Knowledge transfer and value based innovation

Analyzing the effect of science-industry collaboration processes on valorization

Master Thesis

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Acknowledgments

Fi-nal-ly. My master thesis. Finally, it's done. Klaar.

This leaves me with the bittersweet feeling that my time as a beer-loving student is over but that it also releases me from many assignments, finals and of course my master thesis. During these seven years of college one thing especially became clear: word blindness and studying isn't always an ideal combination. Next to some good ol' hard work, many people helped and supported me during these years and especially during the last months.

First of all I would like my thesis supervisor Dr. Frank van Rijnsoever who took the time these past months to read the many versions of my thesis and provided me with feedback to get to this final product. I really appreciated his advice. Furthermore, I would like to thank my second reader Prof. Dr. Ir. Harro van Lente for his feedback.

I also would like to thank Berenschot for this internship and providing me a great subject for my thesis. They gave me the opportunity to conduct very interesting and insightful interviews with leading managers and scientific experts in the photonic industry. Special thanks to my colleagues who always showed their interest in my research by many talks, emails, text messages and Sinterklaas-poems. I really enjoyed my time (abroad) in Brabant. Erik, thank you for sharing your experiences and consulting insights, and Niels, for your patience and friendship.

And last, I would like to thank my family, friends, roommates and teammates who supported me and who all had their own way to keep me motivated and more importantly; smiling. And of course big thanks to my parents for their love and support and for being there during all the ups and downs.

These past years have really developed me academically but also as a person. I experienced many great moments and met inspiring people. I will definitely miss my college years but I will surely not do it again..

Anne den Haan

Utrecht, April 2012

"It always seems impossible until it's done."

Nelson Mandela
Former President Of South Africa

"You can't stay in your corner of the forest waiting for others to come to you. You have to go to them sometimes."

A.A. Milne (1882-1956)
English Author, Best known for his books about Winnie the Pooh

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1. Introduction

Governments can act as stimulators of innovation by organizing research and development (R&D) clusters with multiple private and public research parties. A platform can be created in which a wide range of knowledge and competences are combined (Fallah, 2005; Porter, 1998; Robinson, Rip, & Mangematin, 2007). The variety of input allows exploration and exploitation of many technological, organizational and infrastructural options in order to maintain and stimulate the developments in technology.

The development of these R&D clusters is needed since the rich knowledge base of the Netherlands is not exploited efficiently and the absence of growth in R&D causes a decline of new products, processes and services (Bekkers & Freitas-Bodas, 2010; Innovation Platform, 2009; 2004). Therefore, efforts on the value adding part of the innovation process become key. This value adding- or valorization process is relatively unexplored and more surprisingly, undefined in literature. The current most extensive research is from the Innovation Platform (2008) which defines the valorization process as: 'the process of value creation from knowledge by making it suitable and/ or available for economic and/or social use by translating it into competitive products, services, processes or new commercial activities (p.8)'.

In order to push the rate of innovation, and eventually valorization, in the Netherlands, subsidy was granted from the Smart Mix innovation program to the Memphis R&D project in 2006. The Memphis R&D program focuses on the development of combined electronic and photonic technology. The consortium of Memphis consists of a mix of multinationals, Small and Medium- sized enterprises, Dutch universities of technology and public research institutes. Due to the composition of the consortium a combination of scientific and industrial knowledge is acquired. By merging knowledge bases, routines and networks of the public institutions and the private firms, the knowledge can be translated into concrete applications that can be implemented into the market (Porter, 1998; Robinson, Rip, & Mangematin, 2007).

The applications developed in the Memphis program can be allocated within the areas of Medical and Healthcare, Communication and Information, Imaging and Displays and Light and Sensing which are assessed on market potential and technology demands. Since the technology covers many fields of science and the market for the applications is very broad, it can be expected that investing in this R&D cluster indeed pushes the growth rate of innovation eventually.

Moreover, in order to successfully valorize, the main advances of science and business interaction should be translated to solutions for societal needs (Berkhout, Hartmann, Duin, & Ortt, 2006). Therefore an analysis of the critical factors that facilitate a successful valorization within the R&D cluster can be very useful and can support further developments in the area in which the Netherlands is lagging behind (Bekkers & Freitas-Bodas, 2010; OECD, 2004).

Nevertheless, where the governments generously use the word 'valorization' and build agendas to stimulate this phenomenon, the scientific literature has not embraced the concept yet. Authors address many related topics but fail to describe the actual valorization process. They do however attempt to explain the factors that influence valorization. It becomes clear that the main vital aspect of boosting the value adding part of the innovation process is the interrelationship between knowledge sharing, innovation and ultimately valorization. Many authors therefore highlight the motivations to interact (W. M. Cohen, Nelson, & Walsh, 2002; Fallah, 2005; Fuentes & Dutrénit, 2010), the factors that influence knowledge sharing (Bekkers & Freitas-Bodas, 2010) and the type of channels needed to interact (Bekkers & Bodas-freitas, 2008; W. M. Cohen, Nelson, & Walsh, 2002).

A fruitful effort to describe the valorization process within R&D clusters is done by Berkhout et al. (2006). Their emphasis is on the interaction between science and business, but more importantly on the solutions for societal needs. Berkhout et al. (2006) opt that innovation is embedded in partnerships in which the 'hard knowledge of emerging technologies is complemented by soft knowledge of emerging markets'(p. 393). The main obstacles for valorization are the barriers between science and industry community (scientific isolation) and the barriers between engineering and utilization (technological arrogance). Universities address these obstacles by e.g. emphasizing their active role in the valorization of research outcomes and by increasing the funding for application oriented university research (Hessels, 2010). Although these statements provide more insights in explaining valorization, a solid definition for the valorization process lacks.

The contribution of this research is therefore twofold. First, a typology of the value adding- or valorization process is developed which will combine the knowledge on R&D clusters as well as the knowledge to classify the needs of an actor. Second, the effect of science-industry collaboration processes on valorization is analyzed. The results of this paper are empirically supported by methods of analyzing background information and conducting interviews with relevant actors of the R&D cluster. By doing so, this paper adds to the current literature on R&D clusters by focusing on the valorization process by providing guidelines to bridge the gap between collaboratively developed technologies and the implementation of the technologies into society.

Policy makers and managers can use the results, not only to stimulate the communication between university and industry but also to offer guidelines in the stage where R&D clusters are already settled and the technology needs to be valorized.

In the next section the theoretical background is given, followed by the methodological part of this study. Next the results, conclusion and discussion are given and in the last section managerial recommendations are presented based on the findings of this research.

2. Theoretical framework

Currently, the topic of valorization is adopted by the Dutch government and often used in reports for policy measures. This way the Dutch government emphasizes not only the importance of stimulating innovation but also the importance of actual benefiting from innovations. Moreover, the societal needs fulfilled when implementing these innovations must somehow reflect the investments put in the subsidies for innovation programs. The main focus of the policy recommendations includes stimulating the communication between university and industry and investing in R&D (Innovation Platform, 2009; 2008) and show guidelines to set up and manage these collaborations (OECD, 2004).

As mentioned before, the definition for valorization of the Innovation platform is used to underpin this research (see page 1). When examining the concept of valorization, two important aspects of this definition of valorization can be distinguished. The first part of the definition describes 'the process of value creation' and the second part indicates the process before this value creation, namely 'by making [knowledge] suitable and/or available for economic and/or social use by translating it into competitive products, services, processes or new commercial activities'. This distinction is important as the first part refers to the actual value adding part of the innovation process, and the second part supports this process by developing the needed technologies during industry-science collaboration. Additionally, in this research the translation is made towards the end-user, which is not part of *the knowledge transfer process* but strongly depends on it as it uses the application developed during this process. Therefore, in this research the two processes are strongly related but also separated. So in order to move to the value creation part, barriers in the industry-science collaboration should be identified and described before moving forward to the actual valorization.

Therefore, the next section is dedicated to analyze both parts of the valorization definition. The theoretical framework is based on strands of theory within innovation research that support *the value adding process* and *the knowledge transfer process.* The theoretical framework will be used as an analytical framework for the methodology part of this research. First, the *value adding process* is described according to the theory of Maslow (1962) to classify needs. The part of the theory relates to the *knowledge transfer process* and elaborates on the characteristics that influence knowledge transfer within collaboration networks.

2.1 The value adding process

The success of an implementation of a technology can be measured by the degree of satisfying the actors' needs. In order to analyze the needs of an actor, Maslow (1962) presented a framework for interpretation to classify needs. The classification of Maslow is divided in levels, in the shape of a pyramid with the premise that the lower needs has to be fulfilled in order to move to the higher levels. Without completion of the basic needs, the follow-up levels are not relevant since the most basic human component is survival (Benson & Dundis, 2003). The stage of *basic needs* consists of physiological needs as well as safety needs like anxiety and stress. The second stage is to meet with the *psychological needs*. The needs in this stage contain belongingness and love needs and the reach for self-esteem. The final and upper stage is accomplished when the former stages are completed and here the individual seeks to pursue *self-actualization*. In this stage the full potential of the individual is reached.

