KNOWLEDGE PROCESSES IN NETWORKS AIMED AT INNOVATION

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ABSTRACT

Although there is a growing body of literature on the link between innovation and knowledge processes little is known about the dynamics of this relationship within complex organizational networks. In this paper, we first present an overview of the current literature on the knowledge - innovation link. We also present the results of an in-depth case study within a network of European advanced technology companies. The network was set up among 40 partners, including aerospace manufacturers, airline operators, maintenance providers, research institutes and universities. The network is strongly geographically distributed across the whole of Europe and is complex due to the high levels of diversity among its members in terms of background, culture and interests. The network aims for innovation and knowledge sharing and cooperation present significant challenges. Data were gathered using different methods. Interviews were held with strand leaders and other project officers and an online survey was administered among the members of the network. The survey focused on the needs and preferences of different members in the network with regard to preferences in modes for collaboration and knowledge exchange. Our results provide a detailed description of an actual network of companies that aim for innovation. In order to optimize innovation processes we conclude that it is important to know when to depend on tacit knowledge or when more explicit knowledge may suffice. Specific management strategies for hub firms within network structures are also needed as these play a pivotal role for the innovation process. More research is needed in this area, especially with regard to the management of knowledge mobility, innovation appropriability and network stability.

1 INTRODUCTION

Despite the large and diverse body of literature in the area of the management of innovation, effectively managing organizational knowledge provides numerous challenges for companies. The creation of new knowledge is not only the result of actions of creative employees but also the outcome of the knowledge processes among various actors in innovation systems, such as producers, suppliers, public authorities, and scientific institutions (David and Foray 1995) The development of network theory and network models of innovation have contributed to the current understanding of the relevance of both internal and external networks within for the process of innovation (Dhanaraj and Parkhe 2006; Parkhe, Wasserman et al. 2006).

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Knowledge-intensive firms especially can no longer afford to rely entirely on their own ideas and competences to advance their business. Chesbrough (2003) argues that the process of innovation has shifted from closed internal firm systems to open systems. Such systems involve numerous actors in the value chain of new products and services. Critics may argue that the concept of 'open innovation' is not new (Nonaka and Takeuchi 1995; Trott 2005) but it fits well with the current emphasis on the knowledge-based economy and the availability of cheap tools that enable information flows between numerous actors in the innovation system. As a consequence, many organizations get involved in different kinds of knowledge networks, in order to remain innovative, competitive and efficient.

The purpose of this study was to provide a deeper understanding of the possibilities to optimize networks of companies for innovation and to bridge the gap between the general prescriptions of knowledge management literature with actual initiatives formed in practice. In this paper we present an in-depth case study that provides empirical insights into how a network of companies that are currently involved in a joint project could be transformed into an effective system of innovation. Important questions for further research are how such a network should be structured, facilitated and assimilated into organizational knowledge management strategies. The case study closely documents the European HILAS project, as it began its knowledge management journey. After this introduction, the theoretical foundations of this study are presented. The subsequent sections present the methodological details and the case description; the final section presents a discussion and the implications of the case and conclusions.

2 INNOVATION PROCESSES

Innovation relates to new products and services, production methods and procedures, production technologies, and to administrative changes. It is often defined as the development and implementation of an idea, which is new and useful for the company (Amabile, Conti et al. 1996). Innovation is 'a process of turning opportunity into new ideas and of putting these into widely used practice' (Tidd, Bessant et al. 2005). In this paper, we regard innovation as a process that can be influenced by management practices, even though this process is extremely complex and uncertain. Innovation includes the development and diffusion of products, processes or systems. Another characteristic of the innovation process is the degree of innovation; i.e. incremental versus radical innovation. Innovation processes have grown from first generation linear models to fourth generation interactive models (Berkhout, Hartmann et al. 2006). In the fourth-generation models, innovation can be characterized by (1) partnerships and networks, (2) interactions between science and business, (3) the involvement of both market and scientific knowledge, (4) the need for managing networks (5) entrepreneurship.

As stated, current innovation processes involve networks of organizations, rather than single organizations. Organizations are increasingly dependent on external collaborations for innovations, because they can no longer afford to rely entirely on their own ideas and competences to advance their business, nor can they restrict their innovations to a single path to market (Chesbrough 2003). Therefore, organizations are increasingly involved in complex networks, which are often multidisciplinary and international. Innovation is a

more distributed process that takes place within a wide range of groups and inside as well as outside of the organization (Swan, Newell et al. 1999; Hislop 2003).

