Inter- & Intradepartmental Knowledge Management Barriers when Offering Single Unit Solutions

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ABSTRACT

Single unit solutions become increasingly important in the Business-to-Business market where, e.g., already existing production facilities of the customer require that new products obey to the integral quality constraint while meeting the customer's functionality requirements. In order to be competitive, suppliers must be able to fast identify the essential criteria to generate a fitting solution that optimally exploits available components and minimizes the adaptive work. This process of identification is critical, as even minor variations of a contract may substantially increase the production effort, an effect that can typically only be controlled by high engineering expertise. It is the high frequency in which the sales force has to produce offers for single unit solutions which makes the communication between the sales and the engineering department a bottleneck and correspondingly optimized knowledge management a critical challenge.

The thesis therefore analyses, to my knowledge for the first time, inter- & intradepartmental *knowledge management barriers* and their implications in the context of single unit solutions. This analysis aggregates the results of a literature review and the feedback of an empirical study. It reveals strong interdependencies between (the four categories of) the knowledge management barriers and identifies three measures for overcoming them in order to establish a culture of knowledge sharing: Providing *standardized processes,* e.g., to know when and how to share what, *transparent managerial communication* and *organization-oriented incentives* in order to establish a global culture of trust and common goals, and *IT-based knowledge management* to provide up-to-date knowledge and bridge the semantic barriers. As these measurements need some time to show their benefits and are only effective in combination, this emphasizes the role of the top management which has to allocate a quite substantial budget and to set the scene for a simultaneous start.

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Keywords

Inter- & Intradepartmental Knowledge Management, Knowledge Management Barriers, Single Unit Solution, Semantic Barriers, Standardized Internal Processes, IT-based Knowledge Management.

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1. INTRODUCTION

Roughly two years ago at an international conference a representative of a large manufacturing organization stated the urgent need for an organization wide communication infrastructure that enforces inter-&intradepartmental alignment and eases the internal processes from customer request to the final product installation at the customer's site. Based on this demand-pull in the STAR project of the Innovation and Entrepreneurship module a student team investigated the internal communication and alignment problems at several organizations from different industries. The envisioned IT solution, the Global Communication Infrastructure (GCI), was subsequently elaborated and presented at an international conference (Hessenkämper & Steffen, 2015).

Back then the focus was on the internal communication problems and their implied most severe negative consequences. The investigation revealed that different industries have quite different levels of knowledge management (KM) standards. Most striking was the difference between the IT and manufacturing industries where the former struggled significantly less. Despite these differences all organizations showed great potential for improvement as especially the diversity and complexity caused by human factors make this topic so challenging.

This thesis aims at the identification of the knowledge management barriers (KMB) that impede the internal KM and thereby the organizations' competitiveness. Based on the findings, the thesis proposes KM enablers and strategies for overarching solutions.

As the Professor of computer science and director of a Fraunhofer Institute stated, "today there is a clear trend towards customer specific solutions in terms of either customization or even the offer of single unit solutions". Hence, the entire development of the thesis focuses on manufacturing organizations that operate in the Business-to-Business market and offer single unit solutions (SUS) to their customers: according to the Senior Director Software Design of a globally operating manufacturing firm they represent the target group that appeared most severely affected by KMBs. The main reason for this vulnerability is the fact that SUS projects are particularly complex and require many stakeholders with different backgrounds. Additionally, the often tight time frame combined with novel requirements lead to high uncertainty. This combination makes accurate information retrieval and the management of the social interactions between different participants a necessity, leading to efficient knowledge sharing (Santos et al., 2012). In this study the SUS projects and the corresponding KMBs are especially analyzed from the sales and engineering perspectives as their interplay is key for SUS-related decision-making.

2. RESEARCH PROBLEM

In Business-to-Business markets, suppliers are often in direct competition with each other as customers typically call for proposals as a decision base before they award a contract for a business critical project. Thus winning a project requires a careful analysis of the customer's problem and the design of a tailored (single unit) solution that convinces the customer of this supplier's superiority. In order to successfully achieve this in a short timeframe and at affordable cost, best in class internal processes and an interdisciplinary alignment are mandatory to assemble the needed, typically interdepartmentally distributed information and to run the order with full customer satisfaction. Especially the (regional-) sales department has to be provided with the best possible information from development, construction, production, sales and various other departments 24/7 to provide 'just in time' offers with maximum reliability.

Today's internal KM strategies do not seem to be satisfactory yet as research estimates that ineffective KM is costing US Fortune 500 companies a lot of money accumulating to a loss of around $31.5 billion yearly due to knowledge sharing failures (Babcock, 2004 as cited in Massingham & Massingham, 2014).

These failures result from organizations struggling with many different KMBs (e.g. employees hesitating to share knowledge, inadequate information technologies in place, lack of time and resources etc.) Thus they fail to accomplish the continuous, streamlined and directed knowledge and information exchange required for the efficient division of labor that is needed to coordinate the internal processes between the organization's different departments. Good KM is a distinguishing factor that constitutes a major competitive advantage: knowledge is a highly valuable organizational resource and its efficient and effective management difficult to accomplish (Ragab & Arisha, 2013; Argote & Ingram, 2000; Chang & Lin, 2015).

This thesis addresses, to my knowledge for the first time, the role and impact of KMBs on SUS projects. Therefore, it aims at identifying the major KMBs when offering SUS, elicits their consequences, reveals the essential requirements for establishing a satisfactory corresponding KM strategy and proposes solution approaches.

Accordingly the **research question** is:

What are inter-& intradepartmental knowledge management barriers and their implications faced by large manufacturing organizations when offering single unit solutions to other businesses?

2.1 Academic and Practical Relevance

2.1.1 Academic Relevance

The thesis investigates an economically important research question, the impact of KMBs on the efficiency and effectiveness of SUS project handling, which is a currently under-researched context in the Business-to-Business market. It analyzes several key concepts via a literature research in order to reveal how they depend on each other, to which extent they act as barriers, and which consequences they impose. This analysis is complemented by an empirical study at an organization fitting the focus of this thesis in order to validate the relevance of the barriers in the targeted context, understand their implications, and learn how the organization currently deals with them. As the customers' demand for rising flexibility is expected to grow in the future this research has the potential to serve as a basis for future research.

2.1.2 Practical Relevance

The practical impact of this research is the identification of major communication bottlenecks that hamper SUS projects, increase the time to market, lower the quality to market, and often impede that an order is won at all. The investigation of the inter- & intradepartmental KMBs reveals ways to overcome the current communication barriers by aligning the sales process, production process, and even the maintenance process. This alignment and communication has a strong impact on time and quality to market and total cost of ownership (TCO), making SUSs attractive when competing against mass customization offers. TCO refers here to all cost issues like fixed and variable costs involved in the customer - supplier relationships (Ellram, 2002). Therefore, the goal of the study is to prepare recommendations to the management for addressing the KMBs and to identify the key requirements for novel IT-based KM solutions for supporting SUS projects.

2.1.3 Outline of the Thesis

The motivation and background of the concept of interest will be presented in Chapter 3. It describes the market changes, the required externally visible rising suppliers' flexibility encompassing an assortment of standard, mass customization, and SUS offers and the imposed impact on internal adaptations regarding knowledge-driven product development ranging from new product development to SUS. The highlighted differences ask for specific handling and therewith face different KMBs. After presenting the applied methodology in Chapter 4, Chapter 5 identifies and discusses in a literature review the relevant KMBs. In Chapter 6 they are validated, complemented and their negative consequences addressed via semi-structured interviews at a globally operating manufacturing organization that matches the thesis' target group. Subsequently, in Chapter 7 the focus is lifted from the individual project to a more global perspective that prepares organizations to competitively offer SUSs by standardizing the handling of customer requests. Here several approaches to solutions are proposed that however struggle with their own set of KMBs and barriers to change. Based on this outcome, the final three Chapters are the discussion, conclusion and limitations and proposed next steps.

3. MOTIVATION AND BACKGROUND

This chapter describes the market changes that motivate organizations to counter the commoditization effect and satisfy the rising expectations of their customers by offering product ranges from standard products, to mass customization, to SUS. These categories differ significantly from each other, therefore there is a need to flexibilize the internal processes on the supplier side to effectively handle the scope of these three offer categorizations. The major challenge is the required KM, which is currently hampered by several KMBs leading to misconceptions, redundant work, and unnecessary delays. These shortcomings of the current practice explains the necessity to identify, analyze and tackle KMBs in particular for organizations offering SUS.

3.1 Market Changes

Continuous market changes require organizations to constantly adapt to stay competitive and survive. Thus standard and mass customization alone cannot satisfy the rising customers' expectations. This is also confirmed by Sharma and Iyer (2011, p. 723) stating that "increased competition due to globalization and therefore increased commoditization of products, have led firms in several industries to competitively differentiate their offerings through the development of sales of solutions (…)". In this thesis, solutions are defined as "individualized offers for complex customer problems (…) whose components offer an integrative added value by combining products and/or services so that the value is more than the sum of its components" (Evanschitzky et al., 2011, p.657). When designing a solution it is therefore important to clearly understand the customer problem which can be done via defining the customer's desired outcome ("what") and how to get there ("how") (Sawhney, 2004; Hessenkämper & Steffen, 2015).

The decision of offering SUS on the Business-to-Business market has a major impact on the organization's strategy and culture, its internal processes, and the development of the final products, and leads to distinguished characteristics and requirements (Wilken & Jacob, 2015). The organization has to exploit its current resources and capabilities while taking advantage of the changes in the external environment which makes the organization's absorptive capacity as well as the organizations memory of particular relevance (Rabeh et al., 2013). Further, on the project level the sales cycle takes longer and requires a great amount of effort as the organization first needs to understand the customer's problems via ongoing communication before it can develop a suiting proposal (Sawhney, 2004). In this context, inter- & intradepartmental KM is the crucial basis for developing satisfying solutions timely and cheaply, this way sustaining the organization's competitiveness.