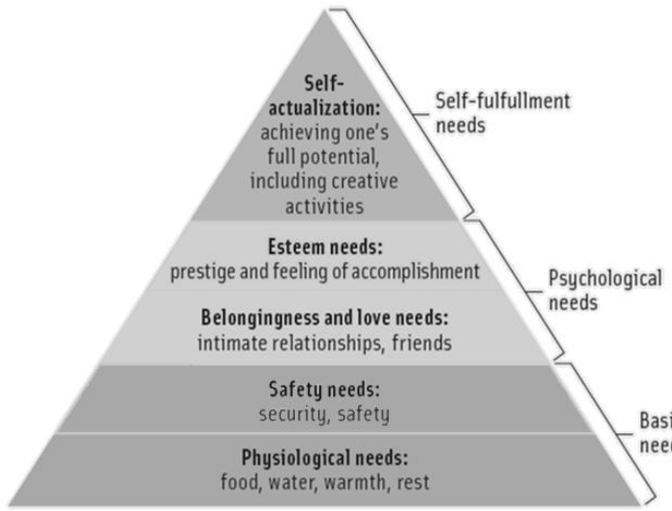

Figure 1 Hierarchy of Needs (Maslow, 1962)

Building on this model it can be argued that the efforts aimed at implementing a technology are based on intervening at a certain level in the Maslow hierarchy. The classification of needs can therefore be used as guidelines for determining the success of the valorization process. The classification of Maslow describes motivations and in this research the translation is made towards individuals that have motivations to fulfill needs. However, the desire to fulfill needs can also be translated towards industrial and scientific parties. For *industrial parties*, the basic need is to survive and exist. The psychological needs refer to interactions with external actors like other firms, suppliers and customers. These connections are not directly necessary to survive but can help the firms to build networks and to be profitable. The growth of an industrial party can be seen as a self-fulfillment need. For *scientific parties*, the basic need is to contribute on scientific level and publish scientific articles. The psychological needs relate to interactions and collaborations with other institutes and industrial parties to obtain knowledge and know-how. The self-fulfillment level is reached when results of scientific research are further developed towards concrete components or applications. These developments are not necessary for the survival of scientific parties but are starting to be more and more important as funding increasingly comes from applied research projects (Hessels, 2010).

In addition, in this research the theory is seen as 'classification' and not as an hierarchy like it originally does. Yet, measurements of levels of valorization rely on the depth of importance for levels of needs for an individual. In other words, the needs that are adequate for an individual can be insufficient for other individuals (Benson & Dundis, 2003).

2.2. Knowledge transfer Process

Over the last decades a shift is noticeable towards partnerships between private and public organizations in order to stimulate innovation (Bekkers & Freitas-Bodas, 2010; Hagedoorn, 2002; NOWT, 2008). Due the fast developments and increasing technological complexity, the partnerships in the technology-industry have become critical for the survival of firms (Aggarwal & Hsu, 2009). Moreover, it shows that universities have an increasing interest towards entrepreneurial activities (Siegel, M. Wright, & Lockett, 2007). These developments have led to more intensive collaborations, although differences in e.g. knowledge, competences and motives are still experienced difficult to overcome (Bekkers & Freitas-Bodas, 2010; OECD, 2004). Van Gils (2010) even stated in his research on industry-science collaboration: 'Even though collaboration has almost become a 'must' for both parties - universities need to show their societal contribution to raise funds and firms have to obtain fundamental research for their long-term competitive advantage - and is facilitated by government, it is fundamentally a marriage against nature (p. 76)'.

To explain the elements of knowledge transfer within industry-science collaboration and to describe possible barriers for this transfer, the knowledge transfer model of Van Gils (2010) is used. This model is based on knowledge transfer literature and is used to overcome the differences in terminology. The five basic elements of this model are: (I) the sender, (II) the receiver, (III) the channel , (IV) the message and (V) the organizational context (internal and external environment) that facilitates the knowledge transfer. Using these elements, Van Gils (2010) describes a linear innovation process, although other strands of literature state that innovation takes place in nonlinear innovation systems where interaction between the actors is key (Edquist, 1997). Therefore, the elements of Van Gils are used as categories but placed in an interactive setting where 'sender' and 'receiver' (further referred as 'actors') both develop knowledge and benefit from knowledge sharing (Fallah, 2005; Lundvall, 1992). The actors can determine the rate of knowledge transfer by influencing the activities and channels during the process and can therefore also influence the rate of the value adding process.

2.2.1. The organizational context

The outcomes of organizational activities like knowledge transfer are predicted by the fit between the components and the context in which the activities take place (Van Gils, 2010). The context is defined by the internal and external environment of the collaboration network, both can influence the rate of knowledge transfer. When focusing on the internal environment, the most intangible asset is *trust or commitment* which can either progress the collaboration due to mutual interest and open communication, but can also hamper the knowledge transfer by a lack of willingness to share(Santoro & Bierly, 2006). In line with this Van Gils (2010) states that 'trust […] serves as a glue that helps to keep industry-science collaboration together (p.79)'. Other intangible factors refer to the *expectations of the parties* and the *similarity of understanding and ideas* about the project. The expectations of the individuals are based on prior academic and entrepreneurial experiences and determine how the parties eventually evaluate the project (Bekkers & Bodas-freitas, 2008). There can for example be a mismatch in expectations in the value chain between the partners, who have an 'effort obligation' towards their superiors and project management, having a 'result obligation' towards their subsidy provider. Also the short turn focus of the industrial parties differs with the long term focus of the scientific parties. One of the options is to facilitate the flow of expectations and ideas by establishing a vital project management that can define the shared project objectives and *manage communication* (Barnes, Pashby, & Gibbons, 2006).

In addition, external influences should also be taken into account when examining the valorization process. Competitive strategy for firms starts with the exploration of the external environment. The external environment determines e.g. the competitive intensity and therefore the attractiveness of a market (Porter, 1998). Marketing strategy is built on segmentation, targeting and positioning (Kotler, Keller, Brady & Goodman, 2009). Companies first *define the market* in which they operate and discover the different needs per target group. Firms that aim at the *usage of early adopters* in their market need to innovate through early application of scientific knowledge (Bekkers & Bodas-freitas, 2008). Consequently, the technology is pushed towards the majority of the market. After the targeting phase, the characteristic offering is positioned. Positioning is about communicating the offering, standing out above the competitors and capturing a unique place in the brain of the target group (Kotler, Keller, Brady, & Goodman, 2009). A rapidly changing market like the photonic market attracts new competitors which will put pressure on the prices. The technological changes of the applications can lead to *price reduction* that can positively alter the dynamics of competitive rivalry in the industry.

2.2.2. Actors: Scientific Institutes and Firms

By participating in public-private partnerships, actors work together in order to gain added value from collaboration instead of developing individually. The collaboration can provide *the firms* with technological knowledge at lower and less risk. When collaborating, the firms will have access to state-of-the-art knowledge and technologies and can therefore perform research that could not be conducted in-house (Barnes, Pashby, & Gibbons, 2006; Bekkers & Freitas-Bodas, 2010). For *scientific institutes* on the other hand the collaboration agreements include more public and private funding in order to proceed their research. For these parties the focus is more on the public funding but also the interest for licensing and patenting income from technology transfer activities grows (Barnes, Pashby, & Gibbons, 2006).

Firms that retrieve external knowledge from collaborations with other firms, and also from their environment and market, use it to build on prior knowledge in order to invent new products or processes. Innovation depends on whether a firm is able to recognize and utilize external knowledge (Cohen & Levinthal, 2007; Nooteboom, Vanhaverbeke, Duysters, Gilsing, & Vandenoord, 2007). The *prior knowledge and resources* of the firm is a key factor in this process and depends on the size of the firm. In this framework the firms are divided in two main categories namely small medium enterprises (SME) and large firms.

The relationship between firm size and knowledge transfer has been investigated on many occasions (Dyer & Singh, 1998; Wernerfelt, 1984; van Wijk, Jansen, & Lyles, 2008). Regarding to SME's it is stated that strategic collaboration with smaller firms can stimulate the generation of new ideas (van Wijk, Jansen, & Lyles, 2008). Rothaermel & Deeds (2004) state that as firms grow and acquire more resources, they tend to minimize the risk of losing projects and knowledge. Therefore these firms are more likely to retain promising projects for in-house development and decrease their reliance on strategic cooperation to discover, develop and commercialize new products. So larger parties that do collaborate in a R&D cluster will use knowledge transfer to complete their in-house resources with state-of-the-art knowledge to compete with current technologies and products.

The scientific institutes consist of the parties most closely to fundamental research, in this case the universities and the public research institutes. One of the main barriers for the universities in a industry-science collaboration is indicated as the lack of an entrepreneurial culture at universities (Siegel, Wright, & Lockett, 2007). Authors opt that stimulating the entrepreneurial activities can be achieved by changing the entrepreneurial culture at universities (Wright, Birley, & Mosey, 2004), by improving the scientific reward system (Siegel, Wright, & Lockett, 2007) and by stimulating commercial activities instead of the need to publish the scientific results (Bekkers & Freitas-Bodas, 2010; Florida, 1999). Currently a shift is noticeable where the scientific parties are concerned more and more with the social and economic contribution of their results. The concept of valorization is placed on the agendas of most universities. However, in order to valorize firms and universities should have agreements on commitment of the firm during the development process and also on the short and long term results of the relating research (Hessels, 2010).

Last, the *composition of collaborated parties* is also an influencing factor in the R&D project. The size of the project and the relation between the number of scientific institutes and firms involved might affect the interaction between the parties and their overall motives to participate. This can be related to the fact that industry-driven projects and university-driven projects lead to differences in spillovers and outcomes (Bekkers & Freitas-Bodas, 2010).