Current literature shows that networks are efficient mechanisms for learning and innovation due to the possible heterogeneity across firms (Gilsing and Nooteboom 2005). Dyer and Nobeoka (2000) argue that a network can be more effective than an organization at the generation, transfer and recombination of knowledge. Access to heterogeneous sources of knowledge is considered a key driving force for the construction of new innovation networks. This implies that managing access to knowledge plays an important role in the innovation processes. In the next section, we focus on knowledge processes

3 KNOWLEDGE PROCESSES AND INNOVATION

3.1 Managing the flow of knowledge

Knowledge intensive organizations are increasingly dependent on transferring and sharing knowledge, experiences, and insights among employees. Two ways to do so can be found in the literature, i.e. codification and personalization (Hansen, Nohria et al. 1999). The first approach leans heavily on knowledge systems and procedures to store and exchange documents. The second approach relies more on interpersonal exchange of knowledge and highlights the role of knowledge intermediaries and knowledge sharing networks such as 'communities of practice'. Both approaches can be considered elements in a knowledge-based perspective on firms which highlight the organizational routines and experiences on which individuals draw to perform optimally and use the creative potential of human action (Tsoukas 2002).

Research suggests that in order to be innovative organizations should focus much more on informal knowledge sharing and informal ways of working (Brown and Duguid 2000). In this personalized knowledge management strategy, the focus is on the exchange of tacit knowledge and on interpersonal knowledge sharing through personal contacts, master-apprenticeship relations, meetings and communities of practice (Verburg and Andriessen 2006). For the transfer of skills, competencies and insights, it is important to have social networks with other people (Wenger, McDermott et al. 2002). These social networks often consist of colleagues, competitors and other experts from different units of the same or another organization. The communication within these social networks is face-to-face or mediated by information and communication technologies (ICTs). The use of ICTs is most prominent when members of the network are geographically dispersed.

Here, we focus on the importance of knowledge processes for innovation, in particular, how knowledge processes may influence innovation processes even when firms increasingly use external networks to enhance innovation. We define knowledge management as the process of systematic organizing and managing knowledge processes, such as identifying knowledge gaps, acquiring and developing knowledge, storing, distributing and sharing knowledge and applying knowledge (Andriessen 2006). The management of knowledge processes has become crucial in improving the performance of organizations, which can either be aimed at more efficiency or more innovations. Knowledge provides the basis for improvements and innovation in organizations (Kakabadse, Kouzmin et al. 2001).

3.2 The innovation process and knowledge as a resource

The literature on innovation processes describes the innovation process as a dynamic, non-linear process. A number of different process models have set knowledge at the basis of innovation (Johannessen, Olsen et al. 1999; Fischer 2001; Tidd, Bessant et al. 2005). Knowledge is regarded as a resource within the innovation process. However, no distinctions between tacit and explicit knowledge are implied in these models and knowledge is regarded as a static aspect rather than a collection of different knowledge processes. We will demonstrate this with a few examples of innovation process models from the current literature. Tidd, Bessant and Pavitt (2005) developed an innovation process model (see Figure 1), with the core set of innovation activities distributed over time. Knowledge is mentioned here in the implementation phase, where the authors elaborate on acquiring knowledge resources to enable the innovation process. Examples of these knowledge resources are R&D, market research and technology transfer. Knowledge is also addressed in the learning phase where learning implies the build up of d a knowledge base (resource) in order to improve the innovation process.

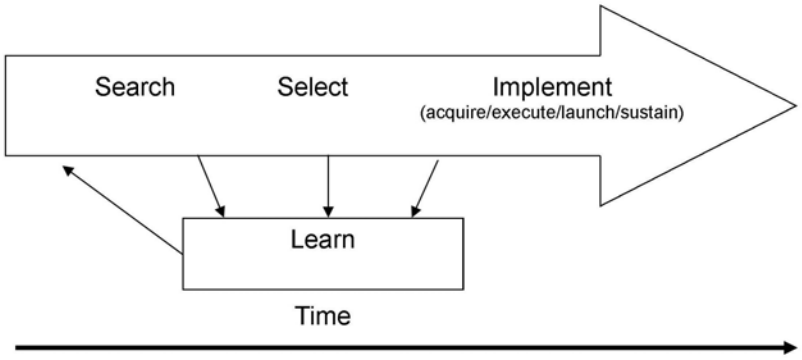

Figure 4: Innovation process model (adapted from Tidd, Bessant & Pavitt, 2005)

Another example is Fischer's (2001) interactive innovation process model.. He highlights a system of innovation that comprises 'a set of actors such as firms, other organizations, and institutions that interact in the generation, diffusion and use of new – and economically useful – knowledge in the production process' (Fischer 2001). Knowledge is also regarded as a resource in this model. Through interaction and feedback loops the author assumes that different pieces of knowledge o will be combined in new ways and that new knowledge is created. In the model by Johannessen, Olsen and Olaisen (1999) innovation is stimulated by a strategic knowledge management and other moderators such as the building of networks. Knowledge management is regarded as one of the moderators of innovation, however, it is not clear how knowledge should be managed in order to promote innovation.