Especially, production-oriented organizations in industrialized environments recognized the potential that they can increase their margin, customer loyalty, and retention via individualized solutions as the fierce competition is otherwise just price driven (Evanschitzky et al., 2011). A good example of such a market is Germany, where around 60% of the produced machines and products in the mechanical engineering industry were adapted and customized based on customer wishes (Widmaier, 1996; Sturm & Bading, 2008; Jacob & Kleinaltenkamp, 2015, p. 278). This is not surprising as the Business-to-Business market is characterized by integral quality constraints, i.e., by the requirement that the bought equipment must adhere to the existent infrastructure, processes, and products in place (Weiber & Ferreira, 2015). This constraint asks often for more invasive modifications of the final product, and therefore cannot be satisfied by just offering standard products or a pre-specified range of modular product customizations. Rather, SUS are often required to fully satisfy the customers (Fließ, 2015). Due to the fact that the customers have such specific requests and the high value of the order, they request proposals from several suppliers among which they then choose along the criteria: need satisfaction, product quality, price, and delivery time. The weight of the individual criteria depends on the specific customer needs.

However, not only the customer has a choice. Also the supplier needs to evaluate under which circumstances it makes sense to enter the acquisition phase, e.g. on the basis of the customer lifetime value, in order to ensure that the development of an individualized SUS is actually in the own best interest (Weiber & Ferreira, 2015). Customer lifetime value is defined as the expected future value a supplier generates from a customer. This evaluation is of importance as the offer generation costs resources in form of time and money, which are lost if the supplier does not win the order. Here, the value of the customer and of the product as well as the likelihood of winning the order must be considered, and the fact that, as SUSs need to be embedded in the customer's operations, the customer's loyalty increases while the likelihood of them changing the supplier decreases (Sawhney, 2004).

The importance of carefully choosing the right projects is further emphasized by Hildebrandt (1997) who revealed that offering customization typically implies direct advantages for the customer while the benefits for the supplier are mostly indirect and insufficient to compensate the direct disadvantages: the additional effort is often not covered by the relatively low profit margins due to an exploding diversity of the product portfolio (Jacob & Kleinaltenkamp, 2015). This problem needs to be tackled to ensure advantages for the supplier. One option is to offer solutions with only 20-30% customization while keeping the rest of the product fully standardized as it ensures that the rising complexity costs can be covered by higher margins thus preventing losses (Jacob, 1995, Schweikart, 1997 as cited in Fließ, 2015). This goal was confirmed by the Director Engineering & Application of a large manufacturing firm who stated "we aim to establish that only 20% of the development effort for a proposed SUS are customized while 80% remain standardized". The other option is "to mitigate the competence risk, [for which] solution providers need to progressively enhance their project and program management capabilities. To overcome the margin risk, solution providers need to proactively pursue the creation of repeatable solutions" (Sawhney, 2004, p.7). In this case investments are paid back in the long-term as the organization's investment in the specific solution increases the organization's assortment and therewith the likelihood that already developed solutions can satisfy future customers.

The criticality of the acquisition phase in the Business-to-Business market explains the importance of effective and efficient processes when deciding which offers to generate. The goal is to find a strategy and internal processes that successfully win orders and efficiently deploy the resources, leading to positive references and a competitive advantage. Therefore, it is important to find ways of ensuring that SUSs can reap financial and economic benefits.

However, the diversity resulting from SUS initiates a vicious cycle where the difficulty of adequate alignment impairs inter- & intradepartmental communication and leads to a lack of reuse, multiple re-inventions of the wheel, and therefore to an additionally increased largely unnecessary diversity (Ekambaram et al., 2010; supported by interviewees).

3.2 Suppliers' Rising Flexibility

A good example of a trade-off between offering solutions and standardized products is the less extreme and more common approach of mass customization, which has been growing in the last thirty years (Fogliatto et al., 2012). Companies noticed that it provides them with the opportunity to offer "unique value to their customers in an efficient manner" as depicted in Figure 1 (Gilmore & Pine, 1997, p.1). Here, the customers have the freedom to specify their desired product within the limitations of choice set by the supplier. This provides the supplier with certainty as, in contrast to SUSs, the effort for providing a product from a pre-defined range of choices is known. In cases where this range suffices this is a win-win situation: Customers typically benefit from fast delivery and moderate costs, while suppliers enjoy higher margins and 'economies of integration'. The latter ensures that the organizations are better informed about the current market trends, enabling them to stay up-to-date regarding the newest trends and to benefit from more loyal customers (Piller et al., 2004).

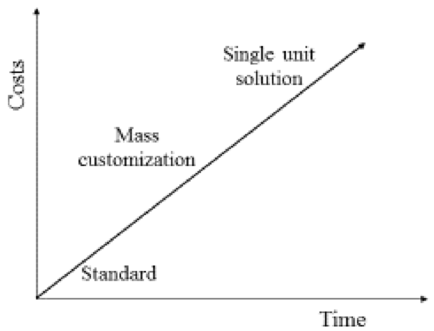

Figure 1: Cost and Time Differences

To reap the benefits of the above mentioned advantages, it is beneficial for the organizations to apply lean and agile strategies for mass customization. Mass customization in fact allows for and requires customer involvement, which generally leads to longer delivery times and higher costs (Squire et al., 2006). These negative consequences are much more severe when offering SUSs and must be countered to ensure that also the producers benefit from offering customization.

To enable efficient and effective mass customization, inter- & intradepartmental KM is of major importance to ensure e.g. the prevention of mistakes. A good KM fosters that the internal knowledge builds up to better ideas, offers and implementations. Here, it is beneficial to exploit the internal knowledge's reuse opportunity (Dixon, 2000). For mass customization, standardized processes and approaches are already in place, easing the product and project handling and allowing for automated and guided involvement of the important parties.

Table 1 compares the standard, mass customization, and SUS contexts, illustrating the major differences in the complexity of management based on findings from the interviews. Due to the fact that the strategy and context describing standardization and mass customization are well understood, it is beneficial to exploit the experiences and gained knowledge also for the SUS context. The goal is to adapt, modify, and build on the ideas and strategy driving mass customization efforts with the aim of making successful, efficient and reusable SUSs possible, e.g. enabling standardization in the processes and customer relationships and executing product composition techniques that allow to easily modify the end-product e.g. via modular architecture of the product, (Belz & Weibel, 2015; Backhaus & Voeth, 2014; Study from Maexparterns and VDMA, 2014). These process preparations as well as the daily workflow result in unique product configurations. They depend on smooth internal KM, in particular between the marketing/sales and R&D/engineering departments, in order to faithfully communicate the customer needs to the people responsible for the production.

Table 1: Differences among Standard, Mass Customization and Single Unit Solutions

Standard	Mass Customization	Single Unit Solution
Push	Push - Pull	Pull
Basic quality	Standardized customer satisfaction	Full customer satisfaction
Almost immediate delivery	Rather short delivery time	Quite long delivery time
Low price	Relatively low price	Relatively expensive
Fixed offer	Foreseen variability	Dedicated development
No customer involvement	Customer chosen configuration	Customer defined desired product
Predictable	Predictable	Unpredictable
Everything is known	Everything is known	Requires innovation and new development
Fixed process	Standardized process	Unique projects → complex processes
Little internal involvement	Involvement of a few stakeholders	Involvement of many stakeholders
Product performance is clear	Product performance is more or less clear	No guarantee of actual performance possible
Standard portfolio	Product portfolio offering variability	Exploding product portfolio
Indifferent relationship	Some loyalty	Loyal customers
Might lose track of market changes	Market changes are partly known via configuration changes	Direct link to market changes

In contrast to eastern civilizations, where knowledge is generally considered as tacit knowledge, the western civilization views knowledge often as explicit, formal and objective, so that it can be processed via computers (Bratianu & Orzea, 2010).

Knowledge can be further differentiated in three categories: theoretical knowledge from research, factual knowledge e.g. about a customer, and practice knowledge concerning how to do something (Trevithick, 2008 as cited in Bloice & Burnett, 2016).

In this thesis, knowledge is considered to be explicit, formal and objective, and to encompass theoretical, factual and practical knowledge in the form of documents, stored in people's heads or stored in KM systems like databases.

Zou and Lim (2002) defined KM as "(…) the management processes of creating, capturing, transferring, sharing, retrieving, and storing data, information, knowledge experiences, and skills by using appropriate information and network technology, with the endorsement of total involvement in organizational learning to enable knowledge acquisition throughout the processes". The highest level of successful KM is 'continuous learning and improvement', which implies that organizations should integrate and reuse experiences made in the past into current and future projects (Kerzner, 2006, Ladika, 2008 as cited in Shokri-Ghasabeh & Chileshe, 2014). In contrast, bad KM due to KMBs may easily lead to misunderstandings impairing customer satisfaction: sales people may not be able to propose the best option to the customer, and the engineers may construct a non-fitting solution. The internal KM should enable the sales force to judge the feasibility of the customer requirements and, together with the engineers, estimate the corresponding production time, costs and quality.

Additionally, also the knowledge transfer to and from the maintenance department to the other two departments becomes crucial in the later lifecycle of the product or machine. On the one hand, the maintenance team needs to know the specifics of the artifacts and machines they are responsible for. On the other hand, they may provide vital feedback from the field, e.g., about acceptance, reliability, losses due to guarantee violations, and imposed long-term costs that may influence the development of new products. Thus a smooth knowledge transfer does not only improve the productivity of maintenance, but it may as well strengthen the customer relationship.

3.3 Internal impact

When developing new standard and mass customization offers organizations generally apply the new product development approach. In this setting a dedicated project team is responsible for developing a well thought through and detailed new product category or new product model. Here the goal is to deploy a successful mix of "maximizing fit with customer requirements, minimizing time to market, and controlling development costs" (Schilling, 2013, p.251). This is mostly internally driven, meaning that the organization develops the products based on the findings and identified trends of the market analysis which they think best satisfies the needs of the general customer. In some cases lead users are involved in the process to actually challenge the features and propose valuable characteristics of the product. These projects normally take years to carry out depending on the scope of the project and the industry, in order to allow radical changes which in some cases might even impact the whole supply chain. This gives the project team sufficient time to adapt their communication in order to establish a level of mutual understanding which lowers existing communication barriers and with them the need for elaborate KM tooling.

SUS projects have a completely different character. They are triggered by a demand-pull of the customer who searches for a solution for a new problem. Here it is important to understand the customer's expectations and their specific problem before one can start to think of solutions (Santos et al., 2012). This customer-driven pull approach asks for high flexibility of the supplier who typically has to fulfill unique needs of many of his customers simultaneously in a relatively short timeframe. While each SUS project increases the variability potential or even the product portfolio, it also adds pressure on KM and by this decreases predictability. The main differences and challenges of SUS projects and new product development as revealed during the interviews are depicted in Table 2.

A particularly crucial aspect repeatedly mentioned in the interviews is the classification of customer requests, as the internal processes may drastically differ depending on seemingly small requirement differences.