2.2.3. The message: Technical knowledge

Knowledge transfer also depends on the message that is exchanged between parties. *The nature of this message* can be an interfering factor during science- industry collaboration. *Tacit knowledge* for example is knowledge that cannot be articulated and that is non-verbalized (Cohendet & Meyer-Krahmer, 2001). This type of knowledge is rooted in action and explains why firms and individuals posses more knowledge than they can explain. *Codified knowledge* on the other hand is knowledge that is, to some extent, articulated and depends on its holders, time or location (Cohendet & Meyer-Krahmer, 2001; Schulz, 2001). This way the knowledge can be transported or replicated (Teece, Pisano, & Shuen, 1997). Yet, complementary knowledge is needed in order to codify and exploit codified information and causes the dynamic and recurring character of knowledge transfer during collaborations. Furthermore, *messages* can change during knowledge transfer and message can be interpreted differently by partners. Also the *message* changes from fundamental knowledge to concrete products.

Additionally the '*applicability of knowledge*' can be an influencing factor as well. The technical knowledge from scientific institutes is often not useful for the short term commercial initiatives of the firms (Cohen, Nelson, & Walsh, 2002; Siegel, Wright, & Lockett, 2007). Also opinions on how far the technological developments of the scientific institutes should be in order to be commercial viable for firms differ for both parties. Scientific institutes believe that the developments have potential for commercial activities but refuse to develop further and make it attractive for industrial parties. For this reason, firms will not take the risk with fundamental technologies that involve high risk and investments. Knowledge transfer is positively influenced by (perceived) usefulness of knowledge (Schulz, 2001). In this light, van Gils (2010) concludes that 'the existing valorization initiatives at scientific institutes in which knowledge is further developed to increase the usefulness for firms should contribute to easier knowledge transfer in due course (p. 78)'.

2.2.4. The transfer channel: Organizational Arrangement

The strands of research that analyze the knowledge transfer process also focus on the aspects of the channels within this process. These channels mainly include subsets of e.g. publications, meetings, patents, research contracts and personal exchange (Cohendet & Meyer-Krahmer, 2001; Gils, 2010; Schulz, 2001). However, the use of these channels widely varies and there is no common taxonomy that explains the differences in usage (Bekkers & Bodas-freitas, 2008). Studies do show that collaborative and contracted research activities are an important form of knowledge transfer (Meyer-Krahmer & Schomch, 1998). Here informal interactions are a shared form of contact between universities and industry, although this form of articulation makes the intensity of channel use hard to measure. Furthermore the type of channel used within collaborations seem to be case dependent (Bekkers & Bodas-freitas, 2008).

The following table provides an overview of the categories and concepts of the knowledge transfer system:

The knowledge transfer process	
Category	*Concepts*
The internal and external environment	
Internal	Trust or commitment
	Expectations of the parties/ Similarity of understanding and ideas about the project
External	Define the market
	Create a marketing strategy
	Usage of early adopters
Actors	Nature of the actor (Firm or scientific party)
	Size of the firm or scientific party
	Prior knowledge and resources
	Composition of collaborated parties
The message	Nature of knowledge (Tacit or Codified)
	Applicability of knowledge
The transfer channel	Type of channel (Tacit of Codified); e.g. publications, meetings, patents, research contracts and personal exchange
	Formal or informal

Table 1 Overview of the concepts of the knowledge transfer process

3. Methods

This study used a case study as research design. Case studies consist of a contemporary set of events which cannot be controlled by an individual and are particularly useful to be generalized to theoretical propositions (Yin, 2009).

Since scientific literature struggles with the subject of valorization processes, the strands of innovation theory described in the theoretical framework are used as an analytical framework to interpret empirical data. The empirical data in this study is collected from the Memphis R&D program. In line with the work of Strauss & Corbin (1990), the research proceeds in three phases: case description, data gathering and data analysis.

3.1. Case description

By granting subsidy from the Smart Mix innovation program to the Memphis R&D project in 2006 a consortium was set up that consists of public and private parties as well as small and large parties. The program is a mix of multinationals, SME's , universities (of technology) and public research institutes. The composition of the consortium is shown in figure 2. Due to this selected team a combination is created of scientific and industrial knowledge. The variety of expertise and resources of the parties is used to compare the samples and to seek for the establishment of causal relationships (Yin, 2009).

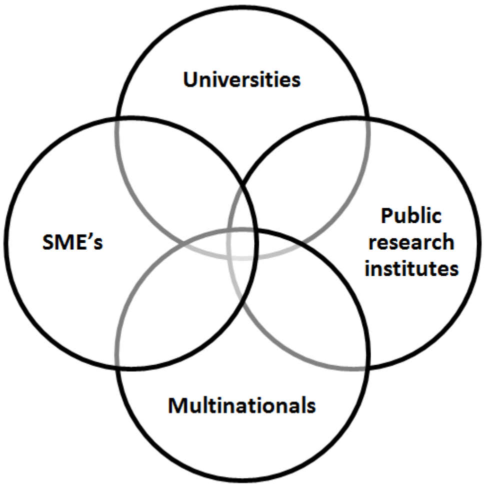

Figure 2 The composition of partners of the Memphis program

The Memphis project is divided in work packages, each working on an application, a component (of an application), fundamental technology or the processes that support technological development. The work packages contain a mix of three to five collaborative industry related parties and scientific institutes, all focusing on a single element in order to collaboratively produce the needed outcome of the involved work package. Eventually there are six applications developed that can be implemented in four indicated markets.

Due to the cumulative activities the value created in each work package adds up when moving to the final application. The internal actors add physical and information processing elements to the product, generating more cumulative value for the end-user (Porter & Millar, 1985). Therefore, the focus of this research is on the applications created in this consortium as they represent the total value created by the work packages.

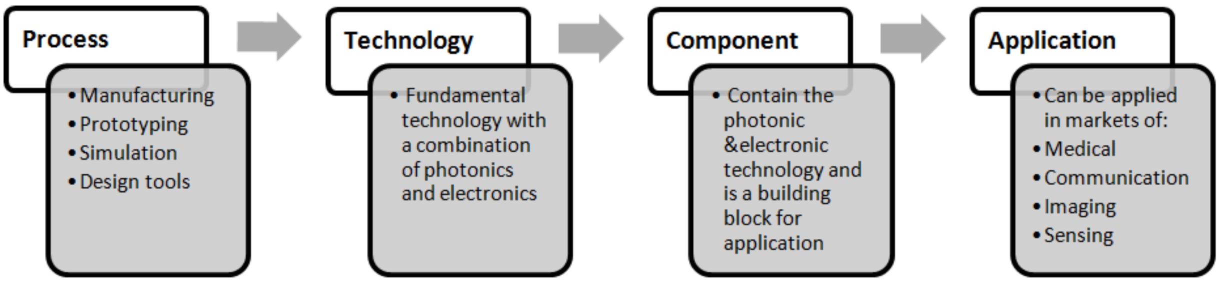

Figure 3 The work packages of the Memphis program, each working on an application, component (of an application), fundamental technology or the processes that support technological development.

The total valorization process of Memphis also involves external actors that are described according to four application areas described in the next section. Table 2 shows the relevant external actors, as it can be expected that the actors only participate in the value chain if it provides them some kind of (competitive) advantage (Porter & Millar, 1985). The total valorization process of Memphis is therefore the contribution to the fulfillment of needs by the developed applications for each external actor group.

		Consortium member	Third party	Retailer	End-user
Communication and Information	**Application 1**	*SME/ Multinationals; scientific parties*		*Telecom companies*	*Users of telecom*
	Application 2				
Medical and Healthcare	**Application 3**	*SME/ Multinationals; Hospitals/ scientific parties*	*Ministry of Health Insurance companies*	*Biomedical research Hospitals General Practitioners*	*Patients*
	Application 4				
Imaging	**Application 5**	*SME/ Multinationals; scientific parties*		*The automotive industry, security and medical application areas*	*People involved in automotive industry Military Search and rescue*
Sensing	**Application 6**	*Scientific parties*		*Air space organizations Telecom companies*	*Many private users Industrial domains*

Table 2 Overview of the main user groups per application market

Application markets

The current knowledge society and economy requires an infrastructure capable of transportation of and processing large amounts of information. Therefore, the need for improvements in personal communication and the creation of intelligent and safe environments rises. In the healthcare sector, a major paradigm shift from disease detection by its first clinical symptoms to very early detection of pre-stages of the disease is being explored. Within these medical developments, the early detection of pathological lesions is almost a prerequisite for successful healing, and greatly influences the choice of therapy.

In these examples, the present technologies are either based on electronics or on photonics and cannot fulfill these requirements. Micro- and nano-electronics support high complexity and intelligence and carry rapidly increasing processing speeds but fail in its limitations in power requirements and lack in its performance to frequencies. In order to move further in technological development, new complex miniaturized devices are needed to increase bandwidth against the lowest possible cost price. An increase of this electronics frequency range is nearly impossible due unpractical designs and technical problems. When looking at micro- and nano- photonic technology, it contains unlimited frequency opportunities (> 1 THz) but is limited in their computational and technological versatility.

By converging the complementary characteristics of micro- and nano- electronics and micro- and nano-photonics, an optimal output is generated. The combined technology, that is low cost and has high frequency capabilities, enables possibilities for new broadband miniaturized electronic-photonic devices and can be applied in many areas like communication and information, and medical- and health care but also in areas of sensing and imaging.

The Smart-mix Memphis program focuses on the development of combined electronic and phonic technology. By bundling and coordinating both types of expertise new value chains can be created. Since the diversity of the technical options is large, structure is needed in which technological research and development is directed in order to create a link with the market demands. The application areas of Medical and Healthcare, Communication and Information, Imaging and Displays, Light and Sensing are assessed on market potential and technology demands. A more detailed description of the application markets can be found in the appendix.