In summary, knowledge is often regarded as a static component or resource in current models of innovation. However, current knowledge management theory assumes a process model in terms of sharing, storing, developing, evaluating, and using knowledge (Jashapara, 2004). Therefore, we propose to analyze innovation processes in relation to knowledge processes rather than to regard knowledge as a single resource within the innovation processes. .

3.3 Innovation processes and knowledge processes

There is not much research to date that empirically links innovation processes to knowledge processes. Knowledge creation is one of the knowledge processes that may support innovation processes. Knowledge creation is perceived as one of the major assets of innovative organizations, and innovative organizations are defined by knowledge creation (Merx-Chermin and Nijhof 2005). Jashapara (2004) combines the management of innovation processes with knowledge processes in a conceptual model (see Figure 5).

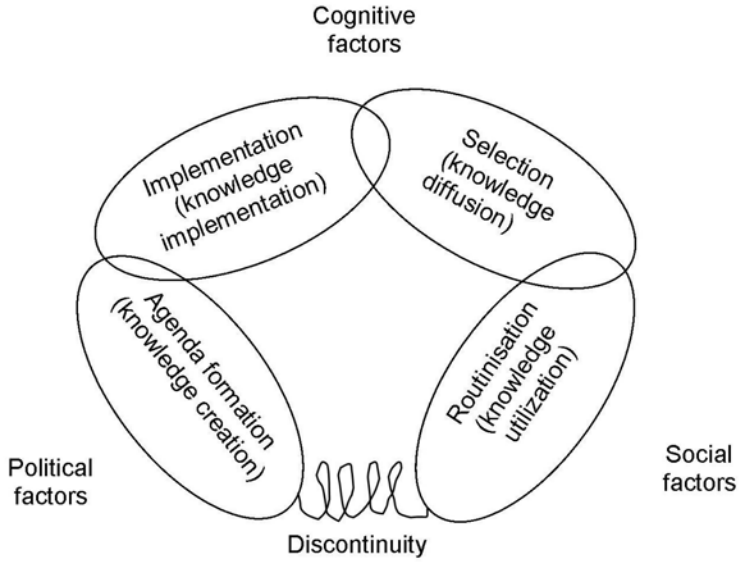

Figure 5: Episodes in the innovation process (adapted from Jashapara, 2004)

Jashapara distinguishes the following innovation processes: agenda formation, implementation, selection and routinization and links these innovation processes respectively with knowledge creation, knowledge implementation, knowledge diffusion and knowledge utilization. He does not elaborate on the interaction of these innovation processes and knowledge processes but argues that tacit knowledge is more important in the first stage of knowledge creation and agenda formation. Explicit knowledge is said to be more useful in the final stages of knowledge utilization and routinization. This may be expained by the fact that the final stage parallels the codification strategy where knowledge codification, storage and retrieval mechanisms are developed (Jashapara 2004). Others argue that tacit knowledge is more important for innovation than explicit knowledge (Senker 1993; Swan, Newell et al. 1999). According to Senker (1993) the complexity of systems is the most common reason for the importance of tacit knowledge for innovation. The management of tacit knowledge requires processes of personal interaction. Therefore socialization strategies (Nonaka and Takeuchi 1995) and personalization strategies (Hansen, Nohria et al. 1999) should be used to optimize knowledge processes and consequently innovation processes.

As said, the number of empirical studies on the knowledge-innovation link is limited. A notable exception is the work by Darroch (2005). She empirically examines the link between three knowledge management processes and innovation and argues that firms with capabilities in the area of knowledge acquisition, dissemination and responsiveness are

generally more innovative than firms without such capabilities. Organizations that develop incremental innovations tend to show more developed knowledge management behaviors and practices than firms that are not involved with such innovations. Darroch shows that, what is done with the knowledge is equally important to just having the knowledge in order to be innovative. Another empirical study addresses the relation between the knowledge reuse process and innovation (Majchrzak, Cooper et al. 2004). The research shows that the process of knowledge reuse is related to the innovation process. Therefore this perspective is too narrow to draw conclusions on the relation between knowledge processes and innovation process in general. Although the number of empirical studies is limited, we may conclude that knowledge processes influence innovation processes. In order to optimize knowledge processes, we need more insights in the relation between knowledge processes and innovation processes. This is especially vital in the case of the growing number of complex organizational networks. The next section will present the theory with regard to networks.

