 – marketing expert)*

"I mean, obviously there are people whose thoughts are way ahead of us thinking this is what we are going to do. And when it comes down to the level of the scientists, whatever background they have, to do this is nonsense. […] It just doesn't fit in. […] So I have a feeling that whoever is making the decisions or setting the frame of the innovation projects have little know-how about how the scientists work […]" *(Source: OTS interview work package 1 leader)*

"The management of OTS is not easy because we have to report to EDP, which is a private company, and also to KIC InnoEnergy, what makes the process lengthier and more complex. This is because we are trying to make the management of the project in a business style, with many reports and reviews […]" *(Source: OTS interview project manager)*

Code	Themes	Categories	Innovation Network Studied
Organisation	Decision-making	Bottom-up	KIC InnoEnergy

"[…] The truth is that as the project was born two years ago with a bottom-up approach, people gathered together and the work package were designed more independently, you build the objectives from the bottom [...]" *(Source: OTS interview project participant 4)*

"When I joined the project it was already running, but I can tell you the idea that I have about it, […] As far as know, in July 2010 there was a meeting with different partners from KIC InnoEnergy who gathered here with the objective of explaining the thematic field of Iberia co-location centre and deciding on the innovation projects to be develop. It was a very participative, bottom-up process where we decided who wanted to take part in each project and what kind of development should be pursued. I can't remember who were the speakers [...]. So people manifested their willingness to participate and the projects were defined based on the capabilities of the partners that wanted to participate in OTS […] *(Source: OTS interview project participant 3)*

Code	Themes	Categories	Innovation Network Studied
Organisation	Degree of Formalisation	Formal mechanisms	KIC InnoEnergy

"[…] I mean it is very common that we on a Thursday get some paper from [the project manager] asking for some reports in few days […]" *(Source: OTS interview work package 1 leader)*
"[…] Documents required to be filled in or that needed to be elaborate, the agreements that had to be signed, etc. […]" (Source: OTS interview project participant 3)
"[…] We are changing the mindset of people through meetings, guidelines, reviews of projects. […] We are launching a project to train project leaders so they know how they have to behave and develop their job. So, these are some of the things that we are currently doing in order to change the mindset of people, but it will take some time. We have many things to fix and many organisational problems to still consider" (*Source: OTS interview CC manager)*
"The management of OTS is not easy because we have to report to EDP, which is a private company, and also to KIC InnoEnergy, what makes the process lengthier and more complex. This is because we are trying to make the management of the project in a business style, with many reports and reviews […]" *(Source: OTS interview project manager)*
"[…] It has been very difficult to get all the signatures on the project plan up to receiving money from KIC InnoEnergy […]" *(Source: OTS interview project manager)*
"KIC InnoEnergy is a product oriented company. We deliver things. And our product has three things: talents (specialised and new), innovation to change the current processes of sustainable energy and to change it for better (more secure, less costly, more operational and less contaminate) and to create use for it. We need to understand what KIC is doing to people contribute, to understand, to respect, to work together, to add. KIC needs to be converted completely into an output-driven company, close to the market and to the industry" *(Source: KIC Family Day - CEO, 2011)*

Code	Themes	Categories	Innovation Network Studied
Organisation	Degree of Formalisation	Informal mechanisms	KIC InnoEnergy

"For example, there was a meeting of an informal nature between the project coordinator and member A because they had more serious misunderstandings. They had lunch together to talk about their issues. I was not present because although I was invited I was on vacation. I tried to have a mediating role to put the two parts closer, but really all merit was theirs, I know a little both of them and they are good people and people of good will. From there it has established a good relationship and mutual respect" *(Source: OTS interview CC manager)*
"[…] He helped us making bridges between old and new mindsets and implementing the seeds of this change […]" *(Source: OTS interview project manager)*
"[…] He orientated us not only to define our products, but he also shed light on a vision that would guide us on how to develop these products based on the market analysis […]" *(Source: OTS interview project coordinator)*
"[…] For example, there was a meeting of an informal nature between the project coordinator and member A because they had more serious misunderstandings. They had lunch together to talk about their issues. I was not present because although I was invited I was on vacation. I tried to have a mediating role to put the two parts closer, but really all merit was theirs, I know a little both of them and they are good people and people of good will. Meanwhile there were calls, face-to-face meetings, and meals together… From there it has established a good relationship and mutual respect" *(Source: OTS interview CC manager)*

Code	Themes	Categories	Innovation Network Studied
Members	Prior Relations	Familiar	KIC InnoEnergy

"When company X joined the project, OTS consortium was already constituted. Member X invited us to participate in the project. I think it was in 2010. He was the one who designated and structured the project at the beginning. He was the one who invited partners to join in the project. Things were constituted this way. During this period, Company X was invited to participate and later on we were invited to be the project leaders. We accepted due to our involvement with KIC InnoEnergy. And during 2011, maybe from February onwards, with member X as general coordinator, our coordination was officialised and we started to work, to manage the team, and to develop the project's activities. The project was structured based on member X's knowledge and experience [...]" *(Source: OTS interview former project manager)*
"[…] We organised the first conference in 2005 in Oslo, the second was in Barcelona, the third was in Oslo again and the fourth was last year in Lisbon. In Lisbon we organised a session on marine engineering and energy, where I met some people [research centre] that are linked to KIC InnoEnergy. This research centre is connected to [engineer university]. So we met in this conference and we discussed the possibilities of collaborating with them and one of the possibilities of collaboration appeared was the collaboration on an ongoing project of KIC InnoEnergy called OTS" *(Source: OTS interview project participant 1)*
"I think that collaboration is as good as it can be despite the geographical distance between us and the fact that we belong to different institutions. These have not affected the way we worked think that work package 2 with the ROV we have very good collaboration. I knew some of them before the project started; for example, I knew them 4 or 5 years before. It is easier to overcome these differences when you know someone already. You trust the person more. And I also know what they are good at. I feel more confortable working with them" *(Source: OTS interview work package 2 leader)*

Code	Themes	Categories	Innovation Network Studied
Members	Diversity	Social Proximity	KIC InnoEnergy

" […] The partners of the project are very nice; we have met in many different occasions because we are from the same field. It is no problem of talking and trying to discuss things […]" *(Source: OTS interview work package 1 leader)*
"I've been in the project since the beginning as I was the person who proposed it. This project started in a very anarchic way. I went to Barcelona to present the work that we were doing in wave energy in Portugal... So, I went to this conference in Barcelona and there it was present one participant of KIC InnoEnergy. For my surprise, I was asked to immediately prepare a draft of the project proposal. Therefore, from one day to the other I had to think about a project plan in offshore energy in no time. Because of this, I had to prepared the proposal all by myself. I did it based on my experience and knowledge. I though about the five different test sites that were already operating or that would start to operate in the future (two in Portugal, two in Spain and one in Sweden) and if we could create a partnership between them it would be amazing. I invited some partners whom I had previously worked with and that I had a good relationship. This was the strategy that we thought that could make sense [...]" *(Source: OTS interview project coordinator)*
"All partners were engineers, with the exception of the business school. Company X was working together with us on this area, so I thought we could carry on working on it. And I thought also that as Spain has a long tradition on Eolic energy perhaps it could be interesting to have some Spanish institution working on offshore wave energy. Besides, I thought that the business school could be interested in participate in the project as we needed an institution to develop these aspects in the project. As research centre X was also interested on developing something on this area they commented that they would consider their participation […]" *(Source: OTS interview project coordinator)*

Code	Themes	Categories	Innovation Network Studied
Members	Diversity	Geographical Distance	KIC InnoEnergy

" In my work package, we are from three different institutions (one technical university, one university and one research centre) and from three different countries (Portugal, Spain and Sweden) […] but the thing is we never met physically, and this is a bit odd. We have not done anything together as each of us is minding their own business by independently developing their tasks. I think that this generates distrust between us because we do not know or hear about the development of others… this is a problem not only for us but also for the whole project. Our task will be done using other partners' data. They will finish their part and send it to us, so we can carry on with out tasks. However, we do not know how it will be done. We still have not met since the December workshop. We finished to define the products; objectives and work plan through e-mails and Skype, what shows that there is little integration between us! The truth is collaboration is very sporadic to say it in a soft way. Perhaps it is caused by the way the project was structured. Our idea, aside from funding, when we joined OTS was to identify partners that would need our tool to develop their own research or products. A collaboration where they would give us their knowledge and know-how on a certain area, for instance in offshore energy, and we would add our expertise and know-how on numerical applications. So, this was our objective. Until now it has not been like this. In fact we are developing our product independently from our partners and even inside our work package there are two separate parts [...]" *(Source: OTS interview project participant 2)*

"Cultural diversity has less importance each day… People are diverse but they share a nucleus, especially if they work together... besides, there is an internal culture of a business company in KIC InnoEnergy […]" *(Source: OTS interview project participant 5 – marketing expert)*

"[…] Beyond deciding where to have our meetings, I do not see the national factor affecting us. I have worked with many nationalities and cultural diversity has less importance each day. People are diverse but they share a nucleolus, especially if they work together. Besides, there is an internal culture of a business company in KIC InnoEnergy" *(Source: OTS interview project participant 5 – marketing expert)*

"Establish a company is not complicated but when it comes to a company with partners such as universities, technology centres, business school, some from Spain, and others in Portugal, everyone seeks their own interests, etc. […]" *(Source: OTS interview CC manager)*

Partner 1 (engineer): "We are different because of geographical distance. Diversity from Spain, Portugal, Poland […]"
Partner 2 (social scientist): " Yes, but we are talking about differences. We are different because of our nature. Our countries do not affect our collaboration"
(Source: In-Company Training, 2012)

Code	Themes	Categories	Innovation Network Studied
Members	Diversity	Temporal /virtual geographical proximity	KIC InnoEnergy

“We mainly work though Skype conference calls, e-mail, etc.” *(Source: OTS interview project participant 5 – marketing expert)*

“We finished to define the products; objectives and work plan through e-mails and Skype […]” *(Source: OTS interview project participant 2)*

“We don’t have many face-to-face meetings, we normally communicate via e-mail and Skype. And we share information between us. And try to find a common road. I think this is going really good” *(Source: OTS interview work package 2 leader)*

“We have, or theoretically we do have, an established routine, with a minimum number of meetings pre-established, like once per month. But, we usually gather in accordance to the Project needs in terms of coordination. Mainly our meetings and conferences are through Skype and the members of the steering committee attend it. Usually in these meetings we deal with strategic aspects of project management or the technical progress of each Work package are reviewed and then, at least once a year, there is a physical meeting in which, among other things, additional issues may be addressed. The minimum monthly but there may be periods with a little more intensity and perhaps every 15 days there have been contacts. We also exchange much e-mail to prepare documents, do follow-ups of results, etc.” *(Source: OTS interview work package 3 leader)*

Code	Themes	Categories	Innovation Network Studied
Members	Diversity	Cognitive Proximity	KIC InnoEnergy

“I think it is very easy to work with partners because we speak the same language as we are engineers from the same technical field. We are very technical people. We know very much about the subject of our work package, so collaboration was very easy. We are specialised on what we are developing for OTS, so I think it made things much easier. Our meetings are quite straightforward. We were all engineers and so we spoke the same language, which made things easier. We discuss about simulation and prediction of waves in the ocean and we use experimental data to demonstrate that we are going on the right direction. When we face a doubt on which approach is better to follow we write down some equations to decide the direction to follow or the technique to be used. Plus, our experience help us a lot to discuss things and understand it through those equations. As we are experts in our fields, we do not question the decisions of others, as it is very difficult for me to discuss the results of a colleague when he is the expert on that area. Even when results are not as accurate or as good as expected probably there is a reason for that, and we don’t question it. We are not working with people who are doing things in this field for the first time, so it is difficult to discuss or disagree with them. We are in a research world, among our peers” *(Source: OTS interview project participant 1)*

“All partners were engineers, with the exception of the business school. Company X was working together with us on this area, so I thought we could carry on working on it. And I thought also that as Spain has a long tradition on Eolic energy perhaps it could be interesting to have some Spanish institution working on offshore wave energy. Besides, I thought that the business school could be interested in participate in the project as we needed an institution more related to business to develop these aspects in the project. As research centre X was also interested on developing something on this area they commented that they would consider their participation […]” *(Source: OTS interview project coordinator)*

Code	Themes	Categories	Innovation Network Studied
Members	Diversity	Cognitive Distance	KIC InnoEnergy

"[…] It is true that innovation project in KIC InnoEnergy are not flexible, and also not attractive to researchers. Because researchers are used to work on Framework Projects and these project conditions are that the European commission pays 75% of the expenses and 25% of expenses are paid by us in hours dedicated to the project, which we are already receiving from the university as working hours. But in the KIC is reversed, the KIC pays 25% of expenses and 75% have to be justified with working hours as teacher, and you pay the student fellowship with that […]" *(Source: OTS interview project participant 4)*

"When I joined OTS there was already a first proposal consortium, which did not change significantly. What we can say is that on those moments were the first innovation projects were launched within the framework Energy KIC, its conceptions were somehow different from the present scheme of work, due to ignorance of all partners. What was proposed was similar to other European projects, like the Framework Projects. So, the intended project development was, more or less, a nuclear consortium with minimum and sufficient partner countries, in our case Iberia, with participation of Sweden. From there, it is determined the objectives, the structure in work packages, tasks in each of these work packages, some results, and a distribution of efforts; so not very different from a project proposal within a call of a Framework Project […]" *(Source: OTS interview work package 3 leader)*

"[…] In KIC it is the main concern and it drives the development of activities and market analysis. So you must collaborate with partners that have better industrial perspectives on commercialising and take the products successfully to the market. We usually do the other way around. We develop a target, believing that this will have a market value and from that develop the required needs" *(Source: OTS interview work package 3 leader)*

Code	Themes	Categories	Innovation Network Studied
Members	Diversity	Organisational Distance	KIC InnoEnergy

"I would change the coordination of the project, which, on my point of view, is too loose. We still have not met since the December workshop. We finished to define the products; objectives and work plan through e-mails and Skype... what shows that there is little integration between us! The truth is collaboration is very sporadic to say it in a soft way. Perhaps it is caused by the way the project was structured. At least, in our work package, it is missing a closer and continuous follow-up and I think that at project level as well. For example, the September meeting was proposed for July and they announced it just one week before. That just can't be like this, things can't be done like this" *(Source: OTS interview project participant 2)* "We have not done anything together as each of us is minding their own business by independently developing their tasks. I think that this generates distrust between us because we do not know or hear about the development of others… this is a problem not only for us but also for the whole project. Our task will be done using other partners' data. They will finish their part and send it to us, so we can carry on with out tasks. However, we do not know how it will be done […] *(Source: OTS interview project participant 2)* "[…] But I think that not even KIC had OTS rules very clear at the beginning. They defined the rules and the project with time" *(Source: OTS interview project participant 2)* "[…] We don't even know the other work package participants in person and this is a problem. For example, we have an activity that we will have to do which is to use other partners' s data but it is not yet defined how it will be done. So I believe that it is important to know the other project members before we start participating on it. At this moment, the work package partners are doing their work individually and independently. If you look at the project plan you will notice that the different tasks are done separately. When they finish it they will send their part to us and we will have to seat down and use it. I don't know how it will work. Let's see" *(Source: OTS interview project participant 2)* "I would like that, at least with Portugal, the collaboration could be more intense and active. Partner A has been the product leader for three weeks now. There was a Skype call when it was presented that Wavec would be the new leader. There was a meeting two or three months ago, actually another Skype call, when we from UPC heard from the first time that Uppsala was not sure that they would be able to carry on because they did not get the Marie Curie grant. In this Skype call, it was participating [the project manager], [the work package leader], [a project partner], [the project coordinator] and I. It was in this meeting that we got aware of the relationship between [the research centre and an university] and the work package leader told that if they could not get the Marie Curie grant they would not be able to carry on as product leaders. We got surprised. They are free do to whatever they want to do and get with whomever they believe it is good for them, but it would have made a huge difference of they had told us before about this situation… but they did not. After three weeks, we had another Skype meeting when he said that his university was resigning as product leaders *(Source: OTS interview project participant 2)* "[…] So, OTS was a bunch of work packages, which in this case it was very disconnected and inconsistent [...]" *(Source: OTS interview project participant 5 – marketing expert)* "I was very confused to be honest. […] What kind of project OTS was supposed to be, it was not clear at all. Plus, it was very different from a regular Framework Project. Although it is an innovation project I did not get this from the beginning and it happened to many people as well. Now perhaps it is a bit clearer" *(Source: OTS interview work*

package 2 leader)