3.2. Data gathering

The next step is data gathering which is an interrelated process with data analysis (the third step). By analyzing the data directly in the data gathering process, important aspects of the findings will be captured as soon as they are revealed (Corbin & Strauss, 1990). This enables to guide the direction of the research. The data will cover the years 2007 until 2011, from the year of the start-up of Memphis until now. The data collection started with analyzing background information by literature-based enquiries like annual reports, project reports, annual meeting reports, and other documents that allow further investigation on the participating party, available resources and the developed technology.

In order to triangulate the collected information, the data from literature-based enquiries are verified with interviews with the parties concerned (Bryman, 2008). Thirteen interviews were held with participants, covering each party of the Memphis program that is involved with certain work packages and can provide knowledge about the party and their initiated market. For each application project the work package leader (coordinator) was interviewed and for most projects additional interviews with the participants were held as well (see table 3). And three more interviews were held with participants of the supporting work packages, who also gave their opinion on valorization. The interviews will be semi-structured, implying the same designed interviews for all participants, but also allowed participants to explain party specific circumstances. Overall, the participants were asked to give their view on the topic of valorization and to give more in-depth information on the work packages in which they are involved. Hence, the interview had a technical focus, identifying the technical progress, combined with organizational and commercial questions that will need to be answered.

Application 1	Application 2	Application 3	Application 4	Application 5	Application 6
Scientific party University * SME * SME *	Scientific party* Scientific party* Scientific party University* University University SME*	University* University	University* University SME Large firm*	Scientific party University*	Scientific party University* Large firm*

Table 3 The composition of the parties of the six application projects. The *-symbol represents the parties that were interviewed.

3.3. Data analysis

The data from the literature enquiries and interviews are used to complete the analytic framework with concepts derived from innovation literature. Therefore, an analytic method was to seek for universal explanations of phenomena in the data (Bryman, 2008). In this analysis the process of coding is an important first step in the generation of insights on valorization. Coding entails 'reviewing transcripts and/or field notes and giving labels (names) to component parts that seem to be of potential significance and/or that appear to be particularly salient within the social worlds of those being studied' (Bryman, 2008, p. 542). Here the data are seen as potential indicators of concepts and these indicators are constantly compared. In order to achieve the fulfillment of the frameworks, the data will be broken down, examined and categorized. The generated concepts, that match with the concepts in the frameworks of *knowledge transfer process* and *value adding process,* were eventually grouped and placed within categories. By exploring relationships between the categories, this method will hopefully lead to insights regarding a new definition of the valorization process but also to the completion of the analytic framework.

If the information indicated that there are more concepts that influence the *value adding process* or the *knowledge transfer process*, these concepts will be added to the framework in an inductive way. By using this approach, an integrated set of concepts is created which allows theoretical explanation of social phenomena. The richness of such concept development is described as conceptual density (Strauss & Corbin, 1994).

So a following analysis of the data enables of the following steps;

1.) In order to create and validate a definition of valorization process, concepts and categories are derived from the interviews and compared with concepts described in innovation literature.

2.) The *value adding process* will be outlined and these findings are supported by completing a cross table that outlines the needs fulfilled for the external actors by implementing the application (see table 1). The needs in this cross table are ranked according to the classification of Maslow. If the data imply that additional actors or needs are also involved during the valorization process than assumed in the theoretical framework, the cross table can be adjusted to include this information. This way an overview of the need fulfillment is created which makes it possible to draw recommendations regarding the *value adding process* of the Memphis consortium.

3.) Last, using an analysis of the concepts and categories matching the analytical framework of the *knowledge transfer process,* the factors that determine that knowledge transfer within collaboration networks can be identified. If the data imply that additional concepts are also determining factors during the valorization process then assumed in the theoretical framework, the framework can be adjusted to include this information. This way an overview of the concepts is created which makes it possible to draw recommendations regarding the *knowledge transfer process* of the Memphis consortium.

4. Results

In this section the labels that were derived from theory are discussed with the input from the interviewees. In the first section, the definition of valorization is revised. Next, the value adding process of the six applications is discussed. And third, the collected data is used to describe the knowledge transfer process. The conclusions of all parts will help to provide a typology of valorization and give more insights on the (network) factors influencing the valorization process.

4.1. The definition of valorization revised

The starting point of revising the concept of valorization is the definition given by the Innovation Platform (2008) defining valorization as: 'the process of value creation from knowledge by making it suitable and/or available for economic and/ or social use by translating it into competitive products, services, processes or new commercial activities (p.8)'. This definition is widely used in governmental innovation programs and science-industry projects but the vague description can lead to misunderstanding between partners. A respondent of an SME remarks that *"it is sometimes difficult to understand what people mean if they mention 'valorization', and what it covers and where it should lead to".*

Assuming that scientific parties and industrial parties have different views on valorization regarding their place in the value chain, a distinction between the two is made when defining 'valorization'. First the input of the actors involved in scientific parties are discussed, followed by the insights of industrial parties. Second, an overall typology is given.

4.1.1. Scientific parties

The respondents of the scientific parties gave their view on valorization and their input can be bundled in four categories:

Valorization can be used to..

… capitalize science

Or in other words; bringing the results of research to the market. The goal of a valorization project is to implement the innovative technology in a product that can be commercialized. Researchers are forced to focus more on applied science and have to determine what the added value of their efforts is. So the aim of generating knowledge is to eventually develop products and make those products. However, some scientific parties see the production of applications not as their responsibility. So although they state that research should lead to concrete applications for the society, they believe it is the responsibility of the industrial parties to further develop a technology. In this case a complementary (industrial) party should join in order to valorize, allowing the project to eventually gain economic profit. Knowledge has to be converted into cash in such way that society and economy benefit from it. This can be accomplished by implementation and commercialization.

… create a scientific infrastructure

For a scientific party, valorization entails developing scientific standards or infrastructure that allows new research and developments in the same field of science. This infrastructure also facilitates that industrial parties can be attracted as it slowly creates a standard for technological developments. Currently these parties hesitate to join because they do not have sufficient knowledge and tools for this radical innovation.

… contribute to education

An innovation can also be a success even though it is not implemented in the market. For instance by contributing to the education of people and deliver high-skilled employment for the industry. The industry is always looking for high-skilled employees and if they do not find it in the Netherlands they will look for it abroad, as stated by a public research institute. “These [science-industry] programs deliver high qualified researchers and will hopefully find their way to the Dutch industry”.

… create spin-offs/ start-ups

“Valorization can also be the creation of spin-offs or start-ups”, opts an university, “and how components [of an application] can be commercialized”.

To summarize, the definition for scientific parties can be described as;

> *‘Valorization is to capitalize science, as a result of the implementation and/ or commercialization of products, or by creating spin-offs and/or start-ups , but also by developing an infrastructure for a certain field of science and contribution to the education of people.‘*

4.1.2. Firms

The firms find themselves at the final part of the value chain and their input can be divided in four subjects:

Valorization is to derive value from efforts on research and development in terms of..

.. applications.

Valorization is working towards an application. Moreover an application is only developed if there actually is a purpose for it. For one SME, valorization is specifically the transition from prototype/ demonstrator phase (in the research phase) to something product-like that can be brought to the market.

..high-quality employment

However, value can also come from high-quality employment which will lead to new industrial activities.

..new businesses

The government initiates science-industry projects to regain value. The activities in the project will lead to growth of new businesses and new businesses in their turn are based on value creation for the end-user.

The definition for the industrial parties can therefore be explained as followed;

> *‘Valorization is to derive value from efforts on research and development in terms of developing applications, creating high-quality employment and generating new businesses’*.

4.1.3. Definition

Although scientific parties and firms are at both sides of the (linear) value chain, the input of the two groups were relatively similar. They all pointed out three important aspects:

1) Application driven developments
2) Education of high-quality employment
3) Generating new businesses like start-ups and spin-offs

Combining the two definitions of the scientific and industrial parties results in a more in-depth definition of valorization;

> ‘**Valorization is to capitalize science and derive value from the efforts on research and development, by** developing applications, creating high-quality employment and generating new businesses, **as a result of** the implementation and/ or commercialization of products, the creation of spin-offs and/or start-ups , the development of scientific infrastructure and the contribution to the education of people.’

4.2. The value adding process

Now that we have an overall view on valorization, the added value of the application can be determined. Each application is discussed according to external actors involved in their 'value adding process' namely *consortium member*, *third party*, *retailer* and *end-user*. In the following cross table the specific external actors are given. The rate of how the applications satisfy a certain need of the external actor is described with the use of the classification of Maslow. A distinction is made between needs of an individual and needs of industrial or scientific parties.

The stage of **basic needs** consists of physiological needs as well as safety needs like anxiety and stress. The second stage is to meet with the **psychological needs**. The needs in this stage contain belongingness and love needs and the reach for self-esteem. The final stage of **self-fulfillment needs** is accomplished when the former stages are completed and here the individual seeks to pursue self-actualization. In this stage the full potential of the individual is reached.

For *industrial parties*, the basic need is to survive and exist. The psychological needs refer to interactions with external actors like other firms, suppliers and customers. The growth of an industrial party can be seen as a self-fulfillment need and is for example enabled by attracting highly skilled employees. For *scientific parties*, the basic need is to contribute on scientific level, publish scientific articles and to educate. The psychological needs relate to interactions and collaborations with other institutes and industrial parties to obtain knowledge and know-how. The self-fulfillment level is reached when results of scientific research are further developed towards concrete components or applications. This also includes the creation of spin-offs and start-ups.