Accordingly, organizations should clearly define the differences of the categories and rules for the categorization in order to support a correct assignment. Especially the differences between projects that need to be handled as mass customization or as SUS is not always clear. This often leads to situations in which engineers would have made different decisions than the sales force, but now do not have any other choice but to meet the stated contractual specifications, sometimes with major economic consequences.

Table 2: Differences between Single Unit Solutions and New Product Development

Single Unit Solutions	New Product Development
Pull (based on customer wishes)	Push (internal development)
Aligned with market trends	Based on market analyses (but no guarantee that customers will like it)
Leads to individual solutions fully satisfying the customers	Leads to standardized or mass customization offers by fully specifying the machine
Previously developed products get adapted	New products are built
Relatively short-term	Long-term
Many projects run simultaneously	Sole focus on single major projects
Team members are assigned to their functions while working on cross-functional, often geographically distributed projects	Fully dedicated team typically working together at the same location.
Lack of time and resources	Sufficient time and resources

3.4 Importance of Identifying KMBs

"The growing pressures from the external environment are encouraging companies to exploit their employees' critical knowledge" (Cavaliere et al., 2015, p. 1224). Therefore organizations aiming at constantly staying adapted even in changing markets need to be able to generate and maintain knowledge better and faster than their competitors (Gore & Gore, 1999 as cited in Bratianu & Orzea, 2010). Thus the competence of creating and applying new knowledge counts as a main source of competitive advantage (Leonard-Barton, 1990, Nonaka, 1994, Spender, 1996 and Zollo & Winter 2002 as cited in Bratianu & Orzea, 2010; Argote & Ingram, 2000). Due to the fact that it is one of the biggest challenges to distribute the right knowledge from the right people to the right people at the right time, KM is of major importance and separates the wheat from the chaff (Riege, 2005). This is especially relevant because inter- & intradepartmental KM has a strong impact on TCO for the supplier and the customer, in particular when offering SUS.

To strengthen the organizations competitiveness and to keep the TCO as small as possible it is important to improve KM. This requires to first identify the most severe KMBs and their sources in order to develop suitable counter measures. This is especially important due to the significant negative impact KMBs have on the internal processes. The main consequences of present KMBs identified in three interview rounds with five interviewees respectively are the following (Star project; Hessenkämper et al., 2014; Hessenkämper & Steffen, 2015):

- **Misalignment**: Little internal coordination resulting in faulty budget and timespan planning.
- **Lost knowledge**: On-site work remains undocumented and/ or information is distributed/hidden over various sources.
- **Non-conformity**: Previously developed (project) solutions are overseen leading to **re-inventions of the wheel**.
- **Difficult team composition:** There is no systematic support to match projects with employees' competence profiles.
- **Staff education***:* New employees need long training before they are fit for service.

This range of negative consequences shows the ubiquity of KMBs and their causes. They result from e.g. mistakes made on the organizational level, missing IT support, missing sharing and storing platforms, and individual barriers like personal differences or fear to become redundant.

This diversity also makes overarching (IT) solutions difficult as the heterogeneity of the data and systems and the lacking coordination of the involved parties, at least in current practice, prevents the knowledge from being available organization-wide, to all stakeholders who could benefit from it (Young et al., 2007).

4. METHODOLOGY

The applied research approach follows of Hevner's (2007) three cycle view of the design science research cycle, consisting of the relevance, design, and rigor cycles. Throughout the relevance cycle the environment is observed to identify problems and opportunities which require further research to be handled in the design cycle. The arising key concepts from the first analyses and literature review are grounded in the rigor cycle, to ensure that they fit the expertise and scientific theories and methods of state-of-the-art research. The quality and completeness of the findings are validated via empirical research at one large manufacturing organization when reconnecting the design and relevance cycle.

The relevance cycle was triggered by the observation that especially firms offering SUS have the need for an organization-wide KM solution overcoming the current KMB hurdles. In order to refine the requirements for such a solution a study was designed in the design cycle which required a literature review in the rigor cycle to get an overview of the state of the art research on KM and KMBs. To ensure the quality of the literature review the Journal of Knowledge Management was chosen as backbone: it is ranked first considering the citation impact and expert survey for KM literature in 2008 and 2013 (Serenko & Bontis, 2013). All papers published since 2012 were checked regarding their relevance for KM and KMB while the findings were complemented via specific keyword search on google scholar and Scopus with the following keywords 'knowledge management barriers', 'knowledge management', 'knowledge management enablers', 'single unit solution', 'knowledge management and single unit solutions', 'knowledge transfer' and 'knowledge sharing'.

More concretely, the findings from the literature review are addressing the KMBs potentially present in organizations derived from case studies, and other literature reviews. As no literature was found to directly address the SUS context, it is the role of the empirical study to close this gap and to narrow these general findings down to identify the existing KMBs in the SUS specific context which connects the design and relevance cycle.

The empirical study comprises thirteen semi-structured interviews with representatives from the SUS context. Nine of them belong to the same globally operating manufacturing firm whereas the other four belong to another firm operating in the same industry and other industries. The goal is to highlight the SUS context and its KMBs from different angles by interviewing people operating in managing positions of the two main involved departments (sales and engineering) who see the target-performance gap of internal SUS processes and know the causes. Their views are complemented with the perspectives of employees actually active in the day-to-day business or working in the SUS context of other industries.

To gather the information of interest the interviewees were asked about the context they are working in, their customers' requirements, and their SUS handling processes, here especially focusing on the existing KMBs in the internal processes.

Subsequently, they were asked about their satisfaction with the current internal processes and what they would like to change and why. The obtained information is used in Chapter 6.2 to establish requirements for a supporting IT system that are then used in Chapter 7 to propose the derived practical implications.

5. LITERATURE REVIEW

Riege (2005) identified three categories of KMBs, organizational barriers, technology barriers and individual barriers. In this thesis Riege's categorization is refined by one additional category, the *semantic barrier*. This new category is introduced to emphasize an important difference when it comes to overcoming existing individual barriers: whereas it is possible to influence the employees' willingness to share via adequate incentive schemes or guarantees to eliminate fear, differences in cultural background, education, and experience are much harder to bridge and therefore require a dedicated treatment. In fact, semantic barriers can (and should) probably not be eliminated. Rather, they require some kind of *mediation* in order to best exploit individual strength (see Chapter 7).

As Riege's paper is widely recognized and was applied and tested in many different contexts, it was adopted as the basis of the KMB literature review (Bloice & Burnett, 2016). In the literature review his findings were further supported and complemented by additional barriers. In this chapter the KMBs are enlisted separately according to their categories while their interdependencies are addressed along an overarching solution approach in Chapter 7.

5.1 Organizational Barriers

The organizational barriers as depicted in Table 3 generally do not constitute a barrier themselves, but rather influence the environment in which IT systems need to prove themselves valuable and in which individuals must be stimulated to act in the best interest of the organization by setting appropriate strategy and expectations.

If the KM strategy does not fit and is not well integrated into the organization's overall strategy, KM cannot be successfully integrated in the organization (Riege, 2005; Kukko, 2013). Here, it is important to acknowledge that the top-management itself sets the direction of the organization and for the KM and constitutes an example for everybody else. If the management fails to clearly communicate the benefits and importance of well-functioning KM then the corresponding IT systems may not be adopted widely enough, with the consequence that the accumulated knowledge may remain partial and the individuals are not encouraged to use and to contribute because of disappointing user experiences. This vicious cycle can (only) be overcome with top management support, as the organization's culture and the management's expectations are major factors influencing individual behaviour.

Table 3: Overview Organizational Barriers

Organizational Barriers	Sources
O1) Missing integration of KM strategy in the organization's goals and strategic approach	Riege, 2005; Kukko, 2013; Ranjbarfard et al., 2014
O2) Missing top management support and commitment	Singh & Kant, 2008; Williams, 2007; Shokri-Ghasabeh & Chileshe, 2014; Lee et al., 2012; Inkinen, 2016
O3) Lack of leadership and managerial direction regarding KM	Riege, 2005; Kukko, 2013; Cavaliere et al., 2015; Inkinen, 2016
O4) Orientation of organizational growth; too big business units	Mueller, 2012; Riege, 2005
O5) Poor organizational culture ❖ Competitive culture (e.g. between units) ❖ Lack of collaborative culture e.g. intolerance of mistakes ❖ Lack of learning culture	Ghobadi & D'Ambra, 2013; Riege, 2005; Singh & Kant, 2008; Mc Dermott, 1999, McDermott & O'Dell, 2001, Sharratt & Usoro, 2003 as cited in Bloice & Burnett, 2016; Wiewiora et al., 2013; Lee et al., 2012
O6) Poor organizational structure ❖ Formalized, centralized, bureaucratic, complex and hierarchical structure ❖ Lack of an organic, open, flat and flexible structure	Lin, 2008 as cited in Santos et al., 2012; De Long and Fahey, 2000, Nonaka and Takeuchi, 1995 as cited in Riege, 2005; Mc Dermott, 1999, McDermott & O'Dell, 2001, Sharratt & Usoro, 2003 as cited in Bloice & Burnett, 2016; Ghobadi & Mathiassen, 2014; Singh & Kant, 2008; Cavaliere et al., 2015
O7) Lack of infrastructure for continuous organizational learning	Riege, 2005
O8) Restricting work environment and layout	Riege, 2005; Coradi et al., 2015
O9) Shortage of knowledge sharing spaces	Riege, 2005; Kukko, 2013
O10) Lack of feedback loop	Stauss, 2007 as cited in Bloice & Burnett, 2016; Ranjbarfard et al., 2014
O11) Lack of methodology/ clear guidelines/job description	Singh & Kant, 2008; Williams, 2007; Ranjbarfard et al., 2014
O12) Lack of/ wrong HRM incentives	Singh & Kant, 2008; Williams, 2007; Riege, 2005; Oliva, 2014; Inkinen, 2016
O13) Missing adoption of KM systems	Santos et al., 2012

Especially competitive cultures are inhibiting as they push achievements and reward winning: they were found to generally stimulate knowledge hoarding and hesitancy to share knowledge. In particular, from the educational perspective they inhibit effective learning from mistakes as employees fear potential degradation if they openly admit failures (Wiewiora et al, 2013; Ghobadi & D'Ambra, 2013).