4 NETWORKS

There are different theories in the area of networks. Within the (knowledge) management literature, the social network theory is often addressed. This theory highlights networks as social structures. According to Borgatti and Foster (2003) there is a shift in social network research, beginning in the second half of the 20th century, away from individualist, essentialist and atomistic explanations toward more relational, contextual and systemic understandings. In this paper, we focus on inter-organizational networks with a variety of actors (see for examples: (Fischer 2001; Cappellin 2004; Berkhout, Hartmann et al. 2006). Before focusing on the role of knowledge and innovation within networks, we will elaborate on the definitions and typologies of these social networks.

4.1 Social networks

Borgatti and Foster (2003) provide an overview of network theories in organizational research. They define a network as; 'a set of actors connected by a set of ties. The actors (often called "nodes") can be persons, teams, organizations, concepts, etc.' (Borgatti and Foster 2003). The authors elaborate on the network concept from the following perspectives; social capital, embeddedness, network organizations, board interlocks, joint ventures and inter-firm alliances, knowledge management, social cognition, and a catch-all category "group processes."

In their current review of network concepts Parkhe, Wasserman and Ralston (2006) come up with two typologies to contextualize network research. The authors stress the need to place network research in a broader context, temporally and topically (see Table 1). Temporal contextualization uses the time dimension as an organizing principle, from birth to growth to maturity to death. Topical contextualization focuses on central topics of interest to managers and researchers along various phases of a network's life cycle.

Table 1: Two typologies of networks: temporal and topical (adapted from Parkhe, Wasserman & Ralston, 2006)

Temporal:	Antecedents →	Management →	Evolution →	Dissolution
Topical:	Motives →	Member selection/ characteristics →	Control/ conflict →	Stability/ performance

Another overview is offered by Brass, Galaskiewicz, Greve and Tsai (2004) who argue that the research in networks is dominated by research on the characteristics of social relationships. A network is defined as 'a set of nodes and the set of ties representing some relationship, or lack of relationship, between the nodes. We refer to the nodes as actors (individuals, work units, or organizations)' (Brass, Galaskiewicz et al. 2004). The authors divide network research in three levels; interpersonal, inter-unit, and inter-organizational levels of analysis. We are particularly interested in the inter-organizational level. Examples of inter-organizational cooperation include joint ventures, strategic alliances, joint programming, collaborations, business groups, consortia, relational contracts, and some forms of franchising and outsourcing. Early research on inter-organizational level studies focused on motives behind cooperation but later research has focused on the conditions facilitating cooperation, such as learning, trust, norms, equity, and context. Four consequences of inter-organizational networks are distinguished: imitation, innovation, firm survival and performance. With regard to inter-organizational networks aimed at innovation, there are some debates about whether networks should have strong ties (closure) or weak ties (structural holes). The tension between the knowledge diversity offered by structural holes and the trust offered by cohesion can also be resolved through embedding networks in structures that generate trust (Brass, Galaskiewicz et al. 2004).

4.2 Innovation networks and Knowledge networks

A systematic review of networks and innovation is offered by Pittaway, Robertson, Munir, Denyer and Neely (2004). The definition of networks used here is 'a firm's set of relationships with other organizations' (Pittaway, Robertson et al. 2004). In their view, networking can have a positive impact on innovation in all organizational contexts, but empirical research has not yet demonstrated how a network should be configured in order to be innovative. The diversity of partners depends on the type of innovation, incremental or radical. For example complex and radical innovation processes benefit from a wide range of partners such as universities whereas incremental innovations rely on their customers as partners in their network.

Knowledge networks are 'a number of people, resources and relationships among them, who are assembled in order to accumulate and use knowledge primarily by means of knowledge creation and transfer processes, for the purpose of creating value' (Seufert, Krogh et al. 1999). There are different typologies of knowledge networks. For example Buchel and Raub (2002) identified four types of knowledge networks along two dimensions: networks that primarily focus on individual benefits vs. those that focus on organizational benefits; and networks that are self-managed vs. those that are supported by managers. Carlsson (2003) distinguishes three types of knowledge networks: extra-networks, inter-networks and open networks. This typology is based on the possibility for an organization to design and govern a network (designed and governed by the firm vs. not designed and governed by the firm) as well as the openness of a network (open vs. closed networks). Another typology comes from Seufert, Krogh and Bach (1999) who divide knowledge networks into intentional and emergent networks. Intentional knowledge networks are regarded as networks that are created from scratch, whereas emergent knowledge networks already exist but have to be cultivated in order to become innovative. A currently well known definition of a knowledge network is the concept Communities of Practice (CoPs), which groups of people who share a concern, a set of problems, or a

passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis (Wenger, McDermott et al. 2002).