The next section elaborates on the value adding characteristics of the applications with the use of a cross table. Using the new definition of valorization, the value adding process can be realized by contributing to application driven development, education and creation of new businesses. The actors *retailer* and *end-user* are described per application market due to a diversity of results.

The value adding process						
		Consortium member		**Third Party**	**Retailer**	**End-user**
		Industry	***Science***			
Communication and Information	*Type of actors*	*SME/ Multinationals*	*Universities/ public research institutes*		*Telecom companies*	*Users*
	Needs *Criterion*	**Self-fulfilment needs** Production costs can be reduced and enables competitive advantages	**Psychological needs** New collaborations are initiated **Basic needs** Contribute on scientific level	n.a.	**Self-fulfilment needs** Smaller footprints, decrease of costs for the retailer, achieve financial benefits	**Self-fulfilment needs** Providing more entertainment **Psychological needs** Access to information and communication
Medical	*Type of actors*	*SME/ Multinationals*	*Universities/ public research institutes/ Hospitals*	*Ministry of Health Insurance companies*	*Biomedical research Hospitals General Practitioners (Industrial parties)*	*Patients*
	Needs *Criterion*	**Self-fulfilment needs** Financial benefits can be high , production at lower costs **Psychological needs** Improve of relationships in the industry	**Psychological needs** Program is a success if solidarity is created **Basic needs** Obtain new knowledge and experiences	**Basic needs** Reduction of cost for health organizations, reduces the overall health costs	**Self-fulfilment needs** Improvement of treatments can positively change work situation, more safety during surgeries, (new technology creates competitive advantage)	**Self-fulfilment needs** Improvement in care **Basic needs** Improvement of condition and overall health
Imaging	*Type of actors*	*SME/ Multinationals; scientific parties*	*Universities/ public research institutes*		*The automotive industry, security and medical application areas*	*People involved in automotive industry Military Search and rescue*
	Needs *Criterion*	**Self-fulfilment needs** Lead to higher profits	**Basic needs** Development of fundamental knowledge	n.a.	**Self-fulfilment needs** Improve work conditions **Psychological needs** The applications will increase safety and	**Basic needs** Improve safety of end-users.
Sensing	*Type of actors*	*SME/ Multinationals; scientific parties*	*Universities/ public research institutes*		*Air space organizations Telecom companies*	*Many private users Industrial domains*
	Needs *Criterion*	**Self-fulfilment needs** Production at lower costs	**Psychological needs** Access to resources partners, creating partnerships, access to financial resources **Basic needs** Knowledge development	n.a.	**Self-fulfilment needs** Measurements in space **Psychological needs** Allowing better applications and communication	**Self-fulfilment needs** **Psychological needs** **Basic needs** Small improvements in their day-to-day life

Table 4 Overview of the results of *the value adding process*

4.2.1. Consortium member

Firms

The new technology developments can enable competitive advantages to grow the business, which is a **self-fulfillment need** of a firm. With new technology developments production costs can be reduced. Precondition for a successful implementation is however that the product should meet with the requirements of the market for the intended application (market pull). These aspects are important for the survival and the basic needs of the firm.

For the applications targeted at medical environments, quality is more important than profits. But financial benefits can be high if the functionality of the application is proven. Due to the technological developments and mass production, the devices can be produced at lower costs. This matches the needs of customers and patients to be able to offer cheaper treatments.

Furthermore, all devices are smaller and more precise than current competitive applications and can be applied in a broad range of markets. Therefore, the implementation opportunities are high and with the specifications of the devices competitive advantages can be created.

Scientific parties

The primary goal for most scientific parties is to obtain new knowledge and experiences (**basic needs**). A university explains that “it is important that this project contributes on scientific level, for example through publications and citations”. Furthermore, as scientific parties are at the basis of the value chain, the success lies more in for example testing and proving the functionality of a technology.

Overall, the program is seen as a success if solidarity is created and new collaborations are initiated (**psychological needs**). In this project, most partners in the industry participated which improved the relationships in the industry. Joining the project and developing the technology provided access to resources of partners and the opportunity to use the facilities of partners for testing and creating partnerships. This results in more available knowledge from collaborating parties and a decrease in developing costs.

Due to the size, this program will probably put the photonic industry on the map and will become more known if the results are implemented or published. The consortium can contribute to a certain scientific infrastructure in the Netherlands. Furthermore, “valorization can also be accomplished if this consortium results in start-ups and patents”, states a scientific party. During the program two start-ups were founded that continued the technological developments to work towards commercialization.

But even if some projects fail, the program contributed to the education of highly skilled employment. For innovative firms, the areas of expertise are very interesting and they will try to recruit employees after finishing their projects. This will enable growth of the firm (**self-fulfillment needs**) for example. “Perhaps in that case”, a scientific party noticed, “the project still succeeded”.

All in all, the needs of the *firms* and *scientific parties* influence the motives to join the collaboration and also influence further decisions during the project. Eventually this has impact on the development of applications and therefore the rate of value adding. In order to manage the different needs, the motives of the parties should be mapped and discussed. This process is further elaborated on in the next chapter ‘knowledge transfer process’.

4.2.2. Third party

The developments in medical applications will eventually result in cheaper treatments. The devices enable early detection and higher quality of treatments and can for example be placed at general practitioners offices or polyclinics instead of specialized medical departments. The applications therefore have positive influence on the decrease of the number of hospital visits an can prevent costly treatments. This is beneficial for the insurance costs and society since it will lead to a reduction of the overall health costs (**self-fulfillment needs**).

4.2.3. Retailer

Communication and Information

The communication applications can produce higher signals with a more constant frequency then current technology. This means that the retailers can offer their customers an improvement of signal processing in e.g. telecommunication and aviation. These developments meet with the needs of people to have improvements in processing and transporting data and to have more access to communication, even during travelling. For specific industries the application can improve logistic operations and improve navigation systems. The industrial retailer meets with his own **self-fulfillment needs** to grow and expand. The application also means smaller ecological footprints because the product reduces in size (reduction of materials) and uses less energy.

Medical and Healthcare

For the health providers, the developments for medical technology mean innovative clinical applications in many medical fields like dermatology, pathology and chirurgic applications. "With this technology the molecular information is directly translated to diagnostic information" explained the respondent of the SME who develops the technology. Therefore, less human interpretation is needed and more objective results. And the speed of the applications allows surgeons for example to act instantly during surgeries. This can greatly influence the choice of therapy. An improvement of treatments will positively change the work situation of doctors and surgeons (**self-fulfillment needs**).

Moreover, the technology can also be used for other material research in more industrial settings, satisfying the **self-fulfillment needs** of firms to expand their production.

Imaging

With the imaging devices, the interpretation of images shifts from the human operator to smart systems that make or prepare decisions. The respondent of the university clarifies: "the way to send and receive with this imaging device changes and will be more precise". The devices are also smaller than other similar applications and can for example be applied for a handheld scanner (**self-fulfillment needs**). The applications will increase safety (**basic needs**) and improve work conditions.

Sensing

The sensing technology aims to totally control the process of quantum dot lasers. With the technology applied in products, the retailer actors are able to do measurements in space. Air space organizations are very interested because of the precise frequency and the low energy use (**self-fulfillment needs**). The technology can be used for measuring frequencies on both sides of the fiber, allowing better applications and eventually better communication (**psychological needs**).

Overall, the focus in the last stages of the value chain is more on the value added by the application and less on the education of people and the creation of new businesses. However, education on understanding and using the new applications in the day-to-day working environment is needed to fully utilize the possibilities.

4.2.4. End-user

Communication and Information

The current knowledge society and economy requires an infrastructure capable of transportation and processing of large amounts of information. Due to a tool that can dynamically assign bandwidth, the end-user is provided with more bandwidths. For the end-user these technology developments mean that the application will increase safety due to more communication access and is more payable (**psychological needs**). The application will also meet with needs like providing more entertainment and creative activities (**self-fulfillment needs**). Furthermore, the technology can result in a year to year cost (per bit) reduction and bandwidth enhancement.

Medical and Healthcare

For the end-users, the medical applications intervene in their medical condition and overall health. Due to the fact that devices can be placed and used at a larger number of health providers, the patient has easy access to treatments. The medical technologies will contribute to better health (**basic needs**) and more comfortable lives for end-users (**self-fulfillment needs**). And the innovative technology allows an improvement of measurements. The respondent of a university gives an example: "With this technology for skin and tissue research there is no physical biopsy needed. The information is directly visible and can be used to determine the treatment instantly". Overall, the devices will lead to higher quality of treatment, a decrease of time before diagnosis and an early detection of (skin) diseases, preventing unpleasant treatments."

Imaging

Imaging is increasingly applied in automated and semi-automated environments. Therefore, different types of information are needed from the imaging system i.e. distance information, types of objects and chemical composition. The device can be applied for security and defense with for example screening of luggage but also buildings. But antenna application in aviation can also be improved. Therefore, this device mainly targets at the **basic need** of safety of end-users.

Sensing

Finally, the end-user can profit from the sensing technology by innovative developments in the telecom industry. This results in better communication and information. Measurement of time and distance will not directly affect the end-users but will definitely mean small improvements in their day-to-day life. Gradually fulfilling needs at **all levels**.

All in all, the end-user only experiences value instead of also adding value to the application driven developments in the value chain. In the last stage of the value chain there is no sign of education of highly-skilled people or the creation of new businesses.