"We are developing a new product, which is a system or a method to connect wave energy convertors to marine substations that seats on the sea floor using ROV vehicles. They are controlled by above, from cables. The reason for doing this is that we don't want to use divers as before because it is extremely expensive and also dangerous, especially at deep distances like 50 to 80m that will be used in the future in wave farm stations at commercial scale. So we need to develop this product to lie out the cable, find the cable and take it and connect it to the station. In the work package 2 we have two subtasks: [research centre] is doing their own work on developing medium voltage submarine connectors. This they are developing on their own. But, the only thing that they have done so far is the market analysis. I don't remember if you were in my presentation I presented this issue and explained how we may proceed regarding this in the future. We were discussing whether we should go on or not with their work. We were a bit sceptical that this activity could be developed. And the other thing was if we should slip work package 2 in two work packages. Because at the moment and in the forthcoming future, we will not have any collaborative work. Besides, to develop this ROV with medium voltage system it may take years before we are able to do so. Thus, we share common objectives but perhaps in a time frame of 5 or 6 years, but not in the near future. And since the product future is in 2 years, maybe the work package should be split in two" *(Source: OTS interview work package 2 leader)*

"Maybe OTS project is more participative as we take more into consideration the comments and opinions of different participants. The initial stage of OTS was less managed, what implied a bit of chaos and some coordination problems later on. In other project I don't see this happening. OTS is more participative but it is less controlled. It is more complicated to have all parts of the machine working properly. In this sense, it is complicated to make the willingness from different partners to come together in only one recommended objective. It is more complicated, although I would not say that OTS partners are not doing a great job, on the contrary. [But] there is a lack of management; people don't know what to do. We have researchers who don't know what will be their budget in the next year for developing their tasks. Because of this, they don't work with the same dedication. Of course this from the university point of view is very complicated as we are used to work in a different way. Here things are different, the scope of the project can change as it develops or as a market analysis is published. And it is not advancing because all the promises are not being fulfilled. And all this makes that people are not committed as they should be. I hope this can be overcome with time, not only for OTS but also for all KIC InnoEnergy" *(Source: OTS interview project participant 3)*

"I've been here for two years now in OTS and I really don't know what are my activities. People do not understand what we are doing. That is one of my critical points. Actually the work package 1 is to sort of develop new techniques for monitoring… Our notion of what should happen or the direction of the whole KIC has been changing or at least moving since the beginning. What was initially intended is probably never going to occur. We are today very far away from it" *(Source: OTS interview work package 1 leader)*

"I think that in the beginning of the project I didn't hear anything about the commercialization of products, which today is obviously the main purpose today […]"*(Source: OTS interview work package 1 leader)*

"[…] Because from what we were told that the project would be in the beginning has changed drastically and probably not to the better. I don't know, it is just that it has changed to some more unintelligible […]" *(Source: OTS interview work package 1 leader)*

"[…] What is holding things back is that we really don't know what is expected from us, and what conditions. All of us agree that the resources are not what were promised at the beginning. So, with the limited resources we have and the time needed to do what we are all expected to do, I mean there is no way. There is no time and no resource for producing things, at least for my case. I didn't consider myself participating fulltime of this and also you should keep in mind that people might change positions, might change work and things can change. So, if one or two persons disappear or change jobs, then the whole work package might collapse. This is at least from my part. I wouldn't have any colleague that could jump in my place to substitute me" *(Source: OTS interview work package 1 leader)*

"[…] But I am not any longer surprise with what happens in this project. On the contrary, I would be surprise if wouldn't be a change from time to time [...]" *(Source: OTS work package 1 leader)*

"I think that the coordination is part of the problem. But they are just as puzzled as we are. When we get e-mails from [the project manager or the project coordinator] I have a feeling that they are just as frustrated as we are. But on they are on another level and from other reasons, they are frustrated because things are changing, the budgets are low and not as promised… there is nothing wrong with neither the people nor the communication in the project. Of course it could be better. But, the problem comes from above. So don't blame people for not being 100% involved, things are unclear, uncertain and changing all the time, and the budget is not enough. Most of the people working on this have longer academic careers and businesses experiences. It is a harsh and tuff critic. But it is not only my opinion; there are other colleagues who think the same…" *(Source: OTS interview work package 1 leader)*

"[…] There had been coordination meetings to show results but never ever for developing and coordinating activities. I do not think anyone will tell you that there has been coordination to activity because it is impossible, it has not occurred. In the other work packages I do not know, but certainly not in ours, and I think that it did not occur also in relation to global-level project coordination between work packages. That is to say, we had meetings to present ourselves to others but to not produce collaboratively. I wanted to start developing my activities as soon as possible and that is my impression of how they're doing that […]" *(Source: OTS interview number project participant 4)*

"What happens is it was incorporated in a work package that was coordinated by the [an university] and they did not care. He wanted to develop activities related to an underwater microphone and the rest of activities to be developed he did not care. In other words, there was no real coordination in the project […]. And our surprise was on last July when we had a work package telephone meeting, within our work package, and the work package leader said that he had not done anything or he thought he would not do anything because he received the results of a Marie Curie Fellowship that he had applied to develop exactly this and they did not get the fellowship. This was the message. At some point, it was in June or July I think, and also during the spring, April or May, he said in an e-mail that he was awaiting for the results of this Marie Curie Fellowship, but the work package had a work program and he chose that he would not develop it as he was convinced that either he would received the fellowship or he would not do anything. Then he didn't do and a partner from [a research centre] said on that occasion that this man could not remain the coordinator of the work package. For him there was no surprise, as he did not care, he was happy to stop being the coordinator of the work package [...]" *(Source: OTS interview project participant 4)*

"[…] We would be interested in the project again if someone would call me and tell me what to do. Real and concrete guidelines […]" *(Source: OTS interview project participant 4)*

"In Word Package 2, we have a development that is somewhat double or complementary. […] Thus there are two groups that are developing two parallel lines that will converge in the same field. […] And despite the fact that we shared our results with the rest of the group there is no strong interaction among us, as these other partners are more interested in developing connections, procedures or methods to facilitate the connection of devices that already exist and vice versa. They also communicate their progress with us. So we know all the results that we have achieved from the market analysis, the detailed resolutions for developing prototypes or relevant designs to address these two complementary objectives. Somehow we could use this information to complement or improve these two parallel areas in which there are interactions, but we do not have a strong collaboration" *(Source: OTS interview work package 3 leader)*

"What I would suggest is that all new innovation projects have clearer rules and new guidelines prior to the beginning of the project and not once it has been already launched. I believe that for us partners in innovation projects we have the need for a stable framework in terms of the definition of projects, the conditions to develop our activities, the way it is reported, the way it is reviewed, working groups etc. I understand that KIC InnoEnergy is working on that and I think it would ask KIC managers to emphasise these aspects because we have had too many changes that have a direct impact on the effectiveness of the results within innovation projects. To have clear rules, stable procedures. Throughout the Project we had to report in different ways with different information at different moments… these are things that are inherent to launching a new framework, but managers need to be aware that interferes or impacts on the quality of work being performed" *(Source: OTS interview work package 3 leader)*

"[…] As so, some work package leaders were more active than others, coordinating and defining better their activities. In other cases, there were work package leaders that did not do this and, in my opinion, did not fulfil their job. This together with the fact that KIC InnoEnergy has got rules that are not so clear and its orientation towards a market approach all together creates a very heavy burden on researchers but it is less translated into tangible themes like how should I focus my activities or which differences there are between this project and another from FP7? And this is a weakness from OTS and from KIC InnoEnergy as a whole. In this scenario, however, there are some work package leaders that were able to structure their activities better, probably because of their experience, while others were not able to do so. Therefore, all this makes OTS to have some parts that did not function well, what implied on a new structure for the project since last year" *(Source: OTS interview project participant 3)*

"First, I think KIC InnoEnergy should be more stable. When we are talking about market analysis partners knew that they had to do a market analysis, but what else? How to do it? And once it was done, what would it imply for the project? Will we need to change our focus or not? These questions were in our minds at this stage. It was very difficult for us who belong to engineering technical universities, who are used to work in a different way. It was very complicated… Partners didn't know what to do very well and they were not being told what to do neither..." *(Source: OTS interview project participant 3)*

"People were collaborating, but to change this mindset was the difficult thing. For instance, the first project proposal submitted was very research driven, made in the frames of Framework Project. The review we got from KIC was "interesting project but you need to focus because it is a very wide project and so on". This was true and we admitted that it was made as the partners felt more confortable, so following a framework that they are used to. This is a new type of funding from the European Union but no one knew the rules or what to do or what was the difference here. So, then we had to shit completely what we were proposing to do and the whole scope of the project from March 2011 until now. Some people drop from the project, other stayed. But even who has dropped did because they understood the shift and they considered that it was not possible for them to go on with the scope and schedule. And who stayed on-board was very driven to start a much more product approach, market oriented approach […] What I sensed from the partners is that we are trying to explain it but they are a bit lost because they don't know how to proceed […]" *(Source: OTS interview project manager)*

"The very undefined rules along the way and the changes along time… I am not referring to an event or to a moment, but during 2011 for instance many things changed and it was changing at the beginning almost monthly and that can be very bad for partners to understand how the rules work… if everything is not established it is very difficult…" *(Source: OTS interview project manager)*

"[…] What makes KIC InnoEnergy different is that the project has to deliver products and the levels of integration and collaboration between partners have to be bigger. Developing a product requires so and not that each partner does his or her task individually and gather together once and a while. People are still very disconnected and this is not good for the project. I feel frustrated sometimes because I cannot bridge people, as I should. In some moments I am not able to make talk to each other, making communication more complicated and delicate then it should be" *(Source: OTS interview project manager)*

“[…] The collaboration has been difficult because of the bureaucratic issues. Signatures and even the undefined rules of KIC InnoEnergy make it very complicated […]” *(Source: OTS interview project manager)*

“The KIC is a new way of doing things. It is new to many partners. And the processes internal to the partners have not been established. There is a huge work to be done. We still have not established the proper way to manage the network...” *(Source: Family Day A - CEO, 2011)*

Code	Themes	Categories	Innovation Network Studied
Members	Diversity	Institutional Distance	KIC InnoEnergy

“ […] But the funniest thing is that the Product Manager is from a research centre, and there is someone from a business company, and another who is from a university […]” *(Source: OTS interview project participant 5 – marketing expert)*

“In fact what I miss in KIC innovation projects is the participation of industry partners. As promised by KIC InnoEnergy, I think that innovation projects should be industry-led, have a clear goal and that academic partners would be more available to develop the project activities. The innovation projects that I know in KIC, all are academic initiatives and led by university partners and the industry has a shy participation. The objective of KIC InnoEnergy’s innovation project is beautiful but it is missing the real participation of industry. The industry goes on its own, when they have an interesting project it is not developed with KIC because of issues of confidentiality [...] So KIC has a nice speech but at the end it is impossible to implement because industry is not fully committed and they even disturb the development of our work. Why do we need industry participating in innovation projects? Well, ok that in the end we need to sell our products in the market, and the industry partners know the market better than us, but the reality is not the same as the imaginary world created by KIC. […] But the integration between industry and university as wished by KIC is not taking place. I was expecting that the industry would propose projects, products, and ideas and asked us to join in to collaborate with them. But this is not happening. And, on the other hand, if we have initiatives we need to make them up as industrial initiatives to be in line with the KIC speech, and it seems to me outrageous. That's my impression, but I'm telling you sincerely” (*Source: OTS interview project participant 4)*

“[…] The researchers from university A are used to work in European projects. They have experience on it. So, for them is not a new scenario to work with companies and in different countries. Besides, research nowadays is all about collaboration and this implies to collaborate with other research groups or with companies outside Spain. As so, I believe they understand each other well. For me this is not weakness but strength” *(Source: OTS interview project participant 3)*

“We have got teams from many origins and from different institutions […] They have to change the way they view things and this is hard for them as they have been their whole lives working like this. We are changing the mindset of people through meetings, guidelines, reviews of projects. We are working on the diversity so as people who come from different institutions can work together in a better way. We are launching a project to train project leaders. So, these are some of the things that we are currently doing in order to change the mindset of people, but it will take some time. We have many things to fix and many organisational problems to still consider” *(Source: OTS interview CC manager)*

“Establish a company is not complicated but when it comes to a company with partners such as universities, technology centres, business school, some from Spain, and others in Portugal, everyone seeks their own interests, etc. […]” *(Source: OTS interview CC manager)*

“More than being from different countries, the main difficulty is the scope of KIC and to cope with the existing mindsets that the different partners have, normally from universities and other institutions. Universities are very technological driven […]” *(Source: OTS Interview project manager)*

“KIC InnoEnergy is about creating an engine for innovation and entrepreneurship. And you have seen that we have got different interpretations. But all of them add together. It would be quite disturbing to run a company without everybody being on the same page […]” (Source: KIC Family Day - CEO, 2011).