Collaborative cultures, on the contrary, thrive from informality, teamwork, and involvement, increasing the willingness of sharing information of any kinds: Positive experiences are shared to ensure repetition, and negative experiences are shared to avoid them in the future (Wiewiora et al., 2013; Ghboadi & D'Ambra, 2013). These kinds of organizational contexts encourage social interaction between the participants which is required for creating learning environments (Gonzalez et al., 2014).

However, if managers do not support and create an internal environment stimulating the employees to share their knowledge while also adopting and using it, they fail to enable a learning organization (Riege, 2005; Coradi et al., 2015). Also the organizational structure plays an important role here, as strict hierarchies and formalized and complex structures hamper effective knowledge sharing. This is especially a problem in larger organizations as the bigger the organization the more rules, regulations and formalization are in place to manage it effectively (Chase, 2004 as quoted by Riege, 2005). Therefore also a high growth orientation of an organization constitutes a KMB. "If the company hires many new employees, it is difficult to know each other because building relationships takes time" (Mueller, 2012, p. 441). Due to this, increasing business unit size and the resulting formality might hamper the internal trust, commitment and collaboration of the individual which impedes the openness to share knowledge (Riege, 2005).

Also the workspace arrangement and layout may hamper knowledge sharing and facilitate communication barriers. Missing multi-space workspaces which are shared by the different functions, e.g., impede and decrease knowledge sharing as they influence the accessibility and visibility of inter- and intra-functional colleagues (Coradi et al., 2015). Further, the lack of formal and informal knowledge sharing spaces and platforms prevents that knowledge can be virtually shared, stored and found (Riege, 2005 & Kukko, 2013).

Particularly important is a clear communication when introducing a new KM system. The imposed change in the processes and the way of handling things must be internally promoted and supported in order to prevent that the employees switch back to their old habits after a few weeks due to convenience (Santos et al., 2012).

For functioning KM, HRM incentives should be in place which in the best case should explicitly enforce the given work and process guidelines of how to handle specific situations enabling a continuous improvement cycle. However, current incentives typically address the individual's performance. This often stimulates behaviour not in the best interest of the overall organization. E.g. expert knowledge may be regarded as a personal competitive advantage rather than a sharable resource the whole organization can benefit from.

5.2 Technology Barriers

Nowadays the importance and benefits of knowledge sharing are widely recognized, however "the accessibility of knowledge is still limited because most knowledge resides in the head of people (…) or in documents or repositories (sources of explicit knowledge) not readily accessible to others" (Riege, 2005, p.19; Bloice & Burnett, 2016). Even in R&D project contexts dealing with high complexity requiring close cooperation, knowledge sharing is often run via e-mail which cost time to write and take much time before receiving feedback (Santos et al., 2012).

An overview of the KMBs from the technology perspective can be found in Table 4.

Table 4: Overview Technology Barriers

Technology Barriers	Sources
T1) Lack of technological infrastructure and support	Singh & Kant, 2008; Riege, 2005; Lee et al., 2012; Ranjbarfard et al., 2014
T2) Lack of compatibility between IT systems and processes	Riege, 2005; Santos et al., 2012
T3) Lack of knowledge process capabilities through IT	Lee et al., 2012
T4) Limited access to knowledge sources	Bloice & Burnett, 2016
T5) Mismatch between the employee's actual needs and the IT solutions	Riege, 2005
T6) Existent tools are not user friendly	Santos et al., 2012
T7) Excessive use of wrong media e.g. e-mails	Santos et al., 2012
T8) Lack of communication/ demonstration of the new IT system's advantages	Riege, 2005; Kukko, 2013
T9) Reluctance to use new systems e.g. due to lack of familiarity	Nicolini et al., 2008, Lettieri et al., 2004 as cited in Bloice & Burnett, 2016; Riege, 2005; Kukko, 2013
T10) Lack of employee training familiarizing them with the IT systems	Riege, 2005; Tan & Anumba, 2010 as cited in Javernick-Will, 2012
T11) Codification process: ❖ Difficulties in transferring knowledge into an appropriate format ❖ Incapacity to structure and share knowledge in different formats	Santos et al., 2012
T12) Information overload	Santos et al., 2012
T13) Lacking information quality due to incorrect and irrelevant information	Gorla, et al., 2010 as cited in Ghobadi & D'Ambra, 2013

The adoption of an IT infrastructure is envisioned to enable the large scale collection, storage and exchange of diverse knowledge in many different types like documents and pictures without being restricted by geographical dispersion. Therefore, "it contributes to the improvement of organizational learning and performance by facilitating KM processes" where the broader the scope of the IT infrastructure, the better the KM processes (Lee et al., 2012, p. 188). However, the problem and difficulty is to develop and integrate an IT infrastructure in the internal processes which meets the employees' demands, is user-friendly, and ensures alignment and compatibility between the different IT systems (Riege, 2005; Santos et al., 2012). Another challenge is the codification problem of how and in which format to transfer the knowledge into the IT infrastructure or from one IT tool to another (Santos et al., 2012).

A particular hurdle to the adoption of IT systems is the unsatisfactory match with the actual needs hiding the potential benefits behind unfamiliar processes (Riege, 2005; Kukko, 2013; Tan & Anumba, 2012 as cited in Javernick-Will, 2012). To tackle this problem the top-management would need to clearly communicate the envisioned benefits while workshops should train the employees in handling the new processes.

The perhaps most crucial aspect is the knowledge quality (Gorla et al., 2010 as cited in Ghobadi & D'Ambra, 2013). Even if the IT infrastructure is in place and would work perfectly, if it is filled with incorrect and irrelevant information, it is not supportive and might even impair the quality of the end-product. Also information overload resulting from excessive sharing hampers the overall productivity of the organization as it costs time to identify the relevant information and to separate the 'wheat from the chaff' (Santos et al., 2012). Therefore, clear codification guidelines need to be in place, to restrict the knowledge being shared and the format in which it is shared making it easily retrievable and understandable.

The ultimate challenge is then to integrate and share the information and experience gathered and learned throughout the projects so that the project management as well as the support of future projects can benefit from it, preventing re-inventions of the wheel. However, up until now no satisfying solutions are in place which actually allow a global and integrated organization-wide KM system (Young et al., 2007; Kerzner, 2006 as cited in Shokri-Ghasabeh & Chileshe, 2014).

5.3 Individual Barriers

The major KMBs from the category of the individual barriers are lacking commitment, trust, intrinsic motivation, time and resources which lead to knowledge hoarding and resistance of adopting the knowledge of others. A more detailed overview of the KMBs can be found in Table 5 underneath.

The cooperative model of knowledge sharing states that the perception of knowledge sharing depends on the value of the knowledge being shared and the individuals' perception of the gained or lost payoffs by sharing knowledge (Loebecke et al., 1999 as cited in Ghobadi & D'Ambra, 2013). This implies that to increase the knowledge sharing inclination employees need to be aware of its overall advantages for the organization and for the individual personally (Shokri-Ghasabeh & Chileshe, 2014). Another important aspect is that the more the individual perceives the own knowledge as personal property rather than as the organization's property the less likely are they to engage in knowledge sharing (Peng, 2013).

Further, employees must trust each other and the knowledge gained, shared, and possessed to engage in knowledge sharing (Ardichvili, 2003). If employees e.g. fear criticism or are afraid that their knowledge will mislead others due to potential inaccuracy and missing relevance they might hesitate to engage in knowledge sharing (Ardichvili et al., 2003). If employees experience "negative acts representing psychological contract breach [it] elucidates the associated state of reduced trust and justice, leading to an increase of knowledge hoarding behaviours over time" (Holten et al., 2016, p. 224). Nevertheless, hoarding knowledge due to trust issues in the form of, e.g., refusing the adoption of solutions by others (often described as the 'not invented here' syndrome) and lacking trust due to geographical dispersion often lead to the problem of internally re-inventing the wheel. Unnecessary duplication costs time and money and could only be prevented by regular meetings that build trust (Santos et al., 2012).

Table 5: Overview Individual Barriers

Individual Barriers	Sources
I1) Individual's lack commitment/initiative due to e.g. laziness	Santos et al., 2012; Jo & Joo, 2011 as cited in Bloice & Burnett, 2016
I2) Lack of trust ❖ in knowledge gained from practice and others ❖ in others due to potential knowledge misuse ❖ as others might take unjust credit for it ❖ in the value of own knowledge	Riege 2005; Bloice & Burnett, 2016; Tan & Anumba, 2010 as cited in Javernick-Will, 2012; Kukko, 2013; Holten et al., 2016; Casimir et al., 2012; Ardichvili et al., 2003
I3) Lack of intrinsic motivation	Ghobadi & Mathiassen, 2014; Cavaliere, et al., 2015
I4) Lack of awareness of the benefits	Shokri-Ghasabeh & Chileshe, 2014
I5) Lack of time to ❖ share knowledge ❖ find the experts ❖ harmonize approaches and common language	O'Dell & Grayson, 1998 as cited in Riege, 2005; Williams, 2007; Shokri-Ghasabeh & Chileshe, 2014; Santos et al., 2012; Javernick-Will, 2012; Kukko, 2013
I6) Lack of monetary resources	Javernick-Will, 2012
I7) Knowledge hoarding ❖ Lack of willingness to share ❖ lack of/or disbelief in a reward system ❖ Knowledge is power → Fear that sharing jeopardises job security	Tan & Anumba, 2010 as cited in Javernick-Will, 2012; Gagne, 2009; Tohidinia & Mosakhani, 2010 as cited in Bloice & Burnett, 2016; Javernick-Will, 2012; Riege, 2005; Rechberg & Syed, 2013
I8) Unawareness of other's work; lack of recognizing the peers' knowledge sharing efforts	Santos et al., 2012; Javernick-Will, 2012
I9) Not invented here syndrome	Riege, 2005
I10) Lack of good communication skills and competence of staff	Davenport & Prusak, 1998, Hendriks, 1999, Meyer, 2002 as cited in Riege, 2005; Oliva, 2014
I11) Lack of ownership e.g. unassigned jobs	Singh & Kant, 2008; Ranjbarfard et al., 2014
I12) Fear of formalization and traceability of informal conversations	Nicolini et al., 2008 as cited in Bloice & Burnett, 2016
I13) Staff retirement and defection	Sing & Kant, 2008; Riege, 2005; Ranjbarfard et al., 2014

However, "affective trust in colleagues moderates the relationship between affective commitment and knowledge sharing and the relationship between cost of knowledge sharing and knowledge sharing" (Casimir et al., 2012, p. 740). But even in presence of trust, lacking intrinsic motivation, commitment, and willingness to share knowledge lead to knowledge hoarding. Importantly, if employees perceive their gathered knowledge as power, they may fear weakening their own position and endangering their expert status if they make their knowledge readily accessible (Probst et al. 2000, Tiwana, 2002 as cited in Riege, 2005). This is supported by Rechberg and Syed's statement (2013, p.831) "through ownership of knowledge, individuals may hope to have at least some control over their own careers in organisations". If the employees are not intrinsically motivated nor enjoy helping others (Ghobadi & Mathiassen, 2014; Cavaliere, et al., 2015) the abovementioned barriers most probably can only be addressed if the organization creates incentive schemes that lead to direct benefits for employees who engage in knowledge sharing. However, if such incentives and rewards are missing then employees are likely to not show initiative in knowledge sharing (Bloice & Burnett, 2016). Employees may also be simply unaware of the work of others and therefore do not know that they could benefit from each other's experiences (Santos et al., 2012; Javernick-Will, 2012). This is an especially important factor in globally operating organizations with plants all over the world: in this setting it is particularly difficult to keep the overview of running projects and expertise pools.