4.3. The knowledge transfer process

Last, the indicated concepts and categories matching the analytical framework are used to analyze the collected data.

The knowledge transfer process is the underlying mechanism for the value adding process and therefore also for the valorization process. The factors that can affect the knowledge transfer process are described as well as the effects of this process on valorization.

The following table shows an overview of the concepts and categories which are further discussed in the next section.

The knowledge transfer process			
Context			
Internal environment	**Trust or commitment**	**Create an intensive collaboration**	When forming a consortium project management should try not to force collaborations but create an intensive collaboration that works towards an end result.
	Expectations/ similarity of understanding	**Technological developments & Expanding existing research**	The program stimulates technological developments and stimulates progress. And parties can extend a part of their ongoing research or continue with previous research.
		Financial support	The program is interesting for receiving grants. The financial injection enables to expand or continue scientific activities.
		Collaborations	Most organizations of the industry are participating and this stimulates networking.
		Valorization	The focus on valorization of the program can be direct reason to join the consortium.
	Managing communication	**Manage interests**	Adjust interests, interactions and project stadia to achieve a common goal.
		Enhance communication	Parties are able to match ideas of partners.
External environment	**External actors**	**Define the market**	The projects find themselves between market pull and technology push as they are developing an innovative technology.
		Create a marketing strategy	The long learning curve of scientific research enables to identify a target market
		Usage of early adopters	To push the technology towards the majority
Actors: Scientific institutes and Firms	**Nature of actor/ composition of the collaborated parties**	**End-to-end development**	Missing part or component of an application could hamper the development and commercialization.
		Science-science collaboration; all academic	Industrial partners are not needed if one of the parties focuses on the market.
		Science-industry collaboration; combine disciplines	Collaboration can hamper due to the diversity in interests.
	Prior knowledge and resources	**Sufficient prior knowledge**	In order to be capable of building on this knowledge with external material
		Need for manpower	Must be solved in order to continue developments
		Lack of financial resources	Solutions for financial aid: - Attracting industrial parties - Creating start-ups - Joining consortia

		Time is more important than money	When developing new technologies
The message	**Applicability of knowledge**	**Importance of clear structure of the value chain**	To ensure the complementary and reusability character of the projects.
		Tackle hampering factors	- Prevent delay in sub-projects - Close the gap towards production phase by attracting qualified parties and financial injections.
Transfer channel	**Type of transfer channel**	**Project meetings**	Are used to maintain communication with partner and to find solutions for problems or different visions.
		An electronic sharing system	Can be used to share (codified) know-how
		Annual meetings	Where all partners join and share information by giving presentations.
		Overhead	Reporting is needed for the transparency of the projects but very time consuming.

Table 5 Overview of the results of *the knowledge transfer process*

4.3.1. Context

Internal environment: Trust and commitment

The motives and needs of the parties should be managed in order to achieve a common goal. However, the synergy during the project is also influenced by trust and commitment between the partners and can either stimulate the collaboration due to mutual interest and open communication or hamper it by a lack of willingness to share. Therefore a respondent of a large firm states: "When forming a consortium, project management should try not to force collaborations [for example to meet with political agendas] but to **create an intensive collaboration** that works towards an end result".

Internal environment: Expectations/ similarity of understanding

The large number of partners from the industry is a main advantage of this consortium but it also took great efforts to fit the technological contributions of all parties and to ensure that the knowledge could be used in a complementary way. Furthermore, the uncertainty of innovative projects made predictions on the development of the program difficult. Nevertheless, the parties gave many different reasons to join the consortium and how their organization could benefit from this program;

- **Technological developments & expanding existing research.** The program stimulates technological developments and can positively influence the progress in research projects. Some parties joined to start new projects in this design, while most partners extended a part of their ongoing research by entering the program. In that case the subjects of Memphis corresponded with developments in previous programs. The structure was designed to allow application driven development and will therefore reinforce the valorization process.

- **Financial support.** The program can provide financial resources for activities that were already planned and correspond with the subjects of the program. For most parties, joining collaborations is interesting for receiving grants. The additional financial injection they receive enables them to expend or continue their scientific activities. In some cases the Memphis-project is only a side project of ongoing developments. The question is if those parties are really interested in application driven development, or just pretend to be motivated for valorization because they know the objectives of the project management. If the latter statement is true then the difference in motivations can affect trust and commitment between collaborating partners and thereby hamper the valorization process.

- **Collaborations.** The fact that most organizations of the industry are participating is also a reason to enter the consortium. The program stimulates networking between the parties and therefore the program can lead to unexpected collaborations. Many partners saw their networks expanding by joining the consortium. And although this might not happen in all cases, it does facilitate knowledge sharing to improve technological developments.

- **Valorization.** Only one (scientific) party pointed the focus on valorization of the program as direct reason to join the consortium. Translating the motivation for valorization to the new definition, the results of the consortium in terms of application driven development, education and the creation of new business stimulate to participate in the program.

Despite the differences in motivations, the project can only succeed if the partners in a project work towards the same goal or have the same expectations. Once the project achieves this goal, the added value of the collaboration should compensate the individual expectations and satisfy all partners.

Internal environment: Managing communication

Overall, the composition of a project must allow the partners to **manage interests** within the project and the interactions between the partners. Work package leaders must be able to overlook the project and the program, communicate targets and ensure trust and commitment between the partners. This way they are able to adjust interests, interactions and project stadia to achieve a common goal. Furthermore, it is important for large programs like Memphis to have a common theme, states a respondent of a public research institute. This (scientific) theme determines the goal for each project and can provide guidelines to divide the work. The main hampering factor for new projects is that the government provides less grants. "But on the other side", states the same respondent, "this is known and we have to think forward".

Also, to clarify the intentions and the goals of the program "more communication [is needed], starting early in the program", opts a scientific party. Intentions to **enhance the communication** between parties are an important part of the project management. This can be achieved by refining the applicability of knowledge (see '*the message'*) and organizing meetings and creating sharing systems (see *'the transfer channel'*). Communication stimulates the knowledge sharing process and the possibility to do something with external knowledge before it is published. Parties are therefore able to match ideas of partners by knowing what is happening, what partners are doing and how to associate that with your own ideas ('close to the fire').

External: Economic and social influence

Communication with the market starts when the product specifications must be defined. The projects find themselves between market pull and technology push as they are developing an innovative technology. Often it is still needed to **define the market**. One of the scientific parties establishes contact with potential target parties during the product development. An advantage of involving the target market early in the developing process is that the application can be adjusted to the product requirements of the end-user. This increases the value for the end user. During these activities, communication is essential. Yet, others opt that users must be attracted in the maturity phase of the project.

All projects started with fundamental research leading to a long learning process until the actual implementation. The long learning curve enables to identify a target market and **create a marketing strategy**. One of the firms uses its business development department that is specialized in approaching potential customers. In its established networks "there are always interested people for a new technology". For most application markets price reduction is very important in order to compete. Projects therefore focus on the technological developments to reduce the current production costs. Prices of competitive products can be estimated by extensive market research. Although pricing is a main factor during the implementation phase of an application, some applications are built for small markets with large margins. Here, improvement of the incumbent products is essential in order to compete.

However, in order to valorize an application, the feasibility of the product must be proved during the technological developments. If the functionality of the application improved compared to the current products on the market the producer can accomplish a better competing position. "But firms are needed to make the applications accessible", states a scientific party, "and should step in at the starting phase of the project". The market can be approached by **usage of early adopters** who can push the technology towards the majority via word of mouth advertisement.

4.3.2. Actors: Scientific institutes and Firms

Nature of the actor/ composition of the collaborated parties

"The composition of the partners collaborating in a project should be directed to end to end development", as stated by multiple interviewees. So in a classic linear model this means that the more market-oriented focus of firms should complement the research activities of the scientific partners. In some projects parties are missing to complete the value chain. Due to the structure of Memphis, a missing part or component of an application could hamper the application driven development and eventually valorization. Therefore, if new partners are attracted they must be necessary for **end-to-end development** of the value chain to ensure valorization.

In most application projects an industry related party is present targeting at end-to-end-development. In this light, a university suggests that it is important to "not only attract scientific parties [for universities] but also industrial partners which are needed for additional facilities". Yet, two projects are **science-science collaborations**. In this case one of the parties focuses on the target market and is investing in the application side of this research. So here the focus on valorization is still present. But even if the commercialization phase is not reached, researchers are educated in very specific fields of science.

The downside of variety in collaborations are the hard to combine disciplines of the **science-industry collaboration** parties. The collaboration can hamper due to the diversity in interests. For example, the commercial focus of an SME is the opposite of the long term focus of this consortium. Yet, the SME uses the facilities of the universities which they cannot afford. "The university looks over their shoulder [of the SME] during these tests to help if necessary but also to learn. This type of collaboration is an efficient way of knowledge sharing", states the university where the tests take place. In return, the firms can provide universities the knowledge on applications and on what is needed to develop applications. For all types of projects, the learning experience and education is an important part of the collaboration.

Prior knowledge and resources

Regardless of their nature, all parties indicate to posses **sufficient prior knowledge** in order to proceed the technological developments. Their prior knowledge is well developed and the parties are therefore capable of building on this knowledge with external material. But in the research phase the developments can only continue when the **need for manpower** is fulfilled and this can only be enabled with higher budget. The **lack of financial resources** is indicated as a main hampering condition for technological developments. One SME tackles this problem by involving larger industrial parties early in the research phase. When the results are promising they continue the collaboration and start developing. The experience of their business partners can help them to start a product line and introduce their products. A university on the other hand suggests that start-ups are needed to reach the production phase, which can be supported by venture capitalists. The creation of new businesses would add to the valorization process of Memphis.