Code	Themes	Categories	Innovation Network Studied
Members	Conflict	Cognitive	KIC InnoEnergy

“ What I know is that it is the first time we participate in a project like this… At the beginning we didn’t notice that the project as it is now. We thought about it more as a European Project like FP7. So, we now need to be aware that we need to develop a product for the market” (Source: OTS interview project participant 2)

“For someone from the university like us it was a huge surprise to have to develop a market analysis. I cannot measure if it was a good or a bad surprise but we felt like it was an extra activity. Besides, we do not have any experience on it […] (Source: OTS interview project participant 2)

“[…] So the challenge is, being very humble and delicate, to tell them that this change will work well. The first thing you have to do is to see things through a different perspective, and for them it takes a bit of time because they have been their whole life thinking in that way, doing research and from that research I develop a product and take it to the market without considering the needs of the market or if there is market for it […]” (Source: OTS interview project participant 5 – marketing expert)

“They were mainly all engineers. And engineers are in love with technology. Besides, they are used to work in R&D projects, so they see life though this looking glass of developing work packages. It is difficult for them to change their mindset. They develop work packages and later try to find possible markets for what was developed. This is the wrong direction. I have to first identify market opportunities and turn these opportunities into products… I told them that this was the right direction. And there was conflict […]” (Source: OTS interview project participant 5 – marketing expert)

“[…] What happens in KIC is that there is a huge tension and there are expectations, plus management is not a field that they are used to. So, out of the blue that are facing a manager, someone not from their field, to tell you that they way you are working is not correct, that the market that they are aiming does not exist yet, and that they are not ready… it is a bit heavy and tuff to swallow. They are not used to these terms and way of thinking. The immediate answer is to tell you that they have not paid you for this… Plus you add the pressure of the project review and the acceptance of the general management. They will not get the funding to carry on with the project without this acceptance. KIC is something new […]” (Source: OTS interview project participant 5 – marketing expert)

“They are engineers, and engineers like this old structure of project management and to control project achievements with Microsoft Project. They know they have some milestones, with meetings and some of them are just a waste of time. Besides, they waste time discussing things that were previously discussed and accepted. Another day we were in a meeting and they started to discuss an old issue and I said: I am sorry but in the last meeting it was agreed that you would not continue with a certain research line because it would not have a monetary return. They, engineers, were still thinking about work packages” (Source: OTS interview project participant 5 – marketing expert)

“[…] The big difference is that here in OTS we need to deliver products that are ready for the market. We cannot do just research, we really need to define a product or service to be ready to the market. And this is a big difference from what we do as researchers. I think this is a bit good and bad difference. The good side is that research becomes more oriented towards what is hopefully needed in the future. The bad side is that it takes a lot of our time doing things that are not related to engineering work” (Source: OTS interview work package 2 leader)

“We have done by now, all work packages, a market analysis. But, this is nothing that we’d heard from the beginning. And I have never dealt with something like this before. Despite the fact that I have been involved in businesses for many years, it was the first time that I had to do something like this. In our division here we have started more than

10 companies, and all of them are active with people employed. This requirement by KIC was thrown at us in a way that was not very constructive. I felt no support from KIC management. We were obliged to do something that I had no idea about by a simple change of the rules of the game" (Source: OTS interview work package 1 leader)

"What happened was, I have never being personally involved with market analysis. I really don't know what was good with it, to what purpose it was. Ok, it has a positive side, I have learnt a lot. The thing is that we didn't have people able to do this, with the knowledge required, which meant to find someone to do it for us. We really had to look for someone in the market that could do this for us in a short time, which was not easy. Of course one advantage is that being a university you can find good students to do it. And this was what happened for me and probably to Jens. We relied on the students to do this work" (Source: OTS interview work package 1 leader)

"Basically what we did was to incorporate a package that would take into account the development of the market analysis, looking for opportunities in products or services within the lines that were being proposed by project. On that moment it was still not so clear for us the objectives of KIC InnoEnergy' s innovation projects. Because of this, our work packages had a research orientation, without proposing the specific developments or products or services. In the first moment, partners saw the market analysis as an instrument that could help them on identifying market opportunities that would allow suggesting post-project products or services […]" (Source: OTS interview work package 3 leader)

"Partners did not have a clear idea of how to deal with this demand [market analysis]. One of the things that were done was to include [a business school partner] helping us to give this market vision to the project. It was difficult because OTS partners did not have a fully knowledge of what a market analysis implied as they are mainly engineers! This task would require much more effort and dedication […] First because the institutions that participate in OTS do not have fully knowledge of what a market analysis implies and, second, although [the business school] has the knowledge to do a market analysis, it does not know enough about the technical world in which the market analysis had to be done. So, this was a job that required much more effort and dedication than it had been done by [the business school]" (Source: OTS interview project participant 3)

"I believe that people did not understand what were the innovation projects about, they were not told what to do, they did not know how to develop the project, what led some partners to feel disappointed and lost [...] (Source: OTS interview project participant 3)

"First, I think KIC InnoEnergy should be more stable. When we are talking about market analysis partners knew that they had to do a market analysis, but what else? How to do it? And once it was done, what would it imply for the project? Will we need to change our focus or not? These questions were in our minds at this stage. It was very difficult for us who belong to engineering technical universities, who are used to work in a different way. It was very complicated… Partners didn't know what to do very well and they were not being told what to do neither..." (Source: OTS interview project participant 3)

I think we have had many problems, complications, and different approaches in interpreting the market analysis. Then in these projects, people are used to work with technology projects. They are researchers from universities, research centres and industry. But so far the industry has not been very proactive… We started with what we had but we are going to ask for a market analysis and from that try to remedy the situation a bit to what we think needs to be done. I think that researchers in general had never done a market analysis before. For them a market analysis was basically taking existing publications on forecasts of an increase in demand for such technology or product and makes 4 numbers and you're done. I think it took them a while… … there was a seminar in April on the results of market analyses that had been coordinated by [marketing expert] and some MBA students presented the results and I think the perception was that: they are commenting on something that we already know. Besides, it took a long time to get these results that we already knew because it was their sector...I think also, if not from both parties, there were some differences regarding the value that was given to these results and some tension arose in some cases, for example, between the project manager and marketing expert, there were comments like "we are paying your services and you are giving results that are useless because we already knew this, and now what do we do with this...” I also believe that on the other hand there was a lack of involvement of the team that was doing the market analysis with the engineers, it was a bit like I'm the consultant, I come here and I give my opinion, but I will not get involved or compromised with anything. I will have an external role. [Marketing expert] could have done differently with a greater involvement. Probably he would have won a greater cohesion between partners and his team and both would have win a lot together, the team that was analysing the market could have learned to integrate knowledge and techniques from people of renewable energy and engineers could have better understand the process of developing a market analysis and how they have reached the results. Then I don’t know again, if it is something about the culture of the people, saying that as I always have worked as a consultant and I come here with the role of consultant and not the role of partner… but without understanding that what we are asking in KIC InnoEnergy is that everyone has the role of Partner, because all partners are part of it, not only partners of a consortium or a Project… This is a somewhat rare model, we are working to do something jointly with involvement of all partners and I think there was probably one of the clearest examples of difference of view between the very technical people and market people” (Source: OTS interview CC manager)

“Partners did not have a clear idea of how to deal with this demand. One of the things that were done was to include the business school to help us to give this market vision to the project. It was difficult because OTS partners did not have a fully knowledge of what a market analysis implied as they are mainly engineers! This task would require much more effort and dedication. And I believe that the budgets of these projects are not big enough for allowing them to have a market analysis as it had to be done. First because the institutions that participate in OTS do not have fully knowledge of what a market analysis implies and, second, although the business school has the knowledge to do a market analysis, it does not know enough about the technical world in which the market analysis had to be done. So, this was a job that required much more effort and dedication than the business school had done. Ok, the budget was what it was and it could not be changed but perhaps they should have dedicated more hours to the market analysis due to the allocated budget. So I think it was not very well developed probably because it is a complex theme to do a market analysis, the project is very big and finally because we were doing a market analysis for the first time [...]” (Source: OTS interview project manager)

“I also think that it is something normal coming from partners that are dedicated to do research within a country and who belong to universities. For the university, the most important thing is to develop new knowledge and they are not worried about producing something. The mindset is always different from the mindset of someone worried about producing a product. The product is something secondary, it may even be interesting but the focus is on the discovery. Here in OTS it has been different because it does not matter if you have discovered something but to turn that into a product” (Source: OTS interview project manager)

“The explanations we received from KIC InnoEnergy were not clear at the beginning. There was a chain of communication that did not work during the elaboration phase. Some e-mails were not received or got lost or the addressee did not notice that it was an urgent matter. The idea was to orientate OTS towards developing a strategic vision for the offshore energy field. We organised the project in the format that we are used to: each partner will do his work separately and once and a while they would meet. Besides, since research projects are always very flexible, I thought that we would have freedom to do what we believe it would be the best for us. Because OTS was elaborated in an urgent way, I was not able to reflect on the requirements of KIC InnoEnergy… I knew that the proposal was weak, but even tough, I though that its value lied on the conceptual part…” *(Source: OTS interview project coordinator)*

“[…] To be more concrete, partners from university B did not understand the participation of the business school in developing the market analysis as they had internally the expertise to develop it and they are much closer to the project. And there was also from our side a misunderstanding with respect to the perception that business school was not behaving as a partner but they were having a consultant role in the project. A partner is not a consultant, it is someone who gets involved in the project, which participates in the meetings and contributes with something. I do not know, we though that member A acted like this because he belonged to a private institution, although we have other partners from private institutions and they have a different attitude. I do not know this is a common behaviour in his institution, but we thought that the business school acted as an external consultant, as a service provider. I believe that this complicated things a bit. If it was to be like this, then the business school should not be in the consortium. The coordination of the project has been trying to manage this situation trying to make this organisation engage more in the project and to participate more on the Steering Board of OTS. It seems that the business school has a different view from other institutions that are more universities than companies. However, this situation is yet not clear or fully managed. Despite all, I believe member A did a good job… but on that time we were expecting more from him, like telling us the areas where we should invest our efforts, but this did not happen… He only delivered a report with a general analysis of the state-of-the-art of the offshore energy field [...]" *(Source: OTS interview project coordinator)*

Code	Themes	Categories	Innovation Network Studied
Members	Conflict	Affective	KIC InnoEnergy

“[…] There is no interaction or integration between partners in work package 1. Perhaps because of this there is even distrust between us. For example, fifteen days ago the project leader informed in a Skype call that they would not be product leaders. I had a feeling that they thought that we wanted to be the new product leaders. We didn’t want to be so as we preferred [institution of the project coordinator] to be because they have the knowledge and know-how. Besides, distrust arises as each partner does his own things without knowing much about the other. I hope that things change now after September meeting and now with a new product leader. I hope she can fulfil what is expected from her as a product leader […]” *(Source: OTS interview project participant 2)*

“And there was conflict. It was something delicate, besides my working style is “short and sweet”. In some occasions there were discussions. I told them in one occasion that I would not work in another way, that the correct methodology was the one I was mentioning, either they liked it or not. So, we could work on that way or otherwise it was a pleasure” *(Source: OTS interview project participant 5 – marketing expert)*

“ […] This requirement by KIC was thrown at us in a way that was not very constructive. I felt no support from KIC management […] ” *(Source: OTS interview work package 1 leader)*

“One partner however presented a drawing explained that he wanted to put a microphone and so, but he did nothing else. He should have done something else. To me this is a great disappointment and I told him in a teleconference we had, I said that a year ago we signed a piece of paper that we got into this project with a budget to do one thing, and it was obvious that the budget did not allow sufficient resources to all the work, in fact we are paying the student who is developing our activities in project, and now you tell me you were waiting to develop your activities based on the funding that you’d get from the fellowship of the Marie Curie and they denied your fellowship. For me his attitude is breach of contract...The project leader and the project coordinator did nothing. In a Framework Project this does not happens, I’ve never seen in my life something like this. In a Framework Project you have a task in a work package and you develop it. And for that it is covered 75% and the rest you have to find funding from other sources. This is standard in a European project. It is true that in KIC InnoEnergy they pay less, but if you say that you will do it, you did compromise doing it” *(Source: OTS interview project participant 4)*

“[…] People started to complain about it during coffee time. For them it was good that the task was done, but there was a certain feeling of disappointment because there were expectations that were not fulfilled with his presentation. Partners from university thought that they could have done the task in a much proper way, especially because they had internally the expertise required to develop a market analysis” *(Source: OTS interview project participant 3)*

“I have the impression that each work package leader has gone into war looking at their side […]” *(Source: OTS interview project participant 3)*
“I believe that people did not understand what were the innovation projects about, they were not told what to do, they did not know how to develop the project, what led some partners to feel disappointed and lost [...] *(Source: OTS interview project participant 3)*

“ […] There were some differences regarding the value that was given to these results and some tension arose in some cases, for example, between the project manager and [the marketing expert], there were comments like “we are paying your services and you are giving results that are useless because we already knew this, and now what do we do with this...” I also believe that on the other hand there was a lack of involvement of the team that was doing the market analysis with the engineers, it was a bit like I'm the consultant, I come here and I give my opinion, but I will not get involved or compromised with anything. I will have an external role. [Marketing expert] could have done differently with a greater involvement. Probably he would have won a greater cohesion between partners and his team and both would have win a lot together […]" *(Source: OTS interview CC manager)*

"[…] There was a meeting of an informal nature between the project coordinator and member A because they had more serious misunderstandings […]" *(Source: OTS interview CC manager)*

"[…] People are still very disconnected and this is not good for the project. I feel frustrated sometimes because I cannot bridge people, as I should. In some moments I am not able to make talk to each other, making communication more complicated and delicate then it should be" *(Source: OTS interview project manager)*

"[…] The problem between them was related to people not replying to e-mails and causing problems of communication. A simple situation turned into a huge incompatibility between them. They stopped to talk to each other. I tried to manage the situation and to see if there was incompatibility and try to make them see that it was not worthy to carry on with it. Someone from the Steering Board tried to manage the situation and see what was behind it. I was involved in the mediation, in the role of the project manager, in an attempt to make them talk to each other so they could understand the situation. I never understood what happened between them. I think it was nothing especial, just an initial communication failure that led to this situation. This was left aside as after a while they left the project" *(Source: OTS interview project manager)*

"[…] All of this causes complaints and a certain feeling of displeasure. We can't work or carry on like this […]" *(Source: OTS interview project manager)*

Code	Themes	Categories	Innovation Network Studied
Members	Conflict	Administrative	KIC InnoEnergy

“[…] There were other administrative difficulties that we expressed in a letter to the CEO of KIC InnoEnergy two months ago. We commented about the difficulties that we had and, with a positive spirit, we presented them to his consideration. Our comments were related to some difficulties that we have been facing. For example, the project review done in December 2011 was very unclear as it was not published how the project were reviewed and the criteria used, the results were not published, etc. There were the main issues that we approached in the letter. We felt that he and cc Iberia CEO have been willing to help and overcome these issues. We know that KIC InnoEnergy is still at its initial stage. People are willing to overcome these issues. We also think that there is too much bureaucracy in comparison to other European projects, especially FP7 projects. We know that we have to report to the European Commission and to justify their funding, but here in KIC InnoEnergy there is maybe a lot of bureaucracy. And I feel that sometimes it is not worthy to be here. If there are other projects like FP7 that fulfils the demands of the European Commission, why not use the same model? You need to consider that in KIC InnoEnergy the consortium is not easy” *(Source: OTS interview former project manager)*

“[…] But I think that not even KIC had OTS rules very clear at the beginning. They defined the rules and the project with time” *(Source: OTS interview project participant 2)*
“For someone from the university like us it was a huge surprise to have to develop a market analysis. I cannot measure if it was a good or a bad surprise but we felt like it was an extra activity. Besides, we do not have any experience on it. Here in our university we do not have the adequate profile to do a market analysis, we do not know how to do it or even from where to start… And honestly, I did not think that it was my responsibility to do this analysis. We felt like: one task more, one uncertainty more. In our work package Uppsala is doing the market analysis as they said they could do it. They sent us their document last week and we will discuss it in September because of holidays. So, we don’t know yet anything about the market analysis” *(Source: OTS interview project participant 2)*

“We had a new project with new calendar, new products, new participants as we are now organised around products and not work packages. Such decision of having products was, I think, not even clear for KIC. It is my opinion […]” *(Source: OTS interview project participant 2)*

“[…] There are two levels, the project level and the top management level. There was a clash between these two levels. Top management was saying that it was correct, even if they did not like the path that the project had to follow. And project management was saying that the new direction was not useful. So, it was clear that this way of working was new for them, something they were not used to. Hence, they had to learn” *(Source: OTS interview project participant 5 – marketing expert)*

“[…] And on Monday, the result was the same, we need to reorganise all this because like it is structured it will not help us to develop the products… because it was organised for a group of universities get money for funding things they had already done. Now it has to change. Not so much in terms of diversity, but actually, if you want to succeed on the market, it is clear that you have to think in terms of market as a company. As so, you are no longer investigating, you are launching solutions to market” *(Source: OTS interview marketing expert)*

“I think it will be hard to find time to do the work. I am not completely sure that we have the budget to do it. So, we will see the feedback that we will receive. But we will see in the next year because we must develop it. But we already spent so many times doing market analysis that it should be enough. We think it is not needed to keep doing it as KIC keeps telling us.” *(Source: OTS work package 2 leader)*