An aspect mentioned by many employees is the lack of time to share knowledge as it requires to either engage with others or to transfer the knowledge into an IT tool: the additional efforts are not in direct connection to the main tasks (Williams, 2007). Even if the employees are willing to share knowledge, it costs time to translate the knowledge in a common language, find employees in need of this knowledge and experts whom one could ask for support. Such effort is not always perceived as necessary in relation to the expected benefits (Zollo & Winter, 2002 as cited in Shokri-Ghasabeh & Chileshe, 2014).

In addition to these challenges managers must find and develop strategies of how to retain the organization's knowledge in case of employee absence due to sickness, retirement, or contract termination (Riege, 2005; Ranjbarfard et al., 2014). Especially when knowledge is mostly stored in people's heads it is directly lost and unavailable if the employee who possesses it is not around. In this case the organization is highly dependent on key employees which is dangerous as in extreme cases it can lead to the situation that the organization cannot offer products anymore as the internal knowledge is lost. Here, it is important to find strategies ensuring that the knowledge is transferred in time to other people or into IT systems. In general such a dependency on individuals, even if preferred by the employee due to their gained expert status, is not in the best interest of the overall organization.

5.4 Semantic Barriers

Next to the barriers which can be influenced are those KMBs causing the semantic-gap, mostly rooted in the nature of the individual, as depicted in Table 6. Each individual is influenced by its nationality, cultural background, its values, norms and beliefs, gender, age, spoken languages, education, and experiences. The diversity-imposed differences between individuals (although beneficial in many respects) often lead to the problem that even when facing the same experience, they do not perceive this situation, information, and experience etc. in the same way. This phenomenon can be described as semantic barrier. It constitutes a problem per se even in presence of solutions for the other three KMB categories. This is problematic as e.g. project members must be working "on the same page", and this is only possible if knowledge is understood by everyone in the same way. This requires the development of a common language (as a placeholder for our semantic framework) throughout the project process (Reed & Knight, 2010 as cited in Santos et al., 2012).

However, developing such a common knowledge (communication and understanding space) is hardly possible due to e.g. the differences in a person's absorptive capacity and working routines. Knowledge transfer encompasses the transmission and receipt of knowledge. Its success is highly dependent on the recipient's absorptive capacity as the message forms at the receiver (Grant, 1996) and from the communication skills of everyone involved. The problem is that the organization cannot directly influence the absorptive capacity of their employees which hinders mutual understanding.

Further, the focus of KM lays on sharing the information, knowledge and experience targeted on the product specifications and maybe in the assembling of the product. However, in current practice only little knowledge and experience sharing of how to conduct such a project and learn along the way happen, therefore this tacit knowledge gets lost along the way (Santos et al., 2012). As each team member is accustomed to different working practices, coordination and understanding of and between the team members sometimes can be difficult. Additionally, if employees do not put effort in sharing their working practices this knowledge potentially valuable for the project success (and its replication) gets lost.

Especially in complex cross-functional projects where team members are accustomed to their own culture, language and handling, the differences between the team members are intended to stimulate the team's creativity. However, they also complicate the alignment due to diverse professional philosophies and potentially competing project goals (Witt et al., 2001 as cited in Ghobadi & D'Ambra, 2013).

Table 6: Overview Semantic Barriers

	Semantic Barriers	Sources
S1)	Different nationality, cultural background, values and beliefs	Riege, 2005; Ghobadi & Mathiassen, 2014; Santos et al., 2012
S2)	Age and gender differences	Riege, 2005
S3)	Different spoken languages	Ghobadi & Mathiassen, 2014; Louhiala-Salminen & Kankaanranta, 2012
S4)	Geographical distribution	Javernick-Will, 2012
S5)	Different education and experience levels	Riege, 2005; Kukko, 2013
S6)	Diverse professional philosophies and competing goals	Witt et al., 2001 as cited in Ghobadi & D'Ambra, 2013
S7)	Diverse absorptive capacities ❖ Lack of common language due to diverse professional terminologies ❖ Lack of shared meaning	Bloice & Burnett, 2016; Santos et al., 2012; Tan & Anumba, 2010 as cited in Javernick-Will, 2012
S8)	Lack of sufficient adaptation	Bloice & Burnett, 2016
S9)	Difficulty of expressing complex knowledge	Bloice & Burnett, 2016

To briefly summarize the main literature review findings, it can be said that KM cannot be effective if it is not well integrated in the organization's goal, strategy, culture, and structure. Top-management must clearly communicate the value of knowledge sharing, stimulate a collaborative culture, offer a multi-space workspace environment, and integrate a well-functioning IT infrastructure. Otherwise, knowledge sharing is not effectively encouraged. These measures in combination with aligned HRM incentive schemes and allocation of additional time to actively participate in knowledge sharing activities are intended to guide, stimulate and motivate the individuals to engage in knowledge sharing. If the employees understand the value and benefits of knowledge sharing and are supported by workshops familiarizing them with the IT infrastructure they most likely will be motivated and committed to engage in knowledge sharing. A more complicated factor to address is the semantic barrier due to differences in the employees' background and absorptive capacity. This barrier cannot be overcome easily, however the engagement in socialization activities encourages the development of a common understanding thanks to regular and active encounters.

6. EMPIRICAL STUDY

This chapter aims at complementing and enriching the general literature-based discussion of KMBs presented in Chapter 5 with a practical perspective obtained via an empirical study focusing on SUS projects. The goal is to evaluate the importance of the general KMBs in the light of SUS projects, and to look for new SUS-specific KMBs. The outline used for the semi-structured interviews is reported in the appendix. As all interviews were conducted in German, there are a German and an English version.

The thirteen interview partners for the empirical study were chosen because they represent important roles of the SUS context. The interviewees held the following job descriptions (used when referring to them throughout the thesis):

- ❖ two Product Sales Managers,
- ❖ Head of Sales/Business Line Marine & Energy,
- ❖ Director of Business Line Oil & Gas,
- ❖ Head of Development Team PDM,
- ❖ Head of Software for Food & Diary,
- ❖ Head of General Machine Software,
- ❖ Head of Process Control Software,
- ❖ Senior Director Software Design,

The following interviewees are external:

- ❖ Director Engineering & Application (different organization),
- ❖ Architect and chief project developer (architecture),
- ❖ Professor of computer science and IT consultant (IT),
- ❖ Professor of computer science and director of a Fraunhofer Institute (IT).

Their different profiles helped to include the different perspectives and to obtain a good indication of the scope of KMBs in the SUS context. However, the small overall sample size does not allow to generalize the findings before the results are confirmed by larger studies.

The semi-structured interviews allow for relatively natural conversations guided by an interview outline and therefore allow for greater complexity and diversity regarding the interviewees' opinions and beliefs which reduces potential ambiguities and misunderstandings. This reduces the procedural reactivity bias, described as the procedure's effect, while it increases the impact of the personal reactivity bias, described as the interviewer's effect on the interaction with the interviewee. Both biases potentially relativize the reliability of the findings due to the researcher's influence on the interviewees and his interpretation of the results.

Thus the results are hardly fully reproducible by other researchers (Wilson & Sapsford, 2006). In this study it was tried to limit the personal reactivity by asking open ended questions which do not imply or steer answers. This also means that the interviewees could steer the interview by providing examples and personal opinions without being limited by strict questions. Moreover, the interviewer stayed neutral throughout the interview without interrupting the interviewees in their answers and time was never a limiting factor, ensuring that each interviewee got the opportunity to provide the own opinion on all subjects.

Regarding the validity of the findings it can be said that the interviewer could guide the interviews in a goal oriented fashion aiming at addressing the questions of interest.

Of course larger sample sizes would increase both reliability and validity.

Chapter 6.1 presents the empirical evaluation of the KMBs under the SUS perspective, then Chapter 6.2 provides the requirements for a potential KM solution obtained during the interviews.

6.1 KMBs faced in the SUS context

The interviews revealed that in practice the KMBs cannot be separated as strictly as it is done in the literature. In order to establish a link to the previous chapter without losing the essential SUS-process-specific inter-KMB relationships, this chapter is organized as follows. First, Chapter 6.1.1 sketches the SUS handling process, specifying this way the context for the following five Chapters 6.1.2. to 6.1.6, four of which present the most important KMBs according to the classification scheme of Chapter 5. To make the relation between the findings of the literature review findings and the empirical study explicit a code is introduced. Here, the letter indicates the KMB category and the number the specific KMB within this category. For example, O2 refers to the second organizational KMB in the according table. Subsequently, Chapter 6.1.6 discusses the inter-KMB relationships from the SUS perspective.

6.1.1 The SUS Handling Process

SUS projects are typically handled by cross-functional project teams, defined as “temporary work-groups that are charged with the responsibility of completing a development project within a limited time frame, and they consist of member representatives drawn from various functional units” (Ghobadi & D’Ambra, 2013). This implies that such complex projects are handled via continuous internal cooperation and communication.

Organizations that wish to buy a SUS product suiting their specific needs typically call for proposals. At this early stage suppliers can decide whether they want to engage and develop an offer. Depending on the scope of the project, which can easily range from €200.000 to €20.000.000, the customer contact and the internal project handling differs. The bigger the scope, the higher is the relevance of the project for the supplier, leading to top-management support, frequent meetings with the customer, and a fully dedicated project team. However, in an average project the regional salesman meets with the customer or an engineering office acting as intermediary. Together they specify the scope of demand and the terms and conditions to which they must be delivered, e.g., price and delivery date. After the salesman (potentially in cooperation with support from the engineering department) has closed a deal, the project is assigned to a project manager from the Order & Offer Engineering Pool.