Nevertheless, most parties find their financial aid by joining granted projects or consortia and is therefore a main motivation for parties to join this type of collaboration. For some parties, mainly the firms, the financial contribution of a consortium is not regarded necessary but only used as a determining factor to realize a collaboration with another party. And as the respondent of a large firm points out; "When developing new technologies, **time is more important than money**. However, time becomes money when the project does not achieve its targets on time".

4.3.3. The message

Nature & Applicability of knowledge

After struggling to design the program, the main advantage of Memphis is the **clear structure of the value chain**. Each party is aware of their contribution to a certain part of this process. The knowledge that is developed in the supporting (component of technology) work packages can be used and combined for the intended applications. The complementary character of a consortium is clearly visible and is considered positively by the parties. In this light, both universities and firms acknowledge the importance of the reusability of the developed knowledge. In their eyes, it is important that the project is not independent but that the developed technology can also be used for other applications. Therefore, when developing generic technology, like in this program, the applications are broader than the limits of the current consortium and increase the added value of program.

Still, in the value chain where many parties are linked, delay can easily occur if developments somewhere in the chain hamper or fail. So for example, if (component) parts of an application are developed at different organizations, then combining the parts for the end result will delay if one of the parts is not fully developed or even failing. In order to create value, efforts should be directed to **tackle hampering conditions**. An university in a larger sub-project says that "it is always possible that technological developments hamper. However, it is sometimes difficult to find out what went wrong during the process". Also, reaching the final phase of the value chain is restricted by its sort time focus because in most cases the combination of components is not realized yet and a follow-up program is needed to focus more on the actual integration. In some cases this is even more hindered by the lack of expertise of external parties as it involves radical innovations that are needed to extend the standard or scientific infrastructure for the photonic technologies. The missing link towards production and commercialization can hamper the valorization process of Memphis.

4.2.4. The transfer channel

In this program the collaborative research activities are an important form of knowledge transfer. They stimulate application driven developments and create learning environments for employees. Transfer channels facilitate knowledge sharing during projects and can positively influence the valorization process. Managing these channels is essential for preventing developments to hamper or fail. Therefore, for each project a 'work package leader' is chosen to coordinate the developments of the partners in the project but also to communicate with the other work package leaders. Most work package leaders organize technical **project meetings** to ensure progress. The frequency of such meetings differs per project but are mostly once every three or four weeks and exist of face-to-face meetings or conference calls. During these meetings, contacts between the partners are maintained and communication is used to find solutions for problems or to discuss different visions. Universities for example tend to have more focus for publications than for the development of applications. "Therefore, it is important to create common grounds and to fit the converging needs of partners", states one of the work package leaders. These meetings are also used to keep the researchers focused otherwise they will think "nobody cares" and go their own way, says a respondent of a public research institute. To underline the importance of knowledge sharing, an improved electronic database was suggested to keep up to date with developments. An electronic sharing system was used to distribute progress reports and to **share know-how** developed at different organizations.

All partners indicate **the annual meetings**, where all partners of the consortium are joined, as very valuable and a direct motivation to participate in the Memphis program. The information of partners presented during these meetings can be applicable for other projects. The meetings are used to share knowledge and skills and provide an overview of developments in the consortium. Partners can decide if and how they deploy information for their own project before this knowledge is published in scientific papers. The presence of specialized partners of the same industry also allows research groups to ask questions and to collaboratively find solutions.

Joining project- or consortium meetings also brings **overhead** for the work package leaders that are responsible for the transparency of their projects. Reporting to partners on each level is time consuming but stimulated by the management team that coordinates the program. One of the work package leaders states that within the consortium there is easy access to the detail of partners with specific knowledge which makes reporting unnecessary. Reporting is therefore not necessary if it is well known what each partner is developing and what their (personal) details are.

5. Conclusion

This research was carried out to determine how value is added when scientific knowledge is taken up into new applications. The translation is made towards the end-user, who is not part of the knowledge transfer process but strongly depends on it as it uses the application that is developed during this process. Therefore, a distinction was made between the 'value added process' and the 'knowledge transfer process' and they were analyzed separately to;

1.) develop a typology of valorization

2.) analyze the effects of science-industry collaboration networks on the valorization process.

In order to draw conclusions on valorization process, the definition of 'valorization' was revised to generate clarity on what it covers and where it should lead to. The results show a more in-depth definition with more meaning towards the social and economic contributions of valorization. This new concept of valorization is not derived from (higher) project management but from the project actors. Here, the scientific parties as well as the firms all indicate the same aspects as important for 'valorization' namely, *application driven development*, *education* and *the creation of new businesses*. For the valorization process, the views of the partners must be synchronized on the subject and the visions of the partners must be matched to create more focus. In this case, the different interests of partners for joining the collaboration are more relevant assuming that all their needs will be fulfilled as long as they reach their goal and create the added value.

The efforts aimed at implementing a technology are based on intervening at a certain level in the Maslow hierarchy. The classification of needs was used as a guideline for determining the success of the valorization process. Analysis of the four external actor groups that were inducted (consortium member, third party, retailer and end-user) shows that the firms use the application driven development to create competitive advantage by being the 'first mover' in the market or by overruling the current competition with technological improvements. The scientific parties on the other hand fulfill the need to deliver a scientific contribution. The consortium contributed to a certain scientific infrastructure in the Netherlands and also resulted in start-ups and patents. Valorization is also reached since the program contributed to the education of highly skilled employment.

The current shift towards more science-industry collaboration leads to more intensive collaborations, but also leads to differences in e.g. knowledge, competences and motives and can hamper knowledge sharing between partners. The knowledge transfer system supports the valorization process by developing the needed technologies during industry-science collaboration.

Results show that needs of end-users do not depend on the collaboration of partners since for example medical and communication needs will always be present in societies. The developments and knowledge sharing in the projects do however influence the rate of fulfillment. By designing the program in such way that knowledge sharing is facilitated, the (influence of) the outcomes of science-industry collaborations will increase. Moreover, most actors in the value chain contribute to the valorization process of Memphis by developing, producing or using the outcomes of application driven development. But the rate of valorization also increased by creating start-ups, developing scientific infrastructure and contributing to the education of people.

6. Discussion

In this research, data from the case study of Memphis was used to draw conclusions and provide the reader with recommendations on the valorization process within science-industry collaborations. The Memphis program provides many data on the collaborated parties and the multiple application projects. Although there are many more science-industry collaborations, this program is unique due to its structure and focus on a certain technology principle (photonics and electronics). The results are therefore case dependent. The insights on the effect of implementing certain applications can be used to show the societal influences of science-industry collaborations and findings on the knowledge transfer system can be used for prospective follow-up programs.

Furthermore, this study only focuses on one part of the valorization process of Memphis. During this research, the data of six application projects were used. But the program also consists of 'component', 'technology' and 'process' projects where scientific and industrial parties are collaborating. The results of the projects are fundamental building blocks that can be valorized and be applied in many different components and applications. These projects are nevertheless even more fundamental than the application projects where Memphis targets at concrete projects. A valorization study on these projects is therefore too complex and too early.

The data were mostly collected from the interviews with partners and work package leaders of each project for the best inside information. The interviews were arranged upon instructions of the project management. This is the same party that coordinates the program but also decides who joins and how the collected grants are divided. For the project management the subject of valorization is very important since it shows the societal and economical benefits of the program. The partners that were interviewed might have been influenced by this information.
Furthermore, during the interviews most respondents knew the term 'valorization' from what the government acknowledges by it. However, this did not restrain them share their experiences and to give their own vision on the subject and provide more in-depth insights.

All in all, this research aimed to develop a typology of valorization and to analyze the effects of science-industry collaboration networks on the valorization process. The results show that it is important that a typology of valorization is developed from what the people that are enabling valorization think it is and not from what the government or project management think what valorization means. This way, consensus can be reached on the visions and goals for the project and next the needed capabilities and resources of the parties can be determined and exploited.

This research on the typology of valorization can be extended to focus on the views on valorization of other industries and to see what the effects are if these views are different.

The second part of the research was aimed at analyzing the network factors that determine valorization and determine the effects of applications on individual level. Here the societal needs of the individuals from all applications were highlighted. More in-depth research could be done on each application itself to analyze the specific effects on implementing an application as well as the management needed to accomplish that. For all applications, the data of this research could be compared with results of studies in 5 or 10 years when the end-user actually benefits from the application. Furthermore, the focus of the study on knowledge transfer systems was on the overall organizational factors and motivations. This could be extended with an analysis of the financial and legal factors that can influence science-industry collaborations. Overall, this research is based on 15 cases in the photonic industry but more research is needed on other industries and (international) markets.