“We have done by now, all work packages, a market analysis. But, this is nothing that we’d heard from the beginning. […] This requirement by KIC was thrown at us in a way that was not very constructive. I felt no support from KIC management. We were obliged to do something that I had no idea about by a simple change of the rules of the game" (Source: OTS interview work package 1 leader)

"I mean, obviously there are people whose thoughts are way ahead of us thinking this is what we are going to do. And when it comes down to the level of the scientists, whatever background they have, to do this is nonsense. They don't have the background to do this. We are from different worlds. It just doesn't fit in. I am a scientist and I may have very good ideas that might be worthwhile for a market, a commercial market, but again very many scientists don't have interest in doing this. I don't have the know-how. And there are just happy to do what they are doing, which are science or development. So I have a feeling that whoever is making the decisions or setting the frame of the innovation projects have little know-how about how the scientists work. There is a big gap and I think someone are having dreams and these dreams are not ours and they ways to fulfil these dreams are not working easily" *(Source: OTS interview work package 1 leader)*

"[…] Most of people seem to be very puzzled with what is going on any way. I mean it is very common that we on a Thursday get some paper from [the project manager] asking for some reports in few days. I am working full time… people are getting frustrated that information and new information are supposed to be submitted when we are actually busy. For example, I am in a very intense teaching period for one or two months. I am unable to divert my time too much. I think that people are frustrated for not knowing what is really valid. I think that the resources are not adequate for what we are suppose to do, which mean people and I myself, have given up quite a long time ago [...]" *(Source: OTS interview work package 1 leader)*

"[…] Do you know why [company Y] left the project? It was because of IP issues. In many EU projects is stated that companies should allow other companies to have access to their IPs. Of course, no reasonable company would ever do that. No company would ever give away a patent. [Company Y] is a small company and considering the 25 % that KIC would contribute it would be not enough to the company participate. It's been an issue in many European projects. And that's a big problem, also"*(Source: OTS interview work package 1 leader)*

"[…] The project objectives required actions and things and that these would need partners who would develop the needed tools and activities for the project. The truth is that as the project was born two years ago with a bottom-up approach, people gathered together and the work package were designed more independently, you build the objectives from the bottom, what for me does not look good. From what I know and from what I have participated, all research projects have a script, the start here and at this point you have these subtasks or these work packages. In OTS, in contrast, it was the opposite. I expected that project coordinators could guide us to what was intended and for example the work we have done with the requirements of what types of frequencies are relevant, I expected that we should receive this from the other partners, and not that in the end we had to develop ourselves. You see, we had this servile manner in the sense that you tell us what you need and we will do it. At the beginning when I saw that the project would require numerical modelling I thought that someone knew what he or she wanted to do, and so he or she would tell us. And my disappointment and surprise was when I saw that no one had thought about it, they had decided to do numerical simulation without really knowing why. But then, as I said, the process was to find something genuinely useful, sealable, and we did that from the beginning [...]" *(Source: OTS interview project participant 4)*

"Well, I think that apart from documents that have emerged to help project partners understand and effectively target the project objectives, I believe that the feedbacks that have been receiving and the periodic project reports have helped us to go modulating the how, what and where to put an emphasis within the project activities. In fact, the decision to refocus OTS into a bundle of much more concrete actions happened due to some of the past reviews, and based on its recommendations […]" *(Source: OTS interview work package 3 leader)*

"On the one hand, KIC was setting up and starting its operations and that was generating a series of procedures and a set of rules to help managing its innovation projects. So as a consequence, some preconceived ideas were being changed and putting in accordance to this new framework. So OTS objectives had to be adapted accordingly. All innovation projects had to have a market analysis. And this was something that was unknown at the beginning and, as a consequence, we did not organise our activities in accordance to this demand… And we had to reorient the Project and redefine its objectives. And this is what I meant by friction" *(Source: OTS interview work package 3 leader)*

"For me [a new market analysis] is another activity, for me it is an additional activity that would somehow determine the advancement of other technical tasks. And it will somehow delay or change the technical program that was planned" *(Source: OTS interview work package 3 leader)*

"[…] This project was built without a clear focus on the market, but focusing on the capabilities of partners. Through time it has had received a new focus towards the market but the project did not have this approach since its beginning. And if it was there, this approach was not the main concern of the project" *(Source: OTS interview project participant 3)*

"[…] The implication of this re-orientation was huge as it changed everything, even our way of working. Some of the previous work was set aside due to new work plan. And these activities would not receive a payment, as they would no longer be carried on […]" *(Source: OTS interview project participant 3)*

"We are doing things as we move forward. We do not have time to stop. We have got a certain pressure from shareholders, from the EIT. So we cannot stop for two weeks to plan how to do things better. Perhaps we would need to do this, but we have decided to move forward. And we will fix things as we move forward. Of course this has positive and negative effects, but it is the way it has been decided […]" *(Source: OTS interview CC manager)*

"The very undefined rules along the way and the changes along time… I am not referring to an event or to a moment, but during 2011 for instance many things changed and it was changing at the beginning almost monthly and that can be very bad for partners to understand how the rules work… if everything is not established it is very difficult…" *(Source: OTS interview project manager)*

"The project was originally structured with an outlook based on research, like the FP7 projects that we were used to work and have a large experience on it. I think that this was something normal coming from partners that belong to universities or research centres and are dedicated to do research. Besides, on time we did not had a clear idea what was KIC InnoEnergy about or what did they want, so we proposed a very loose project. On the first project review we had in March 2011, it was said in a straightforward way that we needed to change the approach of the project towards something more market oriented and not like it was. We re-structured the project together during some months. We did a workshop in April. It demanded from us a lot of work to leave the previous project orientation aside, to find the products that we would develop and that the market would want. In December we arrived to the conclusion of six products that we ended with four. In 2012 we have been working based on these products, such as doing the market analysis and trying to show the acceptance that these products may have or not and to start developing the products. Last year, little work was done. From December until not we also had a tight adjustment of the budget. Also we tried to make the different teams to start developing the products and to some solve of the problems associated to it. We had some teams that were not able to develop their activities because there was a lack of workforce to develop the products (PhD students were not allow to work on it). Besides, the bureaucracy has also been very complicated. For example, it has been very difficult to get all the signatures on the project plan up to receiving money from KIC InnoEnergy. The demands we have been receiving from KIC are very different from the ones in another European project. Although KIC is trying to quickly solve these issues, it is taking longer than desired. We are in July and we still have not received the money that they have to pay us […]" *(Source: OTS interview project manager)*

“But KIC is a company asking things to other companies, so this is not simple at all. We’ve got reviews twice a year, plus a forecast in March and September; the delivery of a report at the end of the year, business plan at early September...and this is only what I remember. These are the milestones we have for delivering reports. All of this causes complaints and a certain feeling of displeasure. We can’t work or carry on like this. Although we have the support of KIC InnoEnergy to answer questions and help in case of doubts, the process is lengthy. KIC must know that this creates certain reluctance from people to realise the added value of being part of KIC. Partners are wondering why they should be in KIC when they have other European projects that would fund their research and the bureaucracy is much less. The objectives of KIC InnoEnergy and of the partners are not aligned. KIC wants to develop products to the market while partners expect to receive funding for developing their research and products. OTS partners need to look more at products, which are the objectives of both. Universities can make money from products if they are good enough and fulfil the objectives of KIC. I have been trying to talk with partners about this, but it is not easy, especially with those that are more far like partners from Sweden. They are upset and they complain a lot. However, we must be patient and try to explain things for them. No one is forced to be here and if they believe that it is not worthy to carry on being part of KIC InnoEnergy, they should leave. Partners must want to be here to develop products. Then we must try to manage these frustrations as much as possible. We must try to make partners reply once a month, because so far it has simply not worked” *(Source: OTS interview project manager)*

“[…] On the initial proposal it was not reflected the requirement of the business plan. KIC InnoEnergy requested this latter on. It was when I figured out for the first time what was being asked for the innovation projects to include products and business plan. At first partners reacted in a positive way. I think that we all thought that it was a good path to follow. But there were doubts on how to do a business plan of a field, which there was still no business. In this decision it was implied that KIC InnoEnergy was interested on products and not on applied research. We needed to re-orientate the project because OTS was not designed to develop products but to develop a field that companies would later on invest. The project was a collection of working packages that would develop a strategic view of all areas (including economic, legal, etc.). Our products would be the results of these activities. So, the decision of designing a business plan to OTS caused a huge impact on the project. It naturally created difficulties to partners used to work on framework projects and in a different way from the one that KIC InnoEnergy was proposing and definitely not used to work under such tight control. We, in the project coordination, decided then to reformulate the whole project […]” *(Source: OTS interview project coordinator)*

Code	Themes	Categories	Innovation Network Studied
Members	Conflict	Goal	KIC InnoEnergy

"[…] They have different objectives. Partners from universities and research centres are on a huge need to receive funding to continue working on the project. For them KIC InnoEnergy is an important source. And we feel many times that behind some attitudes there is a purpose of maximising this funding. It is natural and we understand it, but in OTS I feel that we have been able to foster a feeling of team to overcome all this difficulty" *(Source: OTS interview former project manager)*

"Well, actually, we are very new in KIC InnoEnergy and in the OTS project. I am still trying to learn on how this works. At this point, we don't have any resource to start working on the project. We are assigned with several tasks related to the creation of an operational tool to predict the behaviour of floating wind turbines. And this is a lucky thing because it is exactly the field where we are working now. So, it's perfect because they can run in parallel. But, at the moment, we are developing our activities in OTS with our own resources because we still haven't received any income from the project. This is a problem or it can be a problem in the future. Of course we can still collaborate and it will not imply any delay on the project. But, in this case, we can develop our tasks because they are related to what we do normally […]
"We are concerned about the fact that we still haven't received the funding promised. We are lucky that we've got other funds to develop this work, but it could have been a problem if we haven't had it. The other issue that worried me in the project is that we need to develop a benchmark and for that we will need data from another OTS partner, who is not in our work package. We are approaching him, but due to property rights the whole discussion is being very difficult […]"*(Source: OTS interview project participant 1)*

"[…] Our idea, aside from funding, when we joined OTS was to identify partners that would need our tool to develop their own research or products. A collaboration where they would give us their knowledge and know-how on a certain area, for instance in offshore energy, and we would add our expertise and know-how on numerical applications. So, this was our objective. Until now it has not been like this. In fact we are developing our product independently from our partners and even inside our work package there are two separate parts [...]" *(Source: OTS interview project participant 2)*

"[…] So we were there to develop not a product, but a methodology, a tool that was not intended to arrive to the market or to result in a product. So, this is how we joined the project in 2010, around one and half year ago […] And we joined this work package because our idea was to develop a simulation tool that would allow predicting before building an offshore farm. This tool was not originally proposed when we first talked about the project. Later on with the reconfiguration of OTS, these parts were joined together in one as they are related to each other […] This is the first European project that I participate where the final product has to be commercialised. We had developed software for companies, who bought and adapted it to their needs… but we had never had as our main objective to develop something that should be sold in the market…"(*Source: OTS interview project participant 2)*

"[…] The first time I heard about it was about the possibility of receiving partial funds but we need to develop this tool. The fund we would receive from KIC would finance some PhD students to work on the project. It is clear that we got into the project because we saw it as a funding source. It was not clear for us that the final result would be a product. It was at the end of 2011 that all changes in the project started. Now things are clearer than before as we now know that our final objective is to develop a product that can be commercialised. Now we need to worry that this product can arrive fast to the market, in a robust and efficient way, which are concerns that are not important when you are doing research"(*Source: OTS interview project participant 2)*

"[…] In this Skype call, it was participating [the project manager], [the work package leader], [a project partner], [the project coordinator] and I. It was in this meeting that we got aware of the relationship between [the research centre and an university] and the work package leader told that if they could not get the Marie Curie grant they would not be able to carry on as product leaders. We got surprised. They are free do to whatever they want to do and get with whomever they believe it is good for them, but it would have made a huge difference of they had told us before about this situation… but they did not. After three weeks, we had another Skype meeting when he said that his university was resigning as product leaders" *(Source: OTS interview project participant 2)*

"What was the origin of KIC? Let's put money into technology initiatives in the field of renewable energy because Europe must be leader in this market. And there was a call for proposals. People who were doing something in renewable energy came to participate because they wanted the money. […] There were some projects that did not go further. In others, people continued because they wanted the money for funding and they kept thinking in term of my work package, on their own research. From the KIC management it was said that they would not give money for research, put they would invest in market products and services that people could buy. Therefore, there was an urgent need of making a significant change from just investigating things into reaching results […]" *(Source: OTS interview project participant 5 – marketing expert)*

"The reason that I was interested in participating in OTS was that I thought that this project would play a good and important part in speeding up the development of ocean energy and technology. I never anticipated this to be something that would be great product or that could be sold. Even if it could be, I would not be the person who would do that. There reason for that is I have a full employment at the university, my salary is ok and I would never get the same salary for trying to sell this. So, that was never a driver for me. Still, if I had the products that I had anticipated, then OTS would be much more attractive. My goals were others, such as many others with scientific background, such as funding our research, answering environmental questions, developing good technologies and equipment, etc. For me to develop a large commercial product is just a fantasy. We are never going to take patents on this" *(Source: OTS interview work package 1 leader)*

"[…] We've got a problem here that as the funding is not so substantial, people need to start to realise that the value lies on the products and not on the funding. Funding is a way to help to develop the product, which is our final added value. We need to focus then on the products. KIC InnoEnergy must know that this creates certain reluctance from people to realise the added value of being part of KIC. Partners are wondering why they should be in KIC when they have other European projects that would fund their research and the bureaucracy is much less. The objectives of KIC InnoEnergy and of the partners are not aligned. KIC wants to develop products to the market while partners expect to receive funding for developing their research and products. OTS partners need to look more at products, which should be the objectives of both. Universities can make money from products if they are good enough and fulfil the objectives of KIC. I have been trying to talk with partners about this, but it is not easy, especially with those that are far from us. They are upset and they complain a lot. However, we must be patient and try to explain things for them. No one is forced to be here and if they believe that it is not worthy to carry on being part of KIC InnoEnergy, they should leave. Partners must want to be here to develop products. Then we must try to manage these frustrations as much as possible. We must try to make partners reply once a month, because so far it has simply not worked" (Source: OTS interview project manager)

"[…] I am very much pessimistic about OTS, because the constructiveness is almost zero and I think that I've been wasting my time. I could be doing other things where I could be productive, like writing scientific papers, or doing applications to raise money in other ways, which could be more productive. I think that one drawback of the project that I realize is that I cannot get out of the work package I am in. I think I have better chances of creating that on my own. And I think that almost half way through. What I understand first that could be worthwhile and interested us to participate in OTS no longer exists. It is not possible to do, at least in the current direction of the project or the KIC" *(Source: OTS interview work package 1 leader)*

"[…] All of us agree that the resources are not what were promised at the beginning. So, with the limited resources we have and the time needed to do what we are all expected to do, I mean there is no way. There is no time and no resource for producing things, at least for my case. I didn't consider myself participating fulltime of this […]" *(Source:*