It is then the project manager’s duty to guide this project through the internal processes comprising, in particular, the refinement of the project specification and further discussions with the customer based on the agreed upon contract, as well as to distribute the responsibilities between the project team members. For SUS projects, most of the team members typically work at different locations and serve in numerous projects, their alignment is therefore a major challenge that requires continuous monitoring.

Once the product is completed and successfully installed at the customer’s site the maintenance/service team takes over the responsibility for the customer’s satisfaction. In this phase, the quality of a product is defined by the costs arising during the warranty period. Today, there is little detailed feedback from the maintenance team to the sale force.

6.1.2 Organizational Barriers

The interviews confirmed that globally operating organizations with several business units most often struggle with internal competition for resources. This generally decreases the willingness to engage in organization-overarching knowledge sharing, especially if the benefits are not clearly communicated by the top-management which is re-addressed in Chapter 6.1.4 in more detail (cf. O5; I4). The competitive atmosphere affects the team even worse when the organization, as one Product Sales Manager told, reshuffles the power of departments in unpredictable ways.

The organization just changed its internal structure moving from business units to separate functions, with a major impact on the internal processes. As explained by the Director Business Line Oil & Gas “here it was tried to substitute trust with bureaucracy which negatively impacts the employees’ motivation”. In particular, it introduced more complexity, formalization, bureaucracy and strict hierarchies which hampers the communication flow as explained by a Product Sales Manager: “Before, I just could walk over to the expert, but now even if I know whom to ask I have to follow the new structure forcing me to send an e-mail which gets forwarded another two to three times until the required connection is established. This is quite frustrating as it adds a lot of administrative work impeding the project progress, costing time and money while causing potentially more misunderstandings and lost knowledge”.

This judgement was supported by the Director Business Line Oil & Gas who stated that “the introduced new indirect way of communication neglects the power of personal relationship and makes it difficult to enforce that urgently required feedback arrives in time”. This is particularly de-motivating in situations where understaffing hardly leaves time to carefully prepare offers, which decreases their feasibility (cf. O6, O7, O8, O9; I5).

Further, the organization currently lacks a global overview of all the processes and projects “making global and efficient planning difficult, depicting an organizational bottleneck as projects cannot be handled in order of priority ranked by the delivery dates set in the contracts” as stated by the Senior Director Software Design. The Head of General Machine Software complements that “the organization already has global processes and guidelines which in theory should define the tasks and responsibilities, however they do not actually suit the practical requirements to accurately allocate time and resources” (cf. O7, T1, T2 and O11).

Currently, as was stated by several interviewees, the sales force operates too autonomously leading to several problems in the order and contract development processes as salesmen do not possess sufficient technical expertise and up-to-date data to make validated and sound decisions (cf. S5, S6 and S7). Due to an incentive scheme which focuses on the volume of sales, this often leads to too optimistic contracts that increase the internal stress to satisfy the promises in order to protect the high reputation almost at all cost. This hampers and harms the envisioned margin and may lead to ad hoc solutions and therefore to high long term costs (cf. O12). It should be noted, however, that this problem is typically caused by the already mentioned high time pressure which often forces the salesmen to proceed without a time consuming involvement of the engineering department, which only leaves the option to rely on outdated data as was remarked by a Product Sales Manager (cf. O7; I5).

Another issue are the missing resources which e.g. requires project members to be simultaneously involved in six to eight SUS projects. This limits their focus on the individual projects, as they need to continuously zoom-in and zoom-out of the projects hampering their focus and overview of the individual projects. In addition, some functions are understaffed, and this does not leave spare time to share knowledge due to the continuous stress to handle the demands timely. Moreover, the internal processes are facing pressure to continuously reduce the process handling time to stay competitive. This pressure increases the error rate and reduces the engagement in knowledge sharing, leading to high long term costs (cf. O6, O7 and I5).

A very important barrier is imposed by the lack of adequate guidance towards the right level of product specification. This often leads to issues like over- or under-specification, with costly consequences (cf. O7 and O11).

Over-specified projects often contain details of no actual importance to the customer, yet leading to major adaptions and increased costs and effort. Here, it would be advantageous if the customer would only state the desired product's output and the actual needed requirements to leave enough room for the engineers to compose the best fitting solution to a fair price and delivery time.

Under-specified projects run the risk that the customer has unforeseen expectations which are only revealed during the iterative specification refinement in the course of the project development. For key customers and large projects this may cause particularly high costs for the organization as they overtake the costs of the changes along the way. This is due to the organization's policy to show goodwill to strengthen the customer relationship and to obtain positive references in the hope of future orders worth the risk and initial investment.

Furthermore, the organization still has potential to more actively encourage organizational learning. An effective measurement are feedback loops. In the context of SUS it would be beneficial if the feedback and level of quality perceived by the sales/maintenance department would be fed back to the engineers, who then can improve their solutions, and to the sales team to prevent that they sell the same suboptimal solutions again. Whereas such a negative feedback is not uncommon, as stated by a Product Sales Manager, any form of positive feedback is missing. Thus there is no positive guidance towards increasingly better solutions and the composition of 'winning teams' (cf. O5, O7 and O10).

6.1.3 Technology Barriers

It was the technical perspective that led to the demand pull initiating a line of discussion that eventually led to this thesis. As the Senior Director Software Design stated "internally we struggle with the lack of an overarching IT infrastructure aligning and providing interfaces among the different IT systems in use" (cf. T1, T2 and T3). One reason for this is that the existing IT tools are unsatisfactory from the users' perspective, and this in turn explains why many employees in the engineering and sales departments are building their own tools and excel sheets, and store the regularly needed knowledge on their own computers (cf. T5 and T6).

This fragmentation trend leads to an infrastructural chaos where too many knowledge sources co-exist in an uncoordinated fashion, with totally unpredictable status. Thus there is no central or global control of knowledge updates, which happen accidentally according to preferences of the individual user. This too hampers alignment as employees work according to different backgrounds, in particular when they come from different departments. In a typical situation, the salesmen might still use outdated data while the responsible engineer already possesses up-to-date knowledge. What is missing are working interfaces for transferring and updating the knowledge among the IT systems, optimally and in a fashion that guarantees alignment. This often leads to a loss of data and misinterpretation of the transferred knowledge (cf. T2, T3, T4 and T11).

In fact, too much knowledge is transferred manually and with the use of wrong media like e-mails or via phone which impedes any form of quality control as the transfer is too dependent on the specific sender/receiver constellation typically embodying semantic KMBs. In particular it is very difficult for the receiver to identify the knowledge actually of interest (cf. T7, T12 and T13).

The rather unorganized information flow, dependent on many different variables like the existing knowledge sources and the employees' usage routines, mandates that knowledge often needs to get re-checked over and over again to detect potential misunderstandings, at high and avoidable costs as was mentioned by the Director Engineering & Application.

However, as stated by the Product Sales Managers, it is often quite difficult and complex to find information even if it is stored in the enterprise resource planning (ERP) system as one needs to know where to search for what knowledge and in which way. Moreover, depending on the employees' status the data access to the ERP systems is restricted for security reasons, which further hampers the quality of project specification as employees simply do not have access to the required knowledge (cf. T4 and T6). So it is not surprising that one of them adds: "in some cases I benefit from the fact that I already work here for 25 years which was sufficient time to build my own network so that I know whom to ask if I get stuck, but I can imagine that these situations are particularly difficult for new employees."

The Head of Development Team PDM emphasized the importance of carefully maintaining the IT systems, which takes much time and effort. The Head of Sales/Business Line Marine & Energy complemented this statement by saying "if the maintenance effort already costs so many resources on this level then there is a lot of resistance when trying to develop and implement an overarching solution. Thus small scale working solutions are necessary to prove the potential advantages".

Therefore, it can be stated that the organization is currently struggling with the problem that no knowledge infrastructure exists which e.g. provides an overview of the available components, possible product configurations, prior SUS projects, their achieved performance or, more globally, a general expertise overview of 'who knows what'. This today lacking knowledge would ease the internal processes, improve the accuracy of the product specifications and contracts, and this way help overcoming the semantic barrier between sales and engineering.

6.1.4 Individual Barriers

On the individual level it needs to be recognized that every employee has an own working style and routines: where some employees organize their work very accurately, others profit from 'creative chaos', which makes smooth communication and coordination difficult (cf. I11). In addition, the interviews revealed that in the SUS context individual KMBs need to be distinguished according to two levels, the local (project/team) level and the global (organization-wide) level.

Employees typically identify themselves very much with their SUS projects and their teams. In this more personal environment, where individual contributions are easily recognized, they are willing to share their expertise and are fully committed to the team's success (cf. O5; I1, I2, I3 and I8; Ghobadi & D'Ambra, 2013).

This cooperative attitude changes, however, at the global level, where competition comes in play, according to the perception 'the own success comes at the expense of others' and vice versa (cf. O5 & I1, I2, I3 and I8; Ghobadi & D'Ambra, 2013). Thus employees fear that if they would share their knowledge and expertise openly this would not be related to their own expertise anymore, jeopardizing their expert status and personal reward.

Another issue is time pressure. Often understaffed project teams have to try to constantly reduce the process time to stay competitive with competitors that just offer standard products. This situation is further described by the Head of Process Control Software mentioning that "we do not have enough time to engage in knowledge sharing due to the work overload resulting in constant stress. Additionally, it is often neglected that not every member of the function can take over all tasks and decisions, which leads to planning issues and delays the progress". One Product Sales Manager adds that "the focus is to keep the day-to-day-business going with minimum resources, coming at the cost of the offers' quality which will be visible in one to two years". This often leads to ad hoc decisions neglecting measures that would relieve the overall situation from a longer term perspective (cf. I3, I5 and I7).

6.1.5 Semantic Barriers

As mentioned before, SUS projects are handled by cross-functional teams that struggle with semantic KMBs due to the project team members' differences in terms of nationality, culture, personal characteristics, education, personal experiences, and geographical position. Thus each team member has its own subjective perception and absorptive capacity leading to individualized views regarding the project definition, the solution, and how to implement it. This heterogeneity impedes alignment and makes it difficult to build a project which fully satisfies the customer's actual needs (cf. S1-8). This problem becomes already visible during the first contact between the supplier and customer, where sales people try to match a rather imprecise customer request based on partial knowledge concerning the technical possibilities. In particular, sales people do not always know how invasive a presumably minor change requirement is, and which slight modifications may drastically complicate the technical realization.