5 KNOWLEDGE PROCESSES WITHIN NETWORKS

Knowledge processes in networks of multiple organizations are complicated. This complexity may be due to the differences in characteristics of the individual organizations, such as differences in organizational strategies, structures, ICT-systems, cultures and the diversity of knowledge, language and jargon. We will first focus on the complexity of networks due to the strength of ties within the network Secondly, we will elaborate on the complexity of managing networks as the optimization of knowledge processes and innovation processes within networks is primarily a management issue.

According to Granovetter (1983) the strength of ties within the network influences the capability of organizations to innovate. We define tie strength as the strength of a relationship within a network, which can be either weak or strong. The strength of an inter-organizational relationship is based on three variables (Capaldo 2007);

1. The relationship's overall duration;
2. The frequency of collaboration, and
3. The intensity of collaboration.

The longer the relationship lasts and the higher the frequency and intensity of collaboration, the stronger the relationship. In literature it is debatable whether a tie should be weak or strong. Burt (2007) argues that weak ties speed up innovation. An organization should maximize the amount of weak ties, in particular the proportion of bridges in the network. Bridges are the links between weak ties. Burt argues that bridges speed up innovation by connecting heterogeneous organizations within networks. Contrasting to Burt's theory on the strength of weak ties, other theories claim the strength of strong ties. Networks based on weak ties facilitate the search for less complex knowledge, while strong tie networks enable the transfer of complex personalized knowledge (Hansen, Nohria et al. 1999; Dyer and Nobeoka 2000). In order to overcome these opposite views in the optimal tie strength for innovation, Capaldo (2007) argues that both weak ties and strong ties are needed. Both kind of ties need to be managed in order to enable the successful transfer of knowledge.

Capaldo (2007) discusses the lead firms theory, which is based on the idea that organizations play a 'strategic center' role within inter-organizational networks. These lead firms require certain 'relational capabilities' to sustain the innovativeness of the network by managing the structure of the network over time. The theory of lead firms links with the hub firm theory by Dhanaraj and Parkhe (2006). A hub firm is an organization that has prominence and power and uses these to perform a leadership role in pulling together the dispersed resources and capabilities of network members and has central position in the network structure (Dhanaraj and Parkhe 2006). The management of the structure of networks is related to the concept of network orchestration, which can be described as the set of actions undertaken by the hub firm within the network. According to Dhanaraj and Parkhe (2006) the orchestration of a network is more than the management of the structure of the network; the knowledge mobility, the innovation appropriability and the network stability need to be managed (see Figure 3).

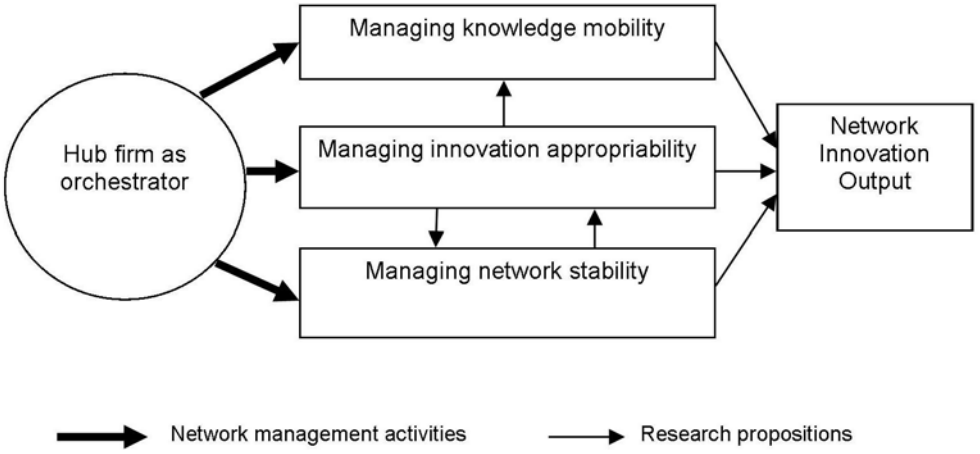

Figure 6: A framework for orchestration in innovation networks (adapted from Dhanaraj & Parkhe, 2006)

We will focus on the management of knowledge mobility first, because this is related to the core of this paper: Knowledge mobility is the ease with which knowledge is shared, acquired and deployed within the network. A hub firm should manage the transfer of knowledge to the points in the network where it is needed (Gulati and Gargiulo 1999). A hub firm should focus on three specific processes: knowledge absorption, network identification, and. inter-organizational socialization. Knowledge absorption is the ability to identify, assimilate and exploit knowledge from the environment. Network identification is creating a common identity to motivate members to participate and openly share valuable knowledge (Dyer and Nobeoka 2000). Inter-organizational socialization is the creation of formal and informal linkages among network members by formal and informal communication channels within and outside immediate organizational tasks(Nonaka and Takeuchi 1995; Brown and Duguid 2000),. Dhanaraj and Parkhe (2006) propose that the innovation output of the network will be greater the higher the level of knowledge mobility orchestrated by the hub firm. How hub firms orchestrate the knowledge mobility within networks needs further research.