OTS interview work package 1 leader) "[…] One of the other challenges has been to change the mentality or the approach was to technology projects and perhaps has been partially achieved because we are not yet at the level we should be. Another challenge has been to change the mentality or the mindset of partners used to technology projects and perhaps we have not completed overcome this because we are not yet at the level we should be […]" *(Source: OTS interview CC manager)* "In the world of technology, these collaborative projects are perceived generally as a source of income, I do my stuff, I put things together, I benefit a little, but sometimes there is no common approach to achieve this, people fulfil their working hours and you're happy but here in KIC InnoEnergy we look for very different things. People came with this culture, we meet, we get money and we go. To keep doing the same thing we do not need to do all this. If we fail to change the culture of collaboration in collaborative projects we do not need all this, what is the purpose of doing all this?" *(Source: OTS interview CC manager)* "I also think that it is something normal coming from partners that are dedicated to do research within a country and who belong to universities. For the university, the most important thing is to develop new knowledge and they are not worried about producing something. The mindset is always different from the mindset of someone worried about producing a product. The product is something secondary, it may even be interesting but the focus is on the discovery. Here in OTS it has been different because it does not matter if you have discovered something but to turn that into a product" *(Source: OTS interview project manager)* Partner 1 (CFO/economist): "Our priorities are different because of the person, the institution, the partner. So, this is a new dimension making interesting constellations and we need to work within it and this is a great challenge, but we share the same enthusiasm […] Partners may have different objectives to participate in this beautiful endeavour." Partner 2 (social scientist): "But there is a common vision. It's written and official." Partner 3 (engineer): "Ok, one thing is that it is published other that it is shared. So we now need to internalise it […]" *(Source: In-Company Training, 2012)* Partner 1 (social scientist): "We have got different expectations from KIC InnoEnergy because we are measured in a different way in our institutions". Partner 2 (engineer): "The dean at the end of the year will ask me [university professor] about articles and not number of products released and start-ups. So, I am embedded in an institution that measures my performance differently from KIC" *(Source: In-company training, 2012)* "[…] But, how to convince a university professor that the goal is not to write a good article but to create a product or service? KIC is not only a source of funding. We need to find a long-term solution otherwise we won't make it. And we won't achieve our objectives" *(Source: In-company training – university professor/social scientist, 2012)*

Code	Themes	Categories	Innovation Network Studied
Coordination	Commanding	Direct supervision	KIC InnoEnergy

"[…] The coordination of the project has been trying to manage this situation trying to make this organisation engage more in the project and to participate more on the Steering Board of OTS […]" *(Source: OTS interview project coordinator)*

"[…] Someone from the Steering Board tried to manage the situation and see what was behind it […]" *(Source: OTS interview project manager)*

Code	Themes	Categories	Innovation Network Studied
Coordination	Commanding	Standardisation of skills	KIC InnoEnergy

"[…] In the new innovation projects, in order to be appointed as a project manager, the partners needs to be from the industry and possesses certain soft skills for dealing with people […] " (*Source: OTS interview CC manager)*

Code	Themes	Categories	Innovation Network Studied
Coordination	Commanding	Standardisation of process	KIC InnoEnergy

"[…] All I know from OTS is based on the written documentation I was given, but it is technical information from my work package only, not related to any organisational or managerial aspects […]" *(Source: OTS interview project participant 1)*

"I think that apart from documents that have emerged to help project partners understand and effectively target the project objectives […]" *(Source: OTS interview work package 3 leader)*

"[…] We are launching a project to train project leaders so they know how they have to behave and develop their job […] " *(*Source: OTS interview CC manager)

Code	Themes	Categories	Innovation Network Studied
Coordination	Commanding	Standardisation of outputs	KIC InnoEnergy

"[…] We know that we have to report to the European Commission and to justify their funding, but here in KIC InnoEnergy there is maybe a lot of bureaucracy […]" *(Source: OTS interview former project manager)*

"[…] The deadline for sending our reports were so tight that sometimes we sent it directly to the project manager. The former project leader sometimes used to reply to him without consulting us or sending a copy of the e-mail to us. It was a bit odd. We sent to the project leader two reports of what we have done until now. We are ahead of schedule […]" *(Source: OTS interview project participant 2)*

"[…] But right now when I am filling the excel sheets for the project review, [the project manager] asked to write these products as two sub-products. I got the information from another partner to put in this report" *(Source: OTS interview work package 2 leader)*

"[…] I believe that the feedbacks that have been receiving and the periodic project reports have helped us to go modulating the how, what and where to put an emphasis within the project activities. In fact, the decision to refocus OTS into a bundle of much more concrete actions happened due to the past reviews, and based on its recommendations, and also due to the market analysis" *(Source: OTS interview work package 3 leader)*

"[…] We've got reviews twice a year, plus a forecast in March and September; the delivery of a report at the end of the year, business plan at early September. There are milestones for delivering reports [...] *(Source: OTS interview project manager)*

Code	Themes	Categories	Innovation Network Studied
Coordination	Enabling	Boundary object	KIC InnoEnergy

"I will present some of the results of KIC InnoEnergy so far. To those who are not in the education side [of the knowledge triangle] please look at the numbers because they show a good success reached by those who are doing education […] Regarding 2012 business plan, one of the areas to be develop is to integrate the three sides of the knowledge triangle as they will reduce deficiency and it is the beauty of KIC InnoEnergy […]" *(Source: KIC Family Day - CEO, 2011)*

Code	Themes	Categories	Innovation Network Studied
Coordination	Enabling	Broker	KIC InnoEnergy

“[…] This is perhaps a bit too strong to say because in fact I am not the boss, but I am the expert. In identifying and seizing opportunities in the market and in the road to market. In the KIC there are many engineers, but few people expert in management. […] I did the market research. Then, with this role of expert, I organised a two-day meeting and in the afternoon we worked with the project leaders, and I said as we were working on products, we could work as a business company, and I thought that this could be a good way of working. They gave me freedom to say that we should work as so, what would require a change in the structure of OTS. With that you have product managers to manage these products, etc. But there are no more levels; the structure is very flat and very operational, and above all based on the development of these products that will be taken to the market […]” *(Source: OTS interview project participant 5 – marketing expert)*

“Since last September, they are working like a team because they are now able to understand the project. In July we had a workshop where we worked all this and participants said that they finally understood the project as a whole for the first time, and they could work because they knew what to do. […] From them is a radical challenge. They have to stop thinking about “my technology” and think about something new, something that people will buy. So they must abandon the technology that they currently use and think that this is going to be developed for someone else. Besides, people do not buy technology, they buy solutions and solutions are delivered in products or services […]” *(Source: OTS interview project participant 5 – marketing expert)*

“Member A had an important role in brokering his knowledge in market analysis so we could understand a bit what we had to do, with this new mindset. After the second workshop then we squeezed the participants to move into this new direction… He helped us making bridges between old and new mindsets and implementing the seeds of this change […]” *(Source: OTS interview project manager)*

“We did a brainstorm session to look for products. I cannot remember well but we gathered together in June (we looked for a favourable date for all partners) to have our first brainstorm session, which was extremely well conducted by member A. It was a session that we thought that all the money that we had paid to the business school was worthy… The workshop in June was completely different. Member A brilliantly conducted the brainstorm session that would help us to initially define our ten products. His work was very important at this transition phase of OTS. He orientated us not only to define our products, but he also shed light on a vision that would guide us on how to develop these products based on the market analysis. I will not only say that in this stage the business school worked as they should have done but it also did an important job. He had an important role for the development of the project” *(Source: OTS interview project coordinator)*

“In the second workshop unlike the previous one, there was dialogue, people locked themselves in a room for eight hours and somehow talked and discussed things. It was a different way of working. This second workshop was very different in comparison to the first. In the first work was done by member A and other business school partners unilaterally and the results were presented. To my judgment there was little interaction with them and other OTS partners. In the second workshop member A made everyone participate, give their opinion, there were a lot of questions. There was much more interaction” *(Source: OTS interview CC manager)*

“Member A’s presentation was nice to hear. The feeling I had is different from other partners. For me his presentation was ok, perhaps it is due to the fact that I do not know the technical aspects of the project, but the general comment was that a student could have done the same presentation as member A did. Perhaps it was because he did not know enough about offshore energy […] People started to complain about it during coffee time. For them it was good that the task was done, but there was a certain feeling of disappointment because there were expectations that were not fulfilled with his presentation. Partners from university thought that they could have done the task in a much

proper way, especially because they had internally the expertise required to develop a market analysis” *(Source: OTS interview project participant 3)*

Code	Themes	Categories	Innovation Network Studied
Coordination	Enabling	Mediator	KIC InnoEnergy

"[…] Member B had an important participation after that first presentation. He helped a lot, talking informally to OTS partners during coffee time to cool things a bit because member A's part was at that moment the most important for the development of the project. So he was trying to help on the backstage of the project" *(Source: OTS interview project participant 3)*

"After results were presented from member A, partners started to comment their opinion with me [member B] and, in general, they were not very positive. From there, I had a series of meetings with some partners. I also met member A separately for a couple of times and we discussed what was going on. I explained him a bit the perspective of partners and what they had told me. I think everyone had their share of reason, things are neither white nor black, and based on that I was able to convince partners to give member A another opportunity. He was going to further develop the market analysis and present it in a new workshop. We worked this relationship in a quite natural way; there has also been the willingness by the parties. For example, there was a meeting of an informal nature between the project coordinator and member A because they had more serious misunderstandings. They had lunch together to talk about their issues. I was not present because although I was invited I was on vacation. I tried to have a mediating role to put the two parts closer, but really all merit was theirs, I know a little both of them and they are good people and people of good will. Meanwhile there were calls, face-to-face meetings, and meals together… From there it has established a good relationship and mutual respect" *(Source: OTS interview CC manager)*

"It took a time for them to accept it. There was a first attempt to this new direction but they did not like the result. So [CC manager] told them that although they did not like it, it did not mean that it was wrong. Perhaps this happened because they were different expectations. And for the first time engineers had to face a new rigorous and methodology for identifying market opportunities" *(Source: OTS interview project participant 5 – marketing expert)*

3. ATLAS Experiment

Code	Themes	Categories	Innovation Network Studied
Organisation	Decision-making	Bottom-up	ATLAS Experiment

"ATLAS has a flat structure where everybody, being considered as equal within the experiment, can attend any meeting and when it comes to decision, it is done based on consensus and the solution considered technically to be the best […] With 3000 people, you need to negotiate to make a decision" *(Source: ATLAS Experiment interview - Subdetector system participant 2)* "[...] When there are discussions about physics, there is a consensus to reach the best solution. If decisions are more political, for instance decide on a certain 3d technology that was being proposed by one group formed by the Germans against another formed by Italians and Spanish. Although they had more money, support, and internal persuasion, we had the support from ATLAS management because it was a newer technology. So it was a decision done with a helping hand from the management. It was not so democratic or reached through a consensus, but it was something better for the experiment […] the technical coordinator talked at backstage with people to support this technology […]" *(Source: ATLAS interview subdetector system participant 7)* "In IFAE there is a kind of informal petit committee formed by three senior physicists with large experience in ATLAS and in physics, with very important positions in ATLAS and within our group, in which we always consult ourselves, irrespective of the meetings, about things in relation to our group, decision from ATLAS that will affect us directly, for instance to accept a certain management position or not. Besides, this petit committee we gather also in the weekly meetings of one hour and a half. They are executive in the sense that we follow an agenda where it is previously defined each subgroup will make a presentation updating on their activities, followed by discussions. So every week a group will be invited to make a presentation […] And then we have virtual meetings with the group that is currently developing research in ATLAS and the meetings that you do physically in CERN" (Source: ATLAS interview subdetector system participant 1) "Although CERN is a bit different with the matter of member states, associate states […], the member state contribute with a certain amount of money, the associate contributes with less, all this kind of stuff. But when it comes to ATLAS Experiment, this is forgotten […]" *(Source: ATLAS interview subdetector system participant 1)* "[…] When there are open position for coordinators, what the management does is to ask for nominees […] and then they select […]" *(Source: ATLAS interview subdetector system participant 1)* " It is very good for you curriculum to have a position as a coordinator of something in ATLAS. It is good because it forces you to see things from a broader level. You need to be a good physicist so you can be a coordinator or supervise the work of others, but it has to be done in a proper time. A coordinator does not decide alone because people who are developing the activities know more than him or her. The coordinator facilitates, mediates collaboration. Besides, there are good and bad coordinators. The good thing is that they have mandates. You bare that coordinator for two years; ignore him or her. To go to the management level to complain is something that we see as very violent. We

are not used to do something like this…" *(Source: ATLAS interview technical coordinator).*

"It is a usual technique that you've probably heard that we never make decisions, actually we do make all the decisions, but we do it in such a way that there is no decision made, so you work by consensus. You make sure that everybody at the end gives up or is convinced. One has to work in a certain way, but you never force anybody to go in a different way, being on the other side of the barrier. So if you find yourself in this situation, you enlarge the barrier in order to have always everybody inside. And you don't force a decision when you see that there are people that do not agree, so you try to work more, to find reasons. If somebody does not agree, normally there is a good reason for it, so you better listen to him. I have learnt that the best way to collaborate with people who have different opinions is to bring them in, to force them in. Right now, for example, if I have a problem and I see there is a decision to be made and there is somebody that does not want or is very critical I create a task force and I put this person in the task force. Because then this guy knows he has to do something, he is obliged to be part of the solution process. When he is there, he cannot have an opinion that is 90 degree from everybody else because there will be no solution, and his mandate is to find a solution. In that way you build consensus but in a clever way, without breaking legs […]" *(Source: ATLAS interview technical coordinator)*

"In this sense, decision-making was very collegiate, though someone has to make the final decision. At that time [the group leader] made the final decisions because he was the group leader. But the discussion of everything, the problems, the options, etc., everyone discussed them. Even the students are there, listening. Though they might get a bit bored because they don't want to listen to everyone, they have to be there […] *(Source: ATLAS interview subdetector system participant 1)*

"[…] In CERN there are subgroups which are organised a bit differently. For example, there is a task force to decide on electronic issues. This group discusses questions with external specialists who supervise what's being done with TileCal on the electronics side. The head of electronics at ATLAS is there when an important decision has to be made. Now, in terms of ATLAS, there's an entire process. The technical coordinator is the person who can explain it best, but there is a design proposal for each important element. There's a letter of intent, which is a first draft of what that component is. It is then approved and presented to collaborators as well. Then there is the technical design report, explaining everything that has to be done in great detail. It also has to be approved at various levels. There is also a production review before entering into production. This review details the production process for scintillators in participating companies. I also took part in some visits to Russia, to see what firms were producing them, how they did it, who worked for them. But each step hast to be approved in the review" *(Source: ATLAS interview subdetector system participant 6)*

" We made decisions at the internal level within the group, decisions about everything that was beginning to affect the experiment but in accordance with global management. If a decision has to be made, then the spokesperson, the person in charge, normally defines a task force. We work a lot with task forces that we create for a particular job. In this case, the question was deciding on the technology for the calorimeter. This happened with TileCal, but a month ago we decided the same thing for the muon system upgrade. It's a never-ending story. The people there understand the technology and respect the decisions because they have to be followed; that's how it works. But they know if they don't accept decisions, real problems can start because it's not easy to impose a decision like that. The Collaboration Board, which represents collaboration between all the institutes, has to ratify all the decisions. In this sense, the board has the final word. All the technical design reports, those describing what's going to be done, have to be approved by the board. And then there are more steps. The CERN's review boards go over everything in terms of economic resources and from a technical point of view. There are also other committees, the review committees for experiments at the technical level and at the management level. These also have to give their okay as well as the funding agent at the end. Afterwards, after everyone has said "yes", we move forward. We sign what we call the "memory of understanding" which is like a deal. In fact, it's between the different countries' funding agents and the collaboration or, let's say, the groups of the different institutes involved" *(Source: ATLAS interview subdetector system participant 1)*