This cognitive situation may be well illustrated by means of a simple day-to-day example. It should, however, be kept in mind that the sales force is typically confronted with very specialized and highly complex technical environments which need years of technical experience and process understanding to be mastered (cf. S5 and S7). Think of a customer wishing to drive from Copenhagen to Amsterdam, unfortunately on a route 10 meters apart from the motorway. The sales staff, looks on the overview map, hardly realizes the existence of this ten meters discrepancy, categorizes the problem as a mass customization problem, agrees to the customer request, and promises in the contract a - in his eyes safe - 15 hours travel time. Solving such requests, which indeed appear quite frequently, in an economical way is simply impossible, setting the supplier under great pressure. This could have most probably been avoided if an adequate expert had been around to guide the customer wishes.

It would not be fair to criticize the sales department. They might have even closed a contract before, with a quite similar change request, but on the waterway, with no complaint whatsoever from the technical department. Knowing the implied difference between land way and water way may be conceptually very difficult in technical scenarios.

This colorfully illustrates the problem stated by the Head of Software for Food & Diary: "sales staff often mischaracterize SUS as mass customization projects, leading to significant time and resource constraints the organization has to accommodate at own cost once the contract is signed".

Of course, when in doubt, sales staff pass their specifications to an engineer before the contract is finalized. However, also in this case the engineer typically only gets the salesman's perspective, which helps to avoid the worst, but which is often insufficient to find the best alternative from the customers' perspective.

Therefore, one of the most important tasks of the project manager is to act as technological gatekeeper, translating between the customer and project team members as everyone needs to be on the same page. This mediation and role are not only challenging at the department level but also at the individual level. "Based on the experiences project members made in prior projects they see potential threats and opportunities leading to diverse prioritizations which are not plausible to the others" as stated by the architect and chief project developer.

Further, the HRM schemes set by the organization stimulate members of the different departments to have different goals as they make it the salesmen's top priority to win the contract and advertise the brand, which might come at the cost of technically realistic contracts. In contrast, engineers are more focused on the implementation of the project and often struggle to live up to the promises made by salesmen to the customer (cf. O12; S6 and S7).

Another problem resulting from the semantic KMBs and the individual differences of the employees is the law of the instrument which is best described by a quote of Maslow (1966, p. 15): "I suppose it is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail". This shall demonstrate that depending on a person's field of expertise everyone is tempted to approach a problem from one's favourite angle. This frequently leads to misunderstandings, opposing views of the problem and needed solution, often with the consequence that progress is impossible because, mediocre versions of the wheel are re-invented over and over again, and declared as "best practice". This is a general tendency that especially project managers have to keep in mind when working on SUS projects.

Smattering is another harmful semantic KMB: a person (enthusiastically) engages in the discussion without being aware how partial the own knowledge is. A striking example of this, which typically affects highly motivated people, happened in a warehouse scheduling project concerning efficient loading and unloading of trucks as was explained by the Professor of computer science and IT consultant. The client, a logistics expert, asked for a solution, where the number of ramps double at noon. When asked how this can be he said that, in average, the loading and unloading processes take half a day, which means that the trucks that arrived in the morning typically leave at noon and free their ramps for the second shift of trucks. He was proud to tell that to his knowledge scheduling systems are not able to directly deal with loading durations and the arrival and departures of trucks. Such misconceptions of IT limitations, which are typically based on certain experiences (perhaps with very premature software systems), are not rare but hard to detect and to overcome, as the underlying strong belief is neither stated nor criticized, and serves as a strong barrier to alternatives and change.

This observation emphasizes the negative impact of semantic barriers and the WHAT/HOW separation in customer supplier dialogues: customers should express their needs without worrying about the way of realization, which is the responsibility of the supplier who may well propose changes to the WHAT description, if that makes sense from a technical perspective. However customers should discuss these changes solely at the WHAT level.

This emphasizes the need for experts at the interconnection points, where e.g., knowledge is exchanged between different departments. Such points where most knowledge is lost and most misconceptions arise are currently underestimated in their relevance as KMBs.

6.1.6 *General Remarks*

A general feedback from the interviews was that KM can only be successful if those who are in need of supportive knowledge find it, understand it, use it, and support it. This requires the KM approach to be adopted by all involved stakeholders, which is only possible if the KMBs of all four categories are overcome. It should be noted, however, that the severity of KMBs differ depending on the organization's maturity level with regard to their KM (Lin et al., 2012; Oliva, 2014).

The empirical study also revealed that the project teams have to handle many SUS projects while having relatively little time and resources they can devote to the individual project. "Due to this resource scarcity and constant stress the employees are only able to extinguish the fire, but there is no time to find and fight the cause which could prevent the same mistake or problem from happening again" as mentioned by the Senior Director Software Design. In this situation many things are only done in passing by, without having the time to sit down, discuss, and solve things in detail. Accordingly, there is often the need to improvise and make things work without building upon a clear and structured plan. The reason for this is that the different project team members are normally not simultaneously working on the same project as they are spread over many projects. This is a major problem, because it impedes the directed communication, collaboration and knowledge sharing when the team member first has to switch context from focusing on a different project.

Aggregating the findings from the empirical study and the literature review reveals that all four KMB categories identified in the literature review impact the performance of SUS projects. Organizational KMBs play a key role and if they are adequately addressed by the top-management to encourage KM, this directly impacts the other three KMB categories, among which the semantic KMBs are particularly difficult to address.

Interdepartmental knowledge sharing struggles with more KMBs than intradepartmental knowledge sharing: Besides the geographical distribution and the more complicated work environment layout, also the semantic KMBs are stronger in the interdepartmental context. This is due to greater differences in the professional terminologies and philosophies, and the fact that there are typically less opportunities to reduce misunderstanding and increase trust through face-to-face conversations.

The interviews revealed two interesting new insights: Firstly, the KMBs mentioned in the literature review are quite generic while the interviews revealed specific instances of the same KMBs. Thus rather than actually providing new KMBs, the interviews revealed insight for refinements and provided examples showing the context and resulting consequences. This made it possible to identify interdependencies between the KMBs, and to recognize those that are particularly relevant in the SUS context, due to its required flexibility and the strong impact of decisions during the sales phase on the quality of the final products.

Secondly, the interviewees revealed an important difference between the global level and the local level. Whereas at the local level trust and willingness to cooperate and share are typically given, this is not the case at the global level, which is often perceived as uncertain and competitive. In fact, many of the problems at the local level are simply consequences of problems at the global level: missing guidance, too strong formalization, enforced indirect communication etc.. This indicates that, with appropriate changes at the global level, it should be possible to establish IT-based support to overcome most of the identified KMBs. Chapter 7 will elaborate on this vision on the basis of the requirements established in the next subsection.

6.2 Requirements for Potential Solution

Here specific requirements directly related to the KMBs are enlisted, paving the way for the next Chapter that provides specific action points. The requirements are set in direct relation to the KMBs as depicted in Table 7. These requirements were either directly stated by the interviewees or implied by the KMBs they named. As before, the requirement numbering scheme with the format R1-20 applied in Chapter 7 refers to this list.

Table 7: Requirements implied by KMBs

Requirements	KMBs
R1) Top-management has to emphasize KM's importance e.g. via HRM incentive schemes	O2, O12; T8; I3, I4
R2) Break the bureaucracy, hierarchy and formalization to allow direct contact	O6; I2,I13
R3) Global IT infrastructure ❖ Guiding the internal processes ❖ Allowing to easily retrieve knowledge ❖ Working interfaces ❖ Providing up-to-date data ❖ Providing access to process steps, product components, who did/is expert of what, shared knowledge pool	O7; T1-7, T11-13; I9
R4) Establish a guiding project process supported and enforced by IT	O7, T3
R5) Establish a guiding communication at the interfaces	I11, I12
R6) Enforce feedback loops	O5, O10
R7) Establish direction and guidance	O7, O11
R8) Enforce internal rules/regulations	O7, O11, O12
R9) Reduce the interfaces	T1-3, T6; S1-7
R10) Access to data required to make sound decisions	T4
R11) Involve as few stakeholders as possible	O4; S1-7
R12) Incorporate a configurator	T7, T11-13,
R13) Specify as much as possible from the start → reduce uncertainty	O8, 9
R14) Provide technological gatekeeper	S5, 6, 7
R15) Provide overview of ❖ Prior projects ❖ Expert knowledge ❖ Product configurations ❖ Machine performance	O7; I9
R16) Multi-workspace environment	O8; I1-3, I8, I9, I10
R17) Provide sharing networks	O9; I5, I9
R18) Establish more meetings in which the different functions are present	O8; I9-12; S8, S9

R19) Provide more time and resources	O5; I5, I6
R20) Workshops to learn how to work with the IT infrastructure	T9, T10

In order to overcome the stakeholders' uncertainty, the perhaps most difficult to address KMBs, clarity and transparency were identified as guiding principles when composing the requirements. They are organized in the categories organization-wide overview, project specification and stakeholder involvement.

The desired organization-wide global overview is further divided into the overview of the internal processes and projects currently running through it, the overview of similar product requests/solutions to allow internal learning and the overview of the actual machine performance measured after successful installation at the customer site. These overviews are meant to provide guidance for the project management and configuration exploiting the internal knowledge and preventing re-inventions of the wheel, thus saving time and costs. Especially the machine performance overview is here of interest as it allows to make performance guarantees, thus increasing the chance of winning the order.

The requested project specification addresses the need to overcome the problem of over- and under-specifications of its products mentioned as KMB before. The goal is to establish a guiding process ensuring that customers only specify aspects of actual importance to them while leaving enough space to develop a suiting solution to the engineers. Clear guidelines here are meant to support the offer of contracts that ease the product development, while, at the same time, increasing certainty and predictability for the supplier as customers would no longer be allowed to change their requests along the way.

The final request for stakeholder involvement also aims at clarity and the reduction of managerial overhead. If everyone involved in the process had full access to the data of interest when starting to contribute in the project the management of the individual tasks and the overall project would become much easier and require less coordination, with fewer people: the Architect and chief project developer emphasised that it is "best if as few stakeholders are involved in the process as possible to decrease the impact of misunderstandings".