The management of innovation appropriability is the ability of an innovator to capture the profits generated by an innovation. The hub firm should manage the knowledge development activities of the network members and prevent free riding problems. Free riding occurs when a member in the network is opportunistic by stealing ideas of other actors within the network. The management of innovation appropriability involves the management of three processes: building trust, procedural justice and joint asset ownership.

The management of network stability is for example preventing isolation and migration to other networks. The hub firm should enhance reputation by linking market leaders, by developing common strategies for future cooperation and by promoting 'multiplexity'. Network 'multiplexity' can be described as two or more types of relationships occurring together to reinforce the ties among the members of the network.

From a managerial point of view of it would be interesting to learn what network structure needs to be managed? In other words, what is the ideal structure of a network in terms of strong or weak ties or a combination? According to Capaldo (2007) a combination of both is ideal; the dual network structure. This is a network with a small core of strong ties, integrated with a larger periphery of weak ties. These two parts have to be managed in different ways. The management strategies for dual network structures need further research (Capaldo 2007). In the next sections we present the results of an in-depth case study within a network of European advanced technology companies. We will highlight the nature of this network, the preferences of its members and we explore the possibilities for innovation in terms of knowledge mobility, innovation appropriability, and network stability.

6 METHODOLOGY

The context of our research is a European 6th Framework project aimed at innovation, HILAS. HILAS stands for Human Integration into the Lifecycle of the Aviation System (McDonald, 2004). The life span of the project is four years and started in June 2005. The main project goal is to integrate knowledge within the lifecycle of the aviation system. Integration of knowledge is a process that should not be limited to the life span of the project as this integration is a long-term on-going process. Therefore knowledge processes within the project need to be optimized for the long term. We are developing a long term strategy and study how this project can further evolve into a sustained network for innovation.

The overall goal of the on-going HILAS project study is to discover and explore insights into the conditions to enable the network to become a system of innovation. Of particular interest here is how the organizations in the network used knowledge management to enhance innovation. We used an interpretive case study method as described by Klein and Myers (1999) to analyze the network of companies within the HILAS project. Data was collected from a variety of sources, such as the systematic use of semi-structured interviews with various employees on the project, including HR officers. So far, over 20 interviews were conducted over a period of 3 months. As interviews were conducted, field notes were taken, particularly highlighting contradictions or reinforcements of particular observations made during the course of the investigation. Other sources of data were utilized to triangulate and confirm the data obtained from the interviews. These include organizational documentation such as organizational documents, web pages, slides of presentations, direct observations, and more specific documents such as minutes and notes of meetings. The analysis was exploratory in focus, and involved multiple readings of the collected data.

We also distributed a survey among all the members of the network, consisting of 40 organizations divided across 10 countries mainly within Europe. The survey was sent to 144 members of the network. The total of useful responses is 72, which is a response rate of 50%. One of the goals of the survey was to get insight in the needs and preferences of the different partners for future collaboration in the area of the management of human factors knowledge. There are many different possibilities to design longer term cooperation between the members of the project. Therefore, we presented three scenarios for future cooperation and asked questions about the preferred openness, geographical scope and the

purpose of a future network. This information aims to help create a sustained network for innovation even after the project period.

7 RESULTS

HILAS is a complex project, comprised of a wide range of partners, including aerospace manufacturers, airline operators, maintenance providers, research institutes and universities. Not only does the HILAS consortium represent diverse research and development interests but the partners are geographically distributed across Europe and beyond. Consequently, knowledge sharing and cooperation represents a significant challenge for the HILAS project. There is a considerable need for the development of robust mechanisms for communication, the facilitation of information and knowledge sharing, the transfer of best practices, and the stimulation of innovation more generally.