“I think one of my main role as project leader is to organize these structures so that it works. And also to create a mechanism of discussion because even between physicists we don’t always agree on the strategy to follow. People may have different strategies… And to arrive to the chosen choice is a mechanism which involves data, simulation, discussion, compromises and usually if it’s done properly once you make a decision the other institutes, which were choosing the other options, will respect your choice when it’s well done… Yes, it may happen and it happened certainly in the past when for example the two experiments were merging in one and one institute may decide, okay this is not the choice I was striving and it may move to another part of the detector, but usually the institutes do not quit the experiment because their choice was not chosen…” *(Source: ATLAS interview subdetector system project leader)*

“[…] On the Executive Board, everyone sits around the table to discuss things; everyone listens to the others. For example, N. has served as technical coordinator for years; he helped to build it all. He has knowledge and authority, and, so, deciding something against him, I’ve never seen it […]” *(Source: ATLAS interview subdetector system participant 6)*

“Decisions were very collegiate, though someone had to make the final decision. At that time M. made the final decisions because he was the group leader. But the discussion of everything, the problems, the options, etc., everyone discussed it. Even the students were there, listening […] There are subgroups that are organised a bit differently. For example, there is a task force to decide on electronic issues. This group discusses questions with external specialists who supervise what’s being done with TileCal on the electronics side. The head of electronics at ATLAS is there when an important decision has to be made. Now, in terms of ATLAS, there’s an entire process. There is a design proposal for each important element. There’s a letter of intent, which is a first draft of what that component is. It is then approved and presented to collaborators as well. Then there is the technical design report, explaining everything that has to be done in great detail. It also has to be approved at various levels. There is also a production review before entering into production. This review details the production process for scintillators in participating companies. I also took part in some visits to Russia, to see what firms were producing them, how they did it, who worked for them. But each step has to be approved in the review” *(Source: ATLAS interview subdetector system participant 1)*

“In principle groups can manage their internal organisation as how they see it best, how they make their selections at that level. There are guidelines in ATLAS for systems, so there are some differences. But the general organisation groups, let’s say, is more or less the same. But, in practice, within the group, each one does what is practical for solving their problem, let’s say” *(Source: ATLAS interview subdetector system participant 6)*

“[…] We meet every week on Mondays for around 2 hours, where people from different areas of TileCal do a follow-up on their activities. Wednesday morning, the coordinators meet. This meeting is more strategic and focus on our problems. And Thursday we have a meeting about data preparation. We go to this meeting to listen and help if a problem arises” *(Source: ATLAS interview subdetector system participant 5)*

“[…] ATLAS is very flat. There is no hierarchical relationship, which is very important to understand. It's not hierarchical at all because all the resources come through the institute, which have signed the memorandum of understanding, so there's… the effort recognised is really between, in a sense, between the institutes not the individuals. The institutes make a commitment to provide the people, so the people come through the institutes into this project called ATLAS”*(Source: ATLAS interview resources coordinator)*

“[…] It's a process where since you are dependent on the resources coming from all the people, and you can't solve it yourself, either you don't have the resources, or you don't have the brain to do it because usually it's a complex problem, you get all the people around the table who are interested in taking ownership, in solving that problem for the good of ATLAS because if the problem doesn't get solved then there is a real problem and ATLAS will not work. So people get together, they discuss, they debate. Sometimes it's tough but people realise that they have to solve the problem in the best interest of ATLAS, so they do. And then there is a compromise. So it's very consensus-driven […] "*(Source: ATLAS interview resources coordinator)*

"[…] In all these meetings with the management, with the ATLAS management, they are usually issues that are not so scientific because those questions are being addressed in the appropriate working groups and so on, so that doesn't come… but then there are some core strategic things that come… it's almost like default. Those are questions that can't be handled in any other groups, they come then to the… I'll give you a silly example. We were discussing Christmas cards, we were discussing Christmas parties, we were discussing looking for suitable people who could represent ATLAS in committees, or giving talks to reviewers who are looking at ATLAS, so those sort of things that… there is not an existing mechanism really elsewhere. So it's… I have to be very clear that when you are running a collaboration like this, big and complex, it's not that every problem is escalated up. People don't say okay this… I don't know. We have a problem with Tile Calorimeter. So the project leader says, oh there's some problem with the high voltage supply […], I mean, I don't know what to do; I would probably kick it. But that's not the right solution. So there's no point in escalating it up, right. So people solve the problem on their level. So it's not like in a company where the management probably has to deal with all sorts of stupid things. Okay, we deal with Christmas cards but you know, it's a relatively simple problem […] "*(Source: ATLAS interview resources coordinator)*

Code	Themes	Categories	Innovation Network Studied
Organisation	Degree of Formalisation	Informal mechanisms	ATLAS Experiment

“[…] I don’t know if you know it, but ATLAS Experiment started with a letter of intent, for this letter a bunch of people gather together to decide something. I think in the case of ATLAS it was in the 90s or the year 2000. In this letter is written two things, more or less what they want to do and who is supporting it in terms of funding coming from the institutes. CERN at that time received many of these letters for its future detector. A committee gather together and started to select the best proposals. Those who were in letter of intent not accepted were given the opportunity to join other groups that had succeeded. This happened in ATLAS […]” *(Source: ATLAS Experiment interview - Subdetector system participant 2)*

“[…] ATLAS is a high-level technocracy […]” *(Source: ATLAS Experiment interview - Subdetector system participant 2)*

“[…] In order to get support for a decision you need to talk to people before meetings. And this is done at the cafeteria during a coffee. It is where and when you negotiate support. You need to have consensus on your decision prior to joining a meeting […] *(Source: ATLAS Experiment interview - Subdetector system participant 2)*

“[…] In ATLAS you have coordinators because you cannot oblige people to do what they don’t want to do […]” *(Source: ATLAS Experiment interview - Subdetector system participant 2)*

“[...] When there are discussions about physics, there is a consensus to reach the best solution. If decisions are more political, for instance decide on a certain 3d technology that was being proposed by one group formed by the Germans against another formed by Italians and Spanish. Although they had more money, support, and internal persuasion, we had the support from ATLAS management because it was a newer technology. So it was a decision done with a helping hand from the management. It was not so democratic or reached through a consensus, but it was something better for the experiment […] the technical coordinator talked at backstage with people to support this technology […]” *(Source: ATLAS interview subdetector system participant 7)*

“In IFAE there is a kind of informal petit committee formed by three senior physicists with large experience in ATLAS and in physics, with very important positions in ATLAS and within our group, in which we always consult ourselves, irrespective of the meetings, about things in relation to our group, decision from ATLAS that will affect us directly, for instance to accept a certain management position or not. Besides, this petit committee we gather also in the weekly meetings of one hour and a half. They are executive in the sense that we follow an agenda where it is previously defined each subgroup will make a presentation updating on their activities, followed by discussions. So every week a group will be invited to make a presentation […] And then we have virtual meetings with the group that is currently developing research in ATLAS and the meetings that you do physically in CERN” (Source: ATLAS interview subdetector system participant 1)

“Working groups usually meet once a week. It is where research being conducted is presented and discussed. Usually postdocs present it. Sometimes these working groups need to present the updates on data analysis, so someone is chosen for presenting this report […]” *(Source: ATLAS interview subdetector system participant 1)*

“[…] There is something important which is the counter experiment of ATLAS, its alter ego CMS. And one provokes the other. Sometimes we decide to not present a certain progress or result in a conference, waiting for their first step […] it is not right but this competition exists and it is internal […]” *(Source: ATLAS interview subdetector system participant 1)*

“[…] For example, if I have a problem and I see there is a decision to be made and there is somebody that does not want or is very critical I create a task force and I put this person in the task force. Because then this guy knows he has to do something, he is obliged to be part of the solution process. When he is there, he cannot have an opinion that is 90 degree from everybody else because there will be no solution, and his mandate is to find a solution. In that way you build consensus but in a clever way, without breaking legs […]” *(Source: ATLAS interview technical coordinator)*

“[…] There are three leaders in ATLAS; the scientific leader who is the spokesperson, the resources coordinator who clusters together all the resources, and then another who is in charge of everything related to technology and the detector. And we are working like a group with clear division of work. X is the spokesperson; she normally does not discuss anything about the detector itself. The same way I do not go to her to tell her she is doing the physic analysis wrong. We, as a team, agreed to share responsibility […]” *(Source: ATLAS interview technical coordinator)*

“[…] We sign what we call the “memory of understanding” which is like a deal. In fact, it’s between the different countries’ funding agents and the collaboration or, let’s say, the groups of the different institutes involved” *(Source: ATLAS interview subdetector system participant 6)*
“[…] How did we work? Well, in part, locally. We created groups that met weekly reviewing all of our progress on different components. Everyone listened to each other.” *(Source: ATLAS interview subdetector system participant 6)*

Code	Themes	Categories	Innovation Network Studied
Organisation	Degree of Formalisation	Formal mechanisms	ATLAS Experiment

"Well, normally there are usually instructions on Wikipedia, which are instructions for users that work a bit like the first guide to them so that they know how these things are organised. There are also mailing lists that you use when you do not know what to do and want to make questions to others. In the mailing lists there are many people writing and collaborating so you expect someone to contact you and tell you what you must do. There are other tools that are a little more detailed, for example, there are tools to find the data grid and make lists from data, including how to download data and take it to your institute so you can process it there. There are many different types of tools. In ATLAS there is a structure, an internal organisation of things, you have meetings, and this at first is quite complicated to learn because there are rules, in the sense that if you want to analyse data, you can take the data as you want and do whatever you want, you have to follow some rules and instructions. It is very bureaucratic in a way because, for example, when writing a paper, which ultimately is a product of physics and that is important as a result of our collaboration, you have to follow some scrupulous rules about how you have to do analysis, how you have to write the paper, the phases of approval and then preparing the manuscript to send to the magazine, is all well documented but also very complicated [...] (Source: ATLAS interview subdetector system participant 4)

"We always have to give examples in the meetings showing how important the work that people are doing is and if it is not done, showing them with examples the difficulties to retrieve the information, to pass it to another person when they leave our when they go to something else. Yes, we always need to keep a watch on that. And then, as ATLAS is a very big collaboration, there are rules that are very important to follow, and new people sometimes break the rules or they do not follow the rules, not because they don't want to, it's just because to learn all the procedures takes time and it´s difficult. So we should keep watching this aspect through the coordinators, as I said […]" (Source: ATLAS interview subdetector system project leader)

"Well, the first pressure it creates at the present is that it's extremely difficult to conciliate the time that physicists spend to do physics and the time that physicists spend to maintain and operate the detector. And this is a big difficulty. And it's difficult also to pass this message to the Institutes, because although the Institutes have to keep part of the manpower, keeping the detector running correctly, they want to be very visible in the physics analysis they are doing. And this is a difficult process because the physicists cannot have good data for good results if the detector isn't running well, so they need to do service work. So, for example, ATLAS has a tool which is called OTP, […] this is a monitoring tool where each service task to operate and maintain the detector for physics correctly, defined by the project leaders and the technical coordination, is stated. We enter into this tool the percentage of the time that each member of the community has spent in this task or on that task, and at the end ATLAS retrieves all this information and theoretically, in principle, if everyone makes a good share of the service task, they should spend at least 30% of the time in helping operating the detail. You can be a software task; it can be a hardware task and so on. And then ATLAS collects all this information and twice per year there it is a report that all the founding agencies showing if the Institute is above or below the so-called quota that they should provide to the collaboration. All these reports are available; everyone can consult them, with names, with the tasks. So OTP is a tool which monitors the performance in terms of tasks, but also put some pressure in some institutes which are very much below the quota that they should provide in terms of technical help for two to three consecutive years. Never in ATLAS has anyone been put in the situation where they do not become authors or were not allowed on signing papers. But, I mean, this is a way of pressure. Frequently we had Institutes coming saying, "what can I help you more?" Because the report is in red. Another tool that ATLAS has put in place that helps the technical work to be done is the qualification task. A person coming to ATLAS becomes an author after passing a so-called qualification. And qualification means that during one year for 50% of the time that person has to a certain task. These tasks are technical activities defined by the project leaders, by the activity coordinators. And after this one year the person becomes an author, and they start signing the papers. So this is, for example, another tool that ATLAS has, CMS has the same, to help the collaboration to fulfil the tasks that are less fun during data taking period. So at the end these results, people have to work in a very, very organised way, if not entropy is there to destroy it" *(Source: ATLAS interview subdetector system project leader)*

Code	Themes	Categories	Innovation Network Studied
Members	Prior Relations	Familiar	ATLAS Experiment

"[…] HEP is a big but not so big world because there are people who I worked before in Chicago that now are in ATLAS […]" *(Source: ATLAS interview subdetector system participant 1)*

"I worked with X before in Chicago and he asked to join him in ATLAS Experiment […]" *(Source: ATLAS interview subdetector system participant 1)*

"[…] TileCal was one of the first groups to be formed and probably the people who joined there were very motivated […] I've created that in 1990 and it was until 1999, the project leader. And so I helped building the collaboration and finding the people to collaborate. And I think it strongly depends on the way you build up such collaboration, and so...in practice the building up the collaboration was with the friends of the friends of the friends. At the end, the Liquid Argon was built around the French community, within a cluster, and then they attracted their friends who were working on other experiments on the same technology. And this was really the core of ATLAS at the very beginning […]" (Source: ATLAS interview technical coordinator)

" […] Even if they were coming from different countries, we all knew each other, one way or the other […]" (Source: ATLAS interview technical coordinator)

"[…] So you get to know the environment where everyone is living, get even to know the families and the children, and so on and so forth. So you are building up relations...and I think it's important to this collaborative effort […]" (Source: ATLAS interview technical coordinator)

"ATLAS started in 1994, 1996. Before that ATLAS was organised in a federation of projects and each project was a collaboration by itself. Slowly emerged all these projects, all these collaborations in a unique collaboration, and this was around 1993, 1994. In 1996 we got ready, the blessing to go at it. So TileCal was born out of a project, an experiment if you want, to develop a certain technology and to get it working, and then emerged with the rest of ATLAS, and everybody else accepted us as a technology and then it got inside the system" *(Source: ATLAS interview technical coordinator)*

Code	Themes	Categories	Innovation Network Studied
Members	Diversity	Social proximity	ATLAS Experiment

"[…] HEP is a big but not so big world because there are people who I worked before in Chicago that now are in ATLAS. […] Of course this had a positive impact on the development of ATLAS Experiment […] People know each other and what everyone is doing […]" *(Source: ATLAS interview subdetector system participant 1)*

" People are selected for working groups based on their knowledge, there is no politics when you decide for accepting someone for a vacant position. It does not matter his or her nationality. […] This creates cohesion. And I believe this is the reason why people get on very well […]" *(Source: ATLAS interview subdetector system participant 1)*

"[…] You were going everywhere making one or two meetings outside to foster collaboration so you get to know the environment where everyone is living, get even to know the families and the children, and so on and so forth. So you are building up relations...and I think it's important to this collaborative effort. You cannot keep people working together for 40 years if you don't have some social behaviour around" *(Source: ATLAS interview technical coordinator)*

Code	Themes	Categories	Innovation Network Studied
Members	Diversity	Geographical distance	ATLAS Experiment

“[…] Have people located around the world […]” *(Source: ATLAS Experiment interview - Subdetector system participant 2)*

“Aside from different nationalities in the experiment, you have different universities

“[…] Our strength is the collaboration, so you have seen we have this huge network of 38 nations, including Brazil, and we have a network which is capable of many things… People are very focused in the knowledge […]” *(Source: ATLAS interview subdetector system participant 1)*

“Of course you have to work harder because you have to understand that not all people think or reason in the same way, you have to be a little more tolerant. There are many differences, obviously, because we are talking about an experiment has physicists from Japan, United States, Europe, with all kinds of mentalities and ways of working and talking too, then you must understand and learn to work in this environment” *(Source: ATLAS interview subdetector system participant 4)*