7. Managerial recommendations

The results of the research were based on Memphis Smart Mix program and mostly case dependent. Therefore, recommendations for improvement will be most relevant for future project managers of follow-up programs of this consortium. However, other consortium leaders and policy makers can use the findings as first practice and embrace the general advice on communication to not step in the same pitfalls.

i. The lack of financial resources is indicated as a main hampering condition for technological developments and joining granted projects or consortia is seen as a solution. However, this depends on governmental supported projects while the number and budget of such projects decreases. Therefore, project managers have to find other solutions in the future. For example by involving larger industrial parties early in the research phase or creating start-ups or spin-offs that are needed to reach the production phase and can be supported by for example venture capitalists. This research shows that creating new businesses is also an important part of the valorization process.

ii. In order to manage the value chain and clarify the intentions and the goals of the program, clear and structured communication is needed, starting early in the program. Very important for the communication are the project and annual meetings where targets that are set at the beginning of the program can be clarified and progress can be monitored. Results of this research indicated that a clear structure is needed to create synergy between the developments in the work package. But also the commitment of researchers is essential to achieved a common goal. The project can only succeed if the partners in a project work towards the same goal or have the same expectations. And also the visions of valorization must be indicated as there must be coherence between the partners about the definition. The main solution here is to start the project with a common (scientific) theme. This theme is interesting for developments in the industry but also allows attractive fundamental research. As one of the respondents points out: "There are so many fun subjects that can be researched; so the philosophy must be: if you can choose, choose something that is useful for the industry".

iii. The richness of a program such as Memphis comes not only from the economic benefits from application driven development. Results of this research show that additional outcomes like knowledge sharing and education are also important aspects of consortia. For example, the essential production phase is difficult for most (scientific) partners and solutions for this problem can be sought within the consortium. The facilities for testing of the universities/ scientific parties can be used by partners that cannot afford it. Also, during the program highly-skilled researchers are educated in a field of science that has increasing industrial potential. The industry is looking for skilled employees and if they cannot find it in the Netherlands, they will try to search in other countries. "Therefore, to show the value of Memphis, you also have to show where those people are working now," states one of the respondents, "that is the flow of knowledge". And this is essential for the maintenance of the rich knowledge base in the Netherlands.

iv. The Memphis program was presented as a program where building blocks can be combined to develop applications but in most cases the combination of components is not realized yet and a follow-up program is needed to focus more on the actual integration. Results point out that in this consortium the link towards production and implementation is missing and this can hamper the valorization process. Therefore, the parties that can realize integration and commercialization must be attracted and involved in the development process. This way, end-to-end development is realized. Furthermore, the work packages find themselves between market pull and technology push as they are developing an innovative technology. Often the market still needs to be defined. A valorization strategy allows to design a consortium structure effectively, to involve requirements of the market into the application, to coordinate the development projects and enables to create value with the science-industry collaboration.

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Appendix I Description of the application market

Application markets

The next section provides an overview of the assessed application markets of the Memphis consortium.

Medical and Healthcare

By the application of optical methods in examination, diagnosis, therapy and surgery, the modern health care has been revolutionized. The electronic-photonic devices can contribute for example to more efficient diagnoses and new analytical methods can give new insights in cellular processes. Due to cost reduction by mass production, in later stages, the sophisticated devices generated based on electronic and photonic technologies might even be available for use in workplaces and homes. This way early detection and prevention of diseases is possible which can prevent unpleasant and costly treatments. The innovations in health and life science through photonics will most likely be driven in four application fields with several topics: Cell and molecular biology, advanced and early diagnosis, preventive medicine and minimally invasive and personalized therapies.

Communication and Information

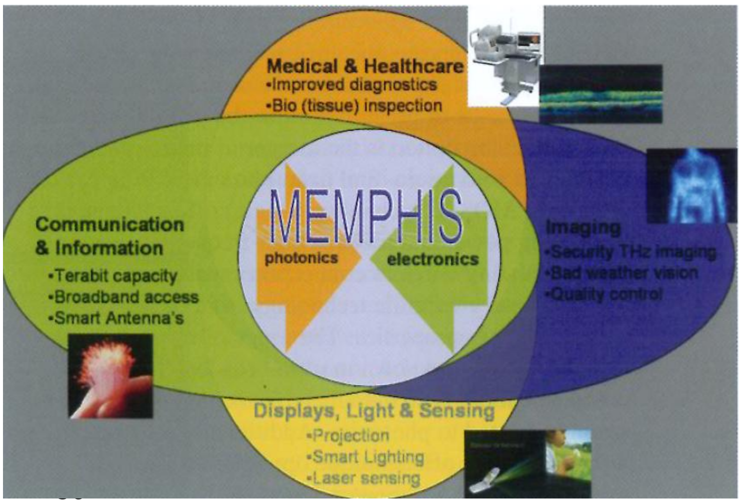
The development of the information society is in need of the improvement of the processing, storage, transport and the visualization of huge masses of data. The information flow and data streams are rapidly increasing and electronic-photonic devices enable to keep up with these changes. Due to the rise of high bandwidth applications such as internet protocol and high definition television, new components and architecture are needed that support bandwidth growth up to 100-1000 times of the current broadband services. Ultimately this can result in a year to year 'cost per bit' cost reduction and bandwidth enhancement.

Imaging

The interpretation of images shifts from the human operator to smart systems that make or prepare decisions. Imaging is increasingly applied in automated and semi-automated environments. Therefore different type of information is needed from the imaging system i.e. distance information, types of objects and chemical composition. These devices can be applied in markets like the automotive industry, security and medical application areas. The so called 'smart antennas' allow for compact systems with the capability of very fast beam scanning and with the increase of frequency these systems meet with the need for increased resolution.

Displays, Light and Sensing

Illumination with laser light sources and the visualization of information by laser displays are new applications with high market growth potential. The development of the illumination with laser light sources has progressed rapidly and can be used as light sources to combine structured and dynamic illumination on free shaped surfaces with additional visualization of information. Further research is needed to make the lighting products more efficient. In addition, lighting systems using the so called 'solid-state light sources' create useful surroundings and save energy . The energy worldwide used for lighting is enormous and the need for lighting will further increase in the near future. This



energy can be saved by introducing solid-state lighting like LEDs and lasers. The laser can be the new source of lighting for applications combining high brightness, low divergence, a small bandwidth and high efficiency in a smaller form. More research and development is needed before the visible laser can be a feasible product for the mass consumer market.

Appendix II Interview schedule

Introduction

My name is Anne den Haan, Student Science and Innovation Management. With this interview I try to collect data for two research questions:

The valorization research of Berenschot focuses on the valorization process of the Memphis program and consists of three phases:

> **Phase 1:** Identifying the current position of the components, applications, technologies, processes and building blocks from the Memphis program.
>
> **Phase 2:** Identifying the market potential for components, applications, technologies, processes and building blocks from the Memphis program and create valorization strategy.
>
> **Phase 3:** Identifying the requirements for the follow-up program Memphis II .

By exploring the characteristics of the applications, components, technologies and processes as well as the potentials of these subprograms, possible gaps in the program can be identified. It is important that the gaps will be filled up in the follow-up program (Memphis II) and that the market potential will be carried out. Once this is known, requirements can be set for new parties to join or to assist. The effect is twofold: with the identified market potential and supporting parties, Memphis I can move to the next phase (valorization), and with the identified gaps in the program and the identified technologies /parties needed to fill up those gaps, the current program can move to the follow-up program (Memphis II).

Furthermore, the contribution of *my master thesis on valorization* is twofold. First, a typology of the value adding- or valorization process is developed which will combine the knowledge on R&D clusters as well as the knowledge to classify the needs of an actor. Second, the effect of networks and combinations of characteristics within such networks, on the valorization process is defined and analyzed.

Procedure: First some general questions, next the technological questions, followed by the organizational and market related questions.

This interview will be recorded.

Memphis

What are the most important developments in the photonic sector in the last 5 years? What will be the most important challenges in the photonic sector for the next years?

What was the most important reason to join this collaboration project?

Before entering this project, what benefits did you think to gain from such large scale consortium, instead of a smaller partnership? Did these benefits came forward during the project? Are there any disadvantages?

How would you define ‘valorization’? And what is your view on this topic (and on valorization for the photonic sector)?

Work package

Can you tell something more about the technology? What is the current phase of the technology? (Proof of Principle, Proof of Concept, Prototype, Demonstrator, Product)

What is needed to proceed to the next phase with the technology? What are current barriers?

Critical parameters[1]

Financial/ organizational

Can you give an estimation of the investment that is needed to implement this product on the market? Does your organization have sufficient resources for this investment? If not, what would be a solution (grants, investors, other partnerships, ...) Is there enough knowledge to continue these developments? (within the company, outside the company (National, International), at SMEs, universities, research institutes, multinational) And are there enough researchers / developers with the needed knowledge available? (within the company, with partners, from the labor market). What will you do if the resources (financial, knowledge, personnel) are not available?

How can the current parties in the work package contribute to the points mentioned above? What kind of other parties are needed for the technology / application to proceed to the next phase? And what are the specific aspects that can be contributed by these parties?'

Market

How can the technology / application actually applied? What are the Unique Selling Points? What is the target user group (application market?)? What is the size of the target user group (quantitative, order of magnitude)? Why these end users (financially the most beneficial, or a high fulfillment of needs ?) And what is the added value for this group? What specific needs can be fulfilled by the technology? What is the broader social value? Do you have ideas on how this target user group can be reached?

Is there anything known about competition? In what stage are they and do they have the same target user group? What is the incumbent technology to be replaced? And do you see that happen in the coming years?

Partnership

Who are currently the main partners? Should this have been more / less partners for more efficiency? What is important for communication? (What channels do you use and how often?) On what kind of issues is there (mutual) misunderstanding / miscommunication? Do you see a positive factor in the current collaboration? What improvements, for this collaboration, would you like to see in a possible follow-up project?

Project

Did this project meet with your previously mentioned expectations? And when is this work package a success for you personally? And when is the Memphis project a success for you personally and as an organization?

[1] As this data is very quantitative, the interview questions on critical parameters for the technologies were replaced by a online questionnaire that was sent to all participants.