The HILAS project aims to capture, explain and explore Human Factors knowledge and activities throughout the lifecycle of European civil aviation systems, including specifically design, operation, and maintenance. How to share, disseminate, and better integrate Human Factors knowledge in a broad sense (including, for example, ergonomic design, human-machine interaction, performance monitoring, and error management), across the firms in the network is the crucial challenge. The project is organized around four strands of research: Flight Deck Technologies, Flight Operations, Maintenance, and Knowledge Integration. The project is organized to develop the Flight Deck Technologies, Flight Operations and Maintenance Strands independently and to unify them in the Knowledge Integration Strand. Activities relevant to design are being pursued in the Flight Deck Technologies strand, where human factors tools relating particularly to pilot evaluation of novel flight deck technologies are themselves evaluated in a collaborative flight simulator study. The Flight Operations Strand focuses on improving airline processes without compromising safety and aims to develop an enhanced performance monitoring tool. The Maintenance Strand emphasizes the development of an integrated maintenance management system. The activities of the Knowledge Integration Strand are aimed at addressing the knowledge sharing and communication needs of the HILAS consortium. Many mechanisms have been put in place to aid effective communication and knowledge sharing, including a web-based content management system, as well as other people-oriented mechanisms, such as regular meetings, workshops and networking events.

The analysis shows that during the first one and a half year of the project (June 2005 – December 2006) all strands have been working separately and are in the process of developing their own concepts and designing separate tools. The aim of the project management is to stimulate cooperation across the strands and to integrate the tools. Consequently, knowledge sharing and cooperation represents a significant challenge for the project.

The survey sheds light on the role of Knowledge Management in the process. The total of 72 respondents took part. They are distributed over airline operators (6), manufacturers (17), maintenance (2), universities (23) and other research institutes (24). Respondents are primarily from relatively large organizations with small human factor departments. More than half of the respondents work in organizations with more than 500 employees (55%), of which 42% are working in organizations with more than 1000 employees. A total of 14% of

the respondents are working in organizations with 500-1000 employees. Almost half of the organizations employ more than four nationalities and 30% report to employ people from one nationality only. There are hardly any differences in representation of nationalities in academic and industrial sectors.

Respondents report different levels of involvement in the project. A total of 58% reports to spend between 10 and 40% of their working hours on the network. 15% of responds spend between 40 and 60% whereas 13% spends between 60 and 80%. Respondents from research organizations spend significantly more working hours on the project than their colleagues from industrial organizations. Most respondents report to want to learn more about the concept of human factors as their reason for participation in the project. Another important reason for joining is the opportunity to do fundamental research but also to have a platform for testing and marketing innovative technologies. Among the additional reasons for becoming involved, 'networking' is often mentioned.

The results of the survey suggest that the role of knowledge processes supporting for innovation differs dramatically within the 40 companies under study. In some companies KM is more or less integrated and in other companies there is no integration at all. When knowledge management is part of the business strategy of an organization, there is often a person responsible for setting out a policy and activities with regard to knowledge management. This person can be a formal knowledge manager or part of the job of Human Resource Management or the Information Management Department. Within the 40 companies under study, having such a dedicated manager is rare. More than half of the respondents (64%) either state that their organization does not employ such a person or they indicate not to know whether such an officer is there or not. All airline operators report not to have a dedicated knowledge manager. The availability of a dedicated knowledge management system shows a comparable picture. This seems not to be present in 67% of the companies under study. A large number of organizations report to have an intranet (69%) and 62% reports to use a system to find information about their colleagues and their expertise.

Table 2: The availability of knowledge managers and knowledge systems within research organizations and industrial organizations

Availability of…	Research organizations	Industrial organizations	Total average
Knowledge manager	39%	53%	36%
Knowledge management system	28%	44%	23%
Intranet	69%	69%	69%
Expert finding system	77%	28%	62%

Human factors knowledge is seldom fully integrated within a knowledge management system. Most respondents (25%) state that it is not part of a knowledge management system or that the organization does not have a knowledge management system. When human factor knowledge is partly integrated, it is often spread over different databases within the organization. One respondent indicates that human factor knowledge is not shared within her organization, but rather with other organizations: 'Human Factors is only of relevance to our group within the university and, therefore, it would not be appropriate for Human

Factor knowledge to be shared within the university network. It is more appropriate for us to have knowledge management processes with outside stakeholders and across a consortium such as HILAS.' A total of 78% of the respondents claim that human factor knowledge is important or very important for the innovative capacity of their organization. How to optimally integrate such knowledge in firms forms both a KM and HRM challenge.

Knowledge can be shared in formal or informal ways within organizations. An example of a formal way is training. Informal ways of knowledge exchange include various master-apprentice schemes in companies. Most organizations use a combination of both formal and informal ways to exchange human factor knowledge (38%). There are also a lot of organizations where people seem to share knowledge primarily in a more informal way (32%), while formal knowledge exchange is applied in only 13% of the organizations. It is interesting to see that formal knowledge exchange is primarily applied within the airliners and maintenance organizations whereas the manufacture organizations report more informal practices. Universities and research institutes show a mix of both formal and informal knowledge sharing. Other reported practices for sharing human factor knowledge include participation in project teams and the use of informal social networks.