“There’s a difference in general between Europeans and North Americans. American students have learned to be more assertive, to talk a lot more, while the Europeans learn after a while, saying, “If we don’t start talking like them, we’re not going to make it.” But that’s how they come here. I don’t know if their educational system is like that, in high schools or wherever, but they are less shy than Europeans. There are also other communities for whom it’s harder to show themselves and let others get to know them, like the Japanese. There are a lot of them, but they have problems with the language, in general. Of course this makes it more difficult. We don’t know Japanese. They have to show much more merit, but it’s an obstacle, which is more difficult for them. But, I also see some Japanese that are a little different, they make more contacts and when, for example, on the committees, they look for people from everywhere a bit […]” *(Source: ATLAS interview subdetector system participant 6)*

“[…] Although physics is our common language, the cultural background is very different [...]” *(Source: ATLAS interview resources coordinator)*

Code	Themes	Categories	Innovation Network Studied
Members	Diversity	Temporal /virtual geographical proximity	ATLAS Experiment

"[…] We rely a lot on ICTs as we have people located around the world, but main decisions are done at CERN facilities. It is where the collaboration meets. It is where day-to-day activities are carried on […]" *(Source: ATLAS Experiment interview - Subdetector system participant 2)*

"[…] Although I do most of my work here in Spain, it is at CERN facilities that you get to talk to people, where you meet them and things happen […] You have a problem and you talk to someone on the hall […]" *(Source: ATLAS interview subdetector system participant 7)*

"[…] And then we have virtual meetings with the group that is currently developing research in ATLAS and the meetings that you do physically in CERN" *(Source: ATLAS interview subdetector system participant 1)*

"[…] In ATLAS we have something like 40 or 50 videoconferences every day. And this is done for these people to show what they are doing and be able to interact with the entire ATLAS. And slowly when they do something, they feel obliged to show what they are doing in an environment that is larger. So they begin to interact, they begin to go to meetings, phone meetings, video meetings, and then there are meetings where people physically get together and then there are working groups where they interact even more frequently in order to make sure everything is maintained, and they get mandates and so on […]" *(Source: ATLAS interview technical coordinator)*

"The key thing to work in a community like this is to communicate. It is one of your main tools. You need to talk to people, you need to communicate, you need to understand what they say, it's true that for Americans in particular is easier, because it is their native language, and perhaps they do a small effort to communicate with others. I think it's sometimes a great problem for people who do not know English well. For example people coming from Brazil, there are many times they do not to come with an acceptable level of English and demands from them an extra effort. I learned a bit of Portuguese but this applies to me, they cannot expect to go a meeting and without speaking English. And I think you can amend this a bit by communicating through e-mails, so at least there is some communication and if they cannot overcome the failure because of the language, the end result is that just leave. So I believe it is essential to be able to communicate not only in physics" *(Source: ATLAS interview subdetector system participant 5)*

"[…] We met a lot, so sometime you have informal meetings in a cafeteria where people gather to talk about a problem, other you have more formal meetings or through videoconference […]" *(Source: ATLAS interview subdetector system participant 4)*

Code	Themes	Categories	Innovation Network Studied
Members	Diversity	Cognitive proximity	ATLAS Experiment

"[…] There are physicists that prefer to build the detector but they appreciate the data coming out and being analysed. They can understand and defend it, but they prefer to dedicate themselves to be involved with the upgrade. There are others that prefer computing, others that prefer data analysis. Well, all this is important. And although you have people from different areas of physics working together it is not a problem because you need this variety for the detector […]" *(Source: ATLAS interview subdetector system participant 1)*

"[…] There were very few fights or problems in the last 20 years...it's amazing. The people who have been cancelled in their project and they had to be reorganised, but this went smooth enough. Because people have a goal. This is just a tool, if you want, you don't care about the tool, and you just care about the goal. So you don't construct cathedrals, you want to arrive to the final...if you construct cathedrals, by now you construct a cathedral but you don't care as the cathedral is just a tool, but we are not attached to the cathedral, we are attached to the knowledge" *(Source: ATLAS interview technical coordinator)*

"[…] Our strength is the collaboration, so you have seen we have this huge network of 38 nations, including Brazil, and we have a network which is capable of many things… People are very focused in the knowledge. We have 159 institutions today, which are universities […] So if you have 176 of these guys that have knowledge inside the university, imagine what kind of network of knowledge you can put together […]" *(Source: ATLAS interview subdetector system participant 1)*

"[…] Work with an objective reality, one that can be detected, one that implies a specific risk or something that they may like more or less. But it's there. And I think this makes it easier to reach consensus at the beginning of the decision because the reality, if everyone presents everything, the conclusion is logical. In the majority of cases, everyone reaches the same conclusion […]" *(Source: ATLAS interview subdetector system participant 6)*

"[…] The underlying force is so strong, there is a common goal, which we discussed earlier. So it's finding the particles that we are looking for. That's really the key. If the focus weren't good enough, this would be a catastrophe. I mean it would be chaos. But because the research problem is so well defined, it unites [...]"*(Source: ATLAS interview resources coordinator)*

Code	Themes	Categories	Innovation Network Studied
Members	Diversity	Cognitive distance	ATLAS Experiment

"One thing that worried us was the physicist, because among the engineers we understood ourselves. But we found in common that we all liked to drink beer with an understandable English to communicate. We had a clear and common objective, which was to build the detector together. We knew that there would be conflicts, but we would solve it as they appeared. I have always had it clear that the physicists have to say what they want to, it is their obligation. And we have to do what they ask. I have always had this in mind when working with them. You have to delineate your territory with them. Besides, you have to know a bit about their world, about physics so you do not say stupid things, so you can communicate with them and they can understand you. You do this so you can be integrated and work together […] *(Source: ATLAS interview subdetector system participant 8 - engineer)*

"[…] The first time I was told about TileCal I thought it was something insane not only because of the size but because it was something never done before. We engineers need to know in advance how to do things. This is the mindset of engineers […] and I have learnt with physicists that ok it has never done before, so let's see what we can do […]" *(Source: ATLAS interview subdetector system participant 8 - engineer)*

"[…] An engineer needs to know that when you change the field you are working, the parameters are different, the necessities are different, but the methodology, the technique is the same. It is simply the way that you apply it. But this is difficult for an engineer to understand […]" *(Source: ATLAS interview subdetector system participant 8 - engineer)*

"Even tough some physicists would say the opposite I will tell you that to work together with engineers is not easy. There is no synergy, it is difficult […]" *(Source: ATLAS interview subdetector system participant 7)*

"I think that the engineers that work with us have a special character. I mean, an engineer that decides to not go to industry and to work in science has much more open spirits and he is open for suggestions. These engineers like not to do always the same things. So I would call them special engineers. […] Contrary to the past experiments, these big experiments like ATLAS or CMS are so complex from the technological point of view that the physicists cannot live without engineers. So we cannot design such an experiment without very, very good mechanics engineers, electronics engineers, software engineers. So there is need of creating a symbiosis between them because on one side the detector is very complex and needs engineers. On the other side, the physicists still need to drive together with them the choices. […] So engineers have sometimes almost an impossible job to absorb the requirements of the physicists. So the physicists and engineers need to work together. The other aspect where the engineers are very much needed for the integration, but also the physicists, is for example when each Institute is providing a piece of the puzzle at the end you need to ensure that all the pieces fit together. So the coordination and the organization of the project leaders for the different subdetectors or the technical coordination for the overall ATLAS detector assembly is a very critical point. And no one really dominates all the aspects of the detector; so again, it's true we spent quite some time in meetings. But it's really by having the experts of many different fields together that we can achieve progress. No one really dominates everything in such a big experiment" *(Source: ATLAS interview subdetector system project leader)*

"[…] Working with engineers sometimes can be bloody and painful […] They need to understand what you want and you need to be patient with them […]" *(Source: ATLAS interview subdetector system participant 3)*

Code	Themes	Categories	Innovation Network Studied
Members	Diversity	Organisational proximity	ATLAS Experiment

"[…] Differently from a company, ATLAS is better prepared to solve a problem because 12.000 people is willing to solve it. In a company this does not happen unless someone is told by the boss to do so. In ATLAS no one is told to fix something, People see in problems the opportunity to work. And I believe that this is a fantastic model […]" *(Source: ATLAS Experiment interview - Subdetector system participant 2)* "[…] ATLAS is formed by large groups based on Athenian democracy, where all physicist are equal […]" *(Source: ATLAS Experiment interview - Subdetector system participant 2)* "ATLAS management is highly connected to the stage of development of the experiment. We had a spokesperson oriented to the construction, now the spokesperson is from the work of pure physics as the experiment is about software. And it will change again on the stage of the upgrade […]" *(Source: ATLAS Experiment interview - Subdetector system participant 2)* "[…] One thing that worried us was the physicist, because among the engineers we understood ourselves. But we found in common that we all liked to drink beer with an understandable English to communicate. We had a clear and common objective, which was to build the detector together. We knew that there would be conflicts, but we would solve it as they appeared […]" *(Source: ATLAS interview subdetector system participant 8 - engineer)* "[…] Engineers and physicists we had the same objective, which was to build the detector. We were not worried with other things. I did not build it for me. I built it for others. I am happy that it works. I build it with the objectives and specifications of physicists. We may have different focus, but my main goal was the same as their, to design, to build and to make it work […]" *(Source: ATLAS interview subdetector system participant 8 - engineer)* "[…] ATLAS has worked because all its participants had it crystal clear that they would do anything necessary to make the experiment succeed, there is a great and common good will. […]" *(Source: ATLAS interview subdetector system participant 8 - engineer)* "In IFAE there is a kind of informal petit committee formed by three senior physicists with large experience in ATLAS and in physics, with very important positions in ATLAS and within our group, in which we always consult ourselves, irrespective of the meetings, about things in relation to our group, decision from ATLAS that will affect us directly, for instance to accept a certain management position or not. Besides, this petit committee we gather also in the weekly meetings of one hour and a half. They are executive in the sense that we follow an agenda where it is previously defined each subgroup will make a presentation updating on their activities, followed by discussions. So every week a group will be invited to make a presentation […] And then we have virtual meetings with the group that is currently developing research in ATLAS and the meetings that you do physically in CERN" *(Source: ATLAS interview subdetector system participant 1)* "The reason that everything works is that we have a common denominator, which is the detector. The detector is one and the same for all. I am responsible for one part of the detector, and that part work well, but if the part of someone else is not working properly then it will affect me as well… so, it is fundamental that each part works well and that

all parts together work well also […]” *(Source: ATLAS interview subdetector system participant 1)*

“[…] ATLAS is organised in groups that work together to do such kind of activities. […] This creates a collaborating culture […]” *(Source: ATLAS interview subdetector system participant 1)*

“[…] There are many meetings to discuss things. Sometimes discussions are infinite. Sometimes there are different groups proposing different ways to follow and then discussions become a bit tuff. So there are always meetings and discussions on how to develop activities. In ATLAS if five universities want to develop similar or the same activities in terms of physics, they will be obliged to sit down together and coordinate their work to speak as one unison voice. So this is done to avoid having “winner and losers”, but everyone collaborating together […]” (*Source: ATLAS interview subdetector system participant 2)*

“It is a usual technique that you’ve probably heard that we never make decisions, actually we do make all the decisions, but we do it in such a way that there is no decision made, so you work by consensus. You make sure that everybody at the end gives up or is convinced. One has to work in a certain way, but you never force anybody to go in a different way, being on the other side of the barrier. So if you find yourself in this situation, you enlarge the barrier in order to have always everybody inside. And you don’t force a decision when you see that there are people that do not agree, so you try to work more, to find reasons. If somebody does not agree, normally there is a good reason for it, so you better listen to him. I have learnt that the best way to collaborate with people who have different opinions is to bring them in, to force them in. Right now, for example, if I have a problem and I see there is a decision to be made and there is somebody that does not want or is very critical I create a task force and I put this person in the task force. Because then this guy knows he has to do something, he is obliged to be part of the solution process. When he is there, he cannot have an opinion that is 90 degree from everybody else because there will be no solution, and his mandate is to find a solution. In that way you build consensus but in a clever way, without breaking legs […]” *(Source: ATLAS interview technical coordinator)*

“[…] There were very few fights or problems in the last 20 years...it’s amazing. The people who have been cancelled in their project and they had to be reorganised, but this went smooth enough. Because people have a goal. This is just a tool, if you want, you don’t care about the tool, and you just care about the goal. So you don’t construct cathedrals, you want to arrive to the final...if you construct cathedrals, by now you construct a cathedral but you don’t care as the cathedral is just a tool, but we are not attached to the cathedral, we are attached to the knowledge” *(Source: ATLAS interview technical coordinator)*

“For example now when we have found the Higgs, it’s amazing because we kept our mouths shut for a while...for six months 3,000 people kept their mouths shut...I would have not believed…I thought that somebody would have gone around and say to somebody, “we have found the Higgs”, but even the people at CERN did not know that we had found the Higgs six months before… People were told “please behave” and 3000 people behaved. And this gives you a scale of the behaviour of this community. So they are really responsible, and they are not doing it to gain money, to gain power, but they are really doing it for the scientific reason. They did not say around that we found the Higgs, not because they wanted to be nice but in a way that if they said they found the Higgs they were exposing themselves to criticism if that was not true” *(Source: ATLAS interview technical coordinator)*

“[…] We are signing papers with 3000 names and we do not allow anybody to sign a piece of paper on his name. Nobody is allowed. Whatever you do you have to sign it with 3000 names, if not you will break this concept of collaboration […]”*(Source: ATLAS interview technical coordinator)*

“[…] How did we work? Well, in part, locally, we created groups that met weekly, reviewing all of our progress on the different components. Everyone listened to each other”

(Source: ATLAS interview subdetector system participant 6)

"[…] In CERN there are subgroups which are organised a bit differently. For example, there is a task force to decide on electronic issues. This group discusses questions with external specialists who supervise what's being done with TileCal on the electronics side. The head of electronics at ATLAS is there when an important decision has to be made. Now, in terms of ATLAS, there's an entire process. The technical coordinator is the person who can explain it best, but there is a design proposal for each important element. There's a letter of intent, which is a first draft of what that component is. It is then approved and presented to collaborators as well. Then there is the technical design report, explaining everything that has to be done in great detail. It also has to be approved at various levels. There is also a production review before entering into production. This review details the production process for scintillators in participating companies. I also took part in some visits to Russia, to see what firms were producing them, how they did it, who worked for them. But each step hast to be approved in the review" *(Source: ATLAS interview subdetector system participant 1)*

"Well, taking the TileCal example, there were two options when we began: the hadron or liquid argon calorimeter. There were two groups competing, that is, they had to demonstrate that their method worked sufficiently well for the experiment, that it could be built at a reasonable price. In the end we had to choose one type. We couldn't make both; it was one or the other. That was when tension arose because each group had worked a lot and they might be told to forget everything they had done thus far: "we're not going to continue with it, we'll use the other option and that's it" *(Source: ATLAS interview subdetector system participant 1)*

"[…] The aim is to build consensus based on the technical reality. In the end, this is something that makes it, I would say, easier for this to work. Physicists work with an objective reality, one that can be detected, one that implies a specific risk or something that they may like more or less. But it's there. And I think this makes it easier to reach consensus at the beginning of the decision because the reality, if everyone presents everything, the conclusion is logical. In the majority of cases, everyone reaches the same conclusion. There may be cases in which, due to the perception of risk, for example, if something is too risky as a solution because there is too much plotting, there can be different opinions, but most of the time I would say that we objectively reach a given conclusion naturally" *(Source: ATLAS interview subdetector system participant 6)*

"The cultures are very different. And we have really to create a mechanism of respecting everybody. It's a competitive environment where each institute has its own ideas, for example TileCal for the electronics or for the optics; the final choices were not there from the very beginning […] we chose different technologies and sometimes one Institute was the driving force from one option and another one was for another option and we basically, I mean the way it worked was that a mechanism of choosing different technologies based on results. So we go to the test beam, we have the Monte Carlo simulations, and it's based on the results on which you take decisions so. Of course we have stronger groups and we have richer institutes, but we try to take decisions based on performance and of course also based on costs. So it's an optimisation between cost and performance. This is a process that needs careful coordination and sharing of responsibilities among all the institutes. As I was saying, each one brings something. Even being poor or less powerful institutes, we tried, at least at the coordination level, to give room to each Institute to participate and be involved in the construction by bringing pieces of iron or pieces of electronics or pieces of optics and developing the mechanism that each Institute could bring their expertise and we have wonderful engineers, technicians from all over the world […]" *(Source: ATLAS interview subdetector system project leader)*

"I think one of my main role as project leader is to organize these structures so that it works. And also to create a mechanism of discussion because even between physicists we don't always agree on the strategy to follow. People may have different strategies… And to arrive to the chosen choice is a mechanism which involves data, simulation, discussion, compromises and usually if it's done properly once you make a decision the other institutes, which were choosing the other options, will respect your choice when it's well done… Yes, it may happen and it happened certainly in the past when for example the two experiments were merging in one and one institute may decide, okay this is not the choice I was striving and it may move to another part of the detector, but usually the institutes do not quit the experiment because their choice was not chosen…"

(Source: ATLAS interview subdetector system project leader)

"[…] Yes, it's true that sometimes a choice which is pushed by a very, very strong group may help because then it's clearer that this choice can be funded, can be constructed with money. A certain solution can be very, very good but if there is not a group or groups behind that to ensure its operation and maintenance, it will not work. You have to have groups behind that will either adopt a new solution or that are driving the solution, but… I try always as project leader to keep all the community doing good work. Using their complementary expertise, their different skills and trying also not to be big unbalanced. This at the end is a very competitive medium, and at the end people are competing. Sometimes, two or three groups may be doing similar analyses. First, it's important that we don't have bugs, that we didn't forget something, so it's competitive medium but it's a very healthy as well, that's also true. So you have to be careful that this competition does not turn into the wrong side…" *(Source: ATLAS interview subdetector system project leader)*

Code	Themes	Categories	Innovation Network Studied
Members	Conflict	Cognitive	ATLAS Experiment

"[...] When there are discussions about physics, there is a consensus to reach the best solution. If decisions are more political, for instance decide on a certain 3d technology that was being proposed by one group formed by the Germans against another formed by Italians and Spanish. Although they had more money, support, and internal persuasion, we had the support from ATLAS management because it was a newer technology. So it was a decision done with a helping hand from the management. It was not so democratic or reached through a consensus, but it was something better for the experiment […] the technical coordinator talked at backstage with people to support this technology […]" *(Source: ATLAS interview subdetector system participant 7)*

"[…] If somebody does not agree, normally there is a good reason for it, so you better listen to him. I have learnt that the best way to collaborate with people who have different opinions is to bring them in, to force them in. Right now, for example, if I have a problem and I see there is a decision to be made and there is somebody that does not want or is very critical I create a task force and I put this person in the task force. Because then this guy knows he has to do something, he is obliged to be part of the solution process. When he is there, he cannot have an opinion that is 90 degree from everybody else because there will be no solution, and his mandate is to find a solution. In that way you build consensus but in a clever way, without breaking legs […]" *(Source: ATLAS interview technical coordinator)*

Code	Themes	Categories	Innovation Network Studied
Members	Conflict	Affective	ATLAS Experiment

"In big experiments like ATLAS there are some confrontations between physicist because some people do this so they can be noticed. But we are mainly opened to criticisms and we solve our differences and go out for having dinner […]" *(Source: ATLAS Experiment interview - Subdetector system participant 2)*

"[…] In the field of HEP sometimes there is a war of egos […] sometimes there is a relation of power […] it is a world dominated by physicists, they are who manage it, the power of deciding. So when you start working with them you need to gain their confidence and show them that you are capable of doing what they are asking […] So you need to behave like them […] To avoid conflicts you need to behave, what and how to say things […] You need to put the other shoes otherwise you are doomed […]" *(Source: ATLAS interview subdetector system participant 8 - engineer)*

"[…] Our working environment was highly competitive with the Germans. We were doing tests together, but competition was so high that we were hiding the results from one another […] We had groups supporting us, but the coordinator of the collaboration board […] kept saying that there was no quorum for deciding. […] Then we got support for the technical coordinator to help make the decision and solve this disagreement […]" *(Source: ATLAS interview subdetector system participant 7)*

" […] Although there is a collaborative culture within ATLAS, there is also competition, of course always with white gloves, because students are competing for a place for conducting their postdocs. If you are known you increase your chances of getting the position […]" *(Source: ATLAS interview subdetector system participant 1)*

"[…] Of course, within groups is where conflicts are most evident at times. Different people compete for different resources, who has a post-doc student working with them, who has the money to do what. We can't do everything, so we have to limit things within groups. Then, when we get to the detector level, if there are too many groups, we also have to decide […]" *(Source: ATLAS interview subdetector system participant 6)*

Code	Themes	Categories	Innovation Network Studied
Members	Conflict	Administrative	ATLAS Experiment

“[…] For me it took a great amount of time to find an engineer to help me […] Here you have an engineer assigned for a kind support. He is not working in something specific or someone. So for me it is not good that he is helping me to solve something today that is not working but tomorrow he can’t continue because he is helping someone else […]” *(Source: ATLAS interview subdetector system participant 7)*

“When you disagree about a decision done by a coordinator typically is that you suffers and wait time goes by, he or she will be there in that position for two years. If you cannot wait or ignore you go a level above to see if there is anything that can be done… but this is violent and we are not used to have such behaviour. In physics we usually ignore that person […]” *(Source: ATLAS interview subdetector system participant 1)*

“[…] I believe that conflicts usually take place at group-level, where people are fighting for funding their research […]. It does not affect the collaboration because, for instance, United States has one voice, although their competing within their universities […]” *(Source: ATLAS interview subdetector system participant 1)*

Code	Themes	Categories	Innovation Network Studied
Coordination	Commanding	Standardisation of process	ATLAS Experiment

"Well, normally there are usually instructions on Wikipedia, which are instructions for users that work a bit like the first guide to them so that they know how these things are organised. There are also mailing lists that you use when you do not know what to do and want to make questions to others. In the mailing lists there are many people writing and collaborating so you expect someone to contact you and tell you what you must do. There are other tools that are a little more detailed, for example, there are tools to find the data grid and make lists from data, including how to download data and take it to your institute so you can process it there. There are many different types of tools. In ATLAS there is a structure, an internal organisation of things, you have meetings, and this at first is quite complicated to learn because there are rules, in the sense that if you want to analyse data, you can take the data as you want and do whatever you want, you have to follow some rules and instructions. It is very bureaucratic in a way because, for example, when writing a paper, which ultimately is a product of physics and that is important as a result of our collaboration, you have to follow some scrupulous rules about how you have to do analysis, how you have to write the paper, the phases of approval and then preparing the manuscript to send to the magazine, is all well documented but also very complicated [...] (*Source: ATLAS interview subdetector system participant 4)* "Well, the first pressure it creates at the present is that it's extremely difficult to conciliate the time that physicists spend to do physics and the time that physicists spend to maintain and operate the detector. And this is a big difficulty. And it's difficult also to pass this message to the Institutes, because although the Institutes have to keep part of the manpower, keeping the detector running correctly, they want to be very visible in the physics analysis they are doing. And this is a difficult process because the physicists cannot have good data for good results if the detector isn't running well, so they need to do service work. So, for example, ATLAS has a tool which is called OTP, […] this is a monitoring tool where each service task to operate and maintain the detector for physics correctly, defined by the project leaders and the technical coordination, is stated. We enter into this tool the percentage of the time that each member of the community has spent in this task or on that task, and at the end ATLAS retrieves all this information and theoretically, in principle, if everyone makes a good share of the service task, they should spend at least 30% of the time in helping operating the detail. You can be a software task; it can be a hardware task and so on. And then ATLAS collects all this information and twice per year there it is a report that all the founding agencies showing if the Institute is above or below the so-called quota that they should provide to the collaboration. All these reports are available; everyone can consult them, with names, with the tasks. So OTP is a tool which monitors the performance in terms of tasks, but also put some pressure in some institutes which are very much below the quota that they should provide in terms of technical help for two to three consecutive years. Never in ATLAS has anyone been put in the situation where they do not become authors or were not allowed on signing papers. But, I mean, this is a way of pressure. Frequently we had Institutes coming saying, "what can I help you more?" Because the report is in red. Another tool that ATLAS has put in place that helps the technical work to be done is the qualification task. A person coming to ATLAS becomes an author after passing a so-called qualification. And qualification means that during one year for 50% of the time that person has to a certain task. These tasks are technical activities defined by the project leaders, by the activity coordinators. And after this one year the person becomes an author, and they start signing the papers. So this is, for example, another tool that ATLAS has, CMS has the same, to help the collaboration to fulfil the tasks that are less fun during data taking period. So at the end these results, people have to work in a very, very organised way, if not entropy is there to destroy it" *(Source: ATLAS interview subdetector system project leader)*

Code	Themes	Categories	Innovation Network Studied
Coordination	Enabling	Boundary object	ATLAS Experiment

"We use Monte Carlo simulation for predicting the mass of Higgs since it cannot be directly. It is also used to build the TileCal, before building it you make a simulation to make a decision what will be the best configuration also in terms of cost. In our case, when you make analysis of data, you use Monte Carlo as well to get number from the theory. Nowadays in all scientific fields where you have physics involved, you will find them using Monte Carlo simulation […]" *(Source: ATLAS Experiment interview - Subdetector system participant 2)* "[…] The Monte Carlo simulation also helped. Because in experiments like ATLAS sometimes you have only one single shot. You have to do it from the engineering side and from the physics side with prototypes and tests. The simulation is fundamental when you are working on something never done before. If you cannot simulate, you cannot see if you are going in the right direction. You cannot test all the parts of the detector because it is not viable, but you can get a good representative sample and from there simulate it. And with the simulation you have a clear idea where to go, points to take into consideration and care, what were strengths and weaknesses […] The simulation is a useful tool to link different, independent or isolated parts of knowledge into a common view that would not be possible otherwise. It allows the integration of knowledge from different interrelated physicists without having to know all the expertise of others… And later on, thanks to the data we gathered from simulations, it was possible to see how the detector would function, the research lines to follow to find Higgs, etc." *(Source: ATLAS interview subdetector system participant 8 - engineer)* "One thing that worried us was the physicist, because among the engineers we understood ourselves. But we found in common that we all liked to drink beer with an understandable English to communicate. We had a clear and common objective, which was to build the detector together. We knew that there would be conflicts, but we would solve it as they appeared. I have always had it clear that the physicists have to say what they want to, it is their obligation. And we have to do what they ask. I have always had this in mind when working with them. You have to delineate your territory with them. Besides, you have to know a bit about their world, about physics so you do not say stupid things, so you can communicate with them and they can understand you. You do this so you can be integrated and work together […] *(Source: ATLAS interview subdetector system participant 8 - engineer)* "[…] When you start a big experiment like ATLAS, when you are building a detector you need to measure certain properties of parts of the detector and to assemble it afterward. You need measures to make simulations to predict and adjust the detector. […] So the Monte Carlo simulation is a tool that allows you to have a plot that you then discuss with other people. When everyone s working to get this plot, people need to work together, to collaborate, to exchange ideas in a certain way, to verify and share the results […]" *(Source: ATLAS interview subdetector system participant 7)* "Well, simulation is important because when you have such a complicated thing as ATLAS experiment, you have to do an estimative or understand what one can expect of a measure that you get from the experiment. Monte Carlo is so important because the type of structure is so complex that it not possible to do a estimation on a piece of paper, to have an idea of what will happen is necessary to do it with Monte Carlo. Then for physics analysis Monte Carlo is almost always necessary because when one wants to compare what you see with what is expected, the expected part is almost always predicted with Monte Carlo. We physicists prefer to get our explanation of the data itself, but sometimes it's not possible. Then you have to use the Monte Carlo simulation to know that we can wait from what you have observed. When for example the experiment was questioned, even now when there are studies being made for the upgrade of the experiment, you always do it through the simulation to know a little more how it will work, what are its possible characteristics and which are also the limits of a solution rather than another. So the simulation concentrates the knowledge on physics and of the experiment, so that people who do not know the experiment in depth can use simulation Monte Carlo. This simulation is used in almost every aspect of the experiment […]"

(Source: ATLAS interview subdetector system participant 4)

"The reason that everything works is that we have a common denominator, which is the detector. The detector is one and the same for all. I am responsible for one part of the detector, and that part work well, but if the part of someone else is not working properly then it will affect me as well… so, it is fundamental that each part works well and that all parts together work well also […]" *(Source: ATLAS interview subdetector system participant 1)*

"[…] We have the Monte Carlo simulations, and it's based on the results on which you take decisions so […] We use the test beam results and the Monte Carlo tuned in the test beams for years, for years. And so the comparisons between the first LHC data and the Monte Carlo data projections were amazingly good for ATLAS and CMS because we had no data for many years, LHC was delayed and physicists really tuned very, very well the Monte Carlo test beams. This was extremely important. Monte Carlo is a crucial tool used in comparison with the different theoretical models and so on. So the Monte Carlo is crucial yes." *(Source: ATLAS interview subdetector system project leader)*

"[…] I think it's very important that the choices are made on objective arguments. If the arguments which lead to a choice is not well explained or it is not very clear to the community, then it's very difficult to not create a big crisis. Once these arguments are well explained (and for example the Monte Carlo simulation is very important) because we trust the simulation based on the results we had with the test beams we can then trust how they would behave in LHC even years before having data. Monte Carlo is an extremely important tool to help us in decisions, so we're not deciding blindly […]" *(Source: ATLAS interview subdetector system project leader)*

"[…] What is driving us and keeping us motivated is the LHC machine, since it started to be built. We are acquiring enormous amounts of data with very successful results, physics results, as you know. But to keep the detector working properly […]" *(Source: ATLAS interview subdetector system project leader)*

Code	Themes	Categories	Innovation Network Studied
Coordination	Enabling	Mediator	ATLAS Experiment

"There are conversations that are not constructive. That happened to me many times, I came to a meeting, present some results and I got some comments that were totally negative. What I usually do is go for a coffee with someone senior (in my case is the project leader) and tell her what happened. Well, in this particular case she told me to not pay attention to that guy because he was rude and there is nothing else to do. So, I took a deep breath, revised some of my results so this guy could be satisfied, I sent it to him, approval was given and there was no more problem. Besides, there are also other types of situation that you go for her for mediation. When someone is not doing his or her job. You talk to the person but still there is no solution… Then you talk to her [the project leader] and explain to her the situation. So she tries to talk to the institute, with the person, she tries to understand the situation" *(Source: ATLAS interview subdetector system participant 5)*

"The discussions sometimes can be more animated than others… And not always the coordinators agree among themselves. And again, I am there to moderate and, at the end, to conclude. Usually, it works okay. But it doesn't mean that it's always 100% consensus. But if the arguments are put together in the most possible objective way, usually it goes through, even if some people may not very, very happy. " *(Source: ATLAS interview subdetector system project leader)*