The analysis of current knowledge management practices within the network shows that most people are primarily involved with people from their own strand. The satisfaction with the different media which are used for communications is in general quite high (72% is satisfied or very satisfied with the Strand Meetings; 75% is satisfied or very satisfied with e-mail; 74% is satisfied or very satisfied with the HILAS Newsletter; 64% is satisfied or very satisfied with the HILAS website; 52% is satisfied or very satisfied with the telephone). The top 3 reasons to visit the website are to download and upload documents, look for contact information of other members and to obtain project management information, such as the planning of meetings. The website is hardly used as a platform for discussions.

As a future network the members would prefer a European research & industry network that is either large or small that is open for newcomers. The communication should be mainly face-to-face, and should be supported by ICT if necessary. The initiative for the development of a future network should be mainly bottom up. The willingness to invest in the development of a network is small as people report to be not willing to invest time or money, and neither do they prefer to become a coordinator of a community. The three most important activities of an innovative community should be to develop standards, methods, best practices; to make useful contacts/networking and to improve the level of expertise of the members.

The knowledge mobility within HILAS is relatively high within each Strand and relatively low between the Strands. Each of the four Strands has a meeting every three months, whereas the meeting for the whole network is only once a year during an annual integration workshop. The knowledge sharing within the Strands is also supported by the HILAS website, because the structure of the website supports the formal structure of the four Strands. The main function of the website is to download and upload documents related to the Strand meetings. These documents are hard to understand for other network members who have not visited the Strand meeting. The knowledge mobility should be optimized within the network, in order to integrate knowledge about Human Factors within the network. The Knowledge Integration Strand has the responsibility to stimulate the

knowledge mobility within the network. Currently they are designing user requirements for knowledge management within the network. The knowledge mobility is so far based on the formal structure, rather than the informal structure of the network.

In order to promote innovation appropriability, the current project management of HILAS pursuits to capture profits generated by an innovation and prevents free riding problems as long as the project is funded by the European Union. The main reason of most project members to be member of the HILAS network is learning from other network members. Other reasons are doing fundamental research and having a platform for testing and marketing innovative technologies.

With regard to the stability of the network, people envision long-term relationships in order to facilitate the integration of Human Factor knowledge in the aviation industry. According to the original project proposal, this integration should be achieved within a period of four years. Therefore, it is necessary to identify hub firms in order to facilitate collaboration. For now, we observe substantial differences in the entrepreneurial behavior of people within the small versus the larger organizations within the network. Small firms in particular tend to spend relatively few hours on the project and are therefore more isolated from other members in the network.

8 DISCUSSION

People are satisfied with the amount of working hours they dedicate to the project. The primary objective to be a member of the network is learning, a goal related to both knowledge management and innovation. There are great opportunities for learning as the members of the network are working in diverse areas of human factors. Within the single organizations the amount of knowledge managers and knowledge systems is relatively low, but organizations have intranet and yellow pages. Knowledge management does not seem to be overly professionalized and its integration with HRM varies but overall is still limited. Also, there are more informal than formal knowledge sharing activities. Human factor knowledge is perceived as very important for the innovative capacity of the organization, although it is not systematically shared within other organizations. Therefore, respondents report to be members of many other human factors networks as well. It would be interesting to know around what specific domains these international networks are developed and how these networks are organized.

Overall the conclusion of this case study is that the HILAS network offers good opportunities for future integration of human factors knowledge. It will remain a challenge to optimize these integration activities in the short term within HILAS. The respondents of the survey indicated to favor a future network that would be open. A total of 77% of the respondents prefer the membership of a future network to be open for newcomers rather than closed for members. The current project is not open for newcomers. The preferred geographical scope of a future network is European. All respondents would prefer a mix between academic and industrial communities, rather than separate communities for industry and science. The current network consists of a mix of research and industrial partners. The main purpose of a future network should be to offer expertise: information of available experts and their knowledge (74 %). Other high-valued purposes of a future network are: to learn new things by exchanging new insights and documents etc. (68%), to

acquire new projects and find potential customers (62%), to gather and exchange best practices (62%) and to network: meet new people and experts (60%). This illustrates the value that such networks may have for innovation.

9 CONCLUSIONS

Knowledge processes are related to innovation processes. Some conceptualizations of innovation processes regard knowledge as a resource and others regard tacit knowledge more important than explicit knowledge for innovation. To optimize innovation processes is important to know when to depend on tacit knowledge or on explicit knowledge. This is related to the issue of weak and strong ties within networks. Further research is necessary to know when tacit knowledge is important and when explicit knowledge in the innovation processes; and when weak ties and strong ties are important within the innovation process. The management strategies for hub firms within network structures, in particular the management of knowledge mobility, innovation appropriability and network stability need further research.

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