7. PRACTICAL IMPLICATIONS

This chapter reviews the findings from the literature review and the empirical study concerning their practical implications. Chapter 7.1 focuses on the organizational implications, essentially covering the organizational and the individual KMBs, whereas the technical implications discussed in Chapter 7.2 aim at addressing the technical and the semantic KMBs.

7.1 Organizational Implications

KM is a so-called 'cross cutting' concern, typically involving stakeholders with different backgrounds, from different departments in different locations with different responsibilities. As clearly indicated by the literature review and the interviews, these complex dependencies make KM vulnerable to KMBs at diverse places. In fact, KM can only be successful if all of them are handled in a satisfactory way, as the quality of the flow of information very much depends on the weakest links in the chain, which may easily introduce a vicious cycle as e.g.:

If the shared quality of knowledge is low, users are disappointed and stop using it, and, in particular, do not update and share new knowledge which further lowers the quality.

Thus introducing KM is challenging, as the intended benefit incrementally builds up in the course of use in a continuous improvement fashion. This requires dedication from all stakeholders right from the beginning, even though the (intended) benefit is initially low. To achieve this the KM strategy must be aligned with the organization's goal and culture to globally clear the way for effective KM, enforcing that employees engage in knowledge sharing and reusing it. The required changes are invasive as a collaborative and learning culture must be created and stimulated while the internal structures and processes must be adapted and innovated at an organization-wide level to reach every employee. Such pervasive changes are difficult to implement, however they are also difficult to imitate for the organization's competitors, making good KM a valuable competitive advantage also in the long-term (Lippman & Rumelt, 1992 as cited in Argote & Ingram, 2000).

It is the top-management's task to "build an organizational culture which values and recognizes employees who interact with information in order to grow the business and their own careers" (cf. R1; Cheuk, 2008, p.139). To be successful, several changes must be implemented. Firstly, an internal standardized process must be introduced enforcing the continuous learning cycle on the local and global level (cf. R4). Secondly, employees need detailed guidelines and job descriptions allowing for a clear task and responsibility division that is especially valuable when working on cross-functional SUS projects (cf. R7). Thirdly, the work environment and layout must allow short ways between cooperating employees and further must offer meeting places which stimulate collaboration (cf. R16, R17 and R18). Fourthly, knowledge sharing stimulating HRM schemes need to be in place (cf. R1). Here, non-financial incentives like achieving the status of being an expert often is perceived as more rewarding than financial incentives (O'Dell & Grayson, 1999 as cited in Lee et al., 2012). Lastly, sufficient time and resources must be allocated to the employees allowing time to share knowledge, e.g. face-to-face, reducing mistakes (cf. R19).

Especially, the first change aspect is of importance: the standardized process, which has to be passed through by every project, guiding and steering all employees involved, and stimulating and enforcing a continuous improvement cycle. Even though standard projects differ quite significantly from SUS projects and the same is true among the SUS projects themselves, it is important to follow a standard process in order to better control the differences, the similarities, and the way to cope with them.

As defined by Davenport (1993, p. 1) "process innovation combines the adoption of a process view of the business with the application of innovation to key processes. What is new and distinctive about this combination is its enormous potential for helping any organization achieve major reductions in process cost or time, or major improvements in quality, flexibility, service levels, or other business objectives". These advantages are envisioned to be achieved once the standardized process is successfully implemented.

As changes are accompanied with uncertainty and the direct benefits are not clear, employees initially have to start on a trust basis, which must be established by the top management (cf. R1). In fact, the introduction of systems such as ERP systems, which is vulnerable to many KMBs and initially may slow the whole administration down for months, shows that the top-management is able to successfully swipe away a lot of KMBs when it assigns a massive initial investment and makes clear that they leave no other choice as stated by the Professor for computer science and director of a Fraunhofer institute (IT).

The requirement of a clear top management support is characteristic for all 'intrusive' innovations that require to change the underlying business processes, and this requirement increases with the globality of the affected processes. Here, the top-management has to consider two important aspects. Firstly, if it intends to execute such invasive changes then these must be clearly visible to demonstrate that the organization is moving from the current state to a new state in which things will be different (Bridges, 1991). Secondly, once the change is implemented, the change is not yet successful, as the top-management still needs to ensure that this change is sustained because employees easily fall back into their old habits making all change efforts superfluous (Lewin, 1951 & 1952).

This does, however, not mean that the other KMBs are unimportant. On the contrary, in cases like KM, where the *quality* of cooperation is essential, a single KMB may be fatal. E.g., sloppy updating of the knowledge may strongly impair its quality and with it the trust in the KM system.

To exploit its potential the standardized process should be combined and complemented with an overarching IT innovation. This is beneficial as Lee et al. (2012, p. 200) state that "IT is the core infrastructure of KM and IT support is the most crucial factor in determining knowledge process capabilities". Therefore it shall guide and align the process by enforcing and coordinating the important steps (cf. R3 and R4). The process should allow an overview of the experts and access to their expert knowledge and to the data and knowledge gathered in prior projects while automatically enforcing process and project rules (cf. R8, R10 and R15). Further, it should ensure that the projects get specified as much as possible from early on as it allows accurate and detailed planning along the way (cf. R13).

Another envisioned advantage is that such a global process and overview of prior and current projects embraces "economies of repetition" (Sawhney, 2004) on the project level but also on the handling level (cf. R3, R10 and R15). An example is that "one manufacturing team may learn from another how to better assemble a product or a geographical division may learn a different approach to product design from its counterpart in another division" (Argote & Ingram, 2000, p.151). This is in line with von Zedtwitz (2002) stating that project managers who overtake a new project benefit from observing post project review processes to stay informed (Karagoz et al., 2014).

It is expected that these changes on the organization level directly impact and affect the individual level as it forms the environment and addresses KMBs that influence the employees' commitment, initiative and trust (Wiewiora et al., 2013; Ghobadi & D'Ambra, 2013). If for example a stimulating organizational culture, structure, and work environment are in place, then the employees get to know their colleagues, their work and expertise while understanding the knowledge sharing benefits (cf. R2). This will increase the employees' engagement and interest in knowledge sharing. Additionally, it is important to state that if intrinsic benefits are in place employees are stimulated to share knowledge even if they do not trust the others (Kankanhalli et al., 2005 as cited in Lee et al., 2012).

Generally it can be stated that it is in the best interest of the organization to keep the business units and project teams as small as possible as it provides overview, eases knowledge sharing and reduces the impact of the semantic barrier (cf. R11).

7.2 Technical Implications

This chapter discusses the technical implications imposed by the technical and the semantic KMBs along a sketch of a SUS product configurator scenario, regarded here as an attractive small scale example for an effective KM system that fits the requirements posed in Chapter 6.2. In addition, it discusses the limitation of current configurator solutions and illustrates how they may be overcome. Particularly important is here the treatment of semantic KMBs by technical means. The chapter closes showing how the SUS product configurator can be embedded in a continuous improvement cycle (cf. R3, R4, R9 and R12).

7.2.1 KM Systems and Product Configurators

As identified in the interviews and throughout the thesis organizational knowledge is typically stored in a variety of ways, often dispersed over heterogeneous system landscapes, explaining why most of a company's intellectual capital is under-used or even lost. There are existent content management systems like Livelink, Microsoft SharePoint and ShareNet that organizations can use, however none meets and exploits the needs of global enterprises. This is due to the fact that these solutions do not make it possible to systematically share and search the organization's internal information and knowledge enterprise-wide, hampering or preventing employees to find the information they are looking for when they need it.

Configuration tools combine pre-defined components while respecting and following prior defined constraints and rules representing relations and dependencies between the components. This way they enable the aggregation of a specific product. The knowledge is processed by a constraint solver that generates solutions obeying the stated dependencies, this way ensuring that the output - the configured variant - is consistent with the structural requirements, i.e. it solves a Constraint Satisfaction Problem (Apt, K., 2003). Component-oriented configuration models have been developed and integrated into commercial configuration tools, as most configuration domains in the business practice are component-oriented (Mittal & Frayman, 1989). The application of recommendation technologies (Jannach et al., 2010) to support domain experts and engineers in creating configuration knowledge is a recent research approach (Felfering et al., 2013). It tackles the major challenge to overcome the difficult and tedious transfer of expert knowledge into a knowledge base, which is known as the knowledge acquisition bottleneck (Hoekstra, 2010).

In the Business-to-Business market, product configurators enable sales staff to offer customer-specific products and that way improve order specification and project planning by generating bills of materials and routing. Most of the product configurators in this context are integrated into ERP-systems that manage product components in a bill of material. As an example, SAP manages a maximum bill of material as well as maximum routing (Haag, 1998). Based on specified relationship knowledge, the system chooses the components and the operations that are required for a specific product variant, respectively.

7.2.2 From Customized to SUS Products

For SUS products, mere product configuration alone is not sufficient as the envisioned product can typically not be composed of existing components in a standardized way but requires technological adaptions whose impact can only be estimated in cooperation with the engineering department. This is where the KMBs and in particular the semantic barriers strike. The barrier between the sales and the engineering departments is particularly critical and high (cf. Chapter 6.1 and 6.2), thus a product configurator for SUS must deal with these barriers in order to be effective - an aspect not covered by commercial product configurators.

This imposes the following technical requirements:

1. *Usability* to have an easy interface and a high and fast learning curve. This requires a *role-based* approach, which in particular addresses the sales and the engineering staff in a different fashion (cf. R14).

2. *Ease in Updating the Configuration Knowledge* in order to enable knowledge updates directly at the place where the knowledge arises. This means, e.g., sales knowledge at the sales department and engineering knowledge at the engineering department.
3. *Accessibility* to be able to use the technical solution everywhere at any time (cf. R10).
4. *Inter-departmental Communication Support to* enable effective, goal-oriented offer production comprising also aspects of new development (cf. R5 and R14).

Whereas requirements 2 and 3 are acceptable in high-end state of the art solutions, requirements 1 and 4, which in particular address essential semantic barriers, are typically neglected. Figure 2 depicts a potential SUS product configurator scenario illustrating the treatment of **Requirement 1.** Customers and sales staff are specifically interested in product features and performance (shown at the right), but not so much in technical details of components (the view for the engineer shown at the left). Each user group is provided with a tailored view according to the respective expertise and competences. In particular, the default entry point should be a feature-centric view for the sales staff while engineers are expected to prefer a rather technical view. However, while the respective information from another view should be hidden in the first place, it must be accessible on demand, for example to enable sales staff to answer detailed questions of customers (cf. R12 and R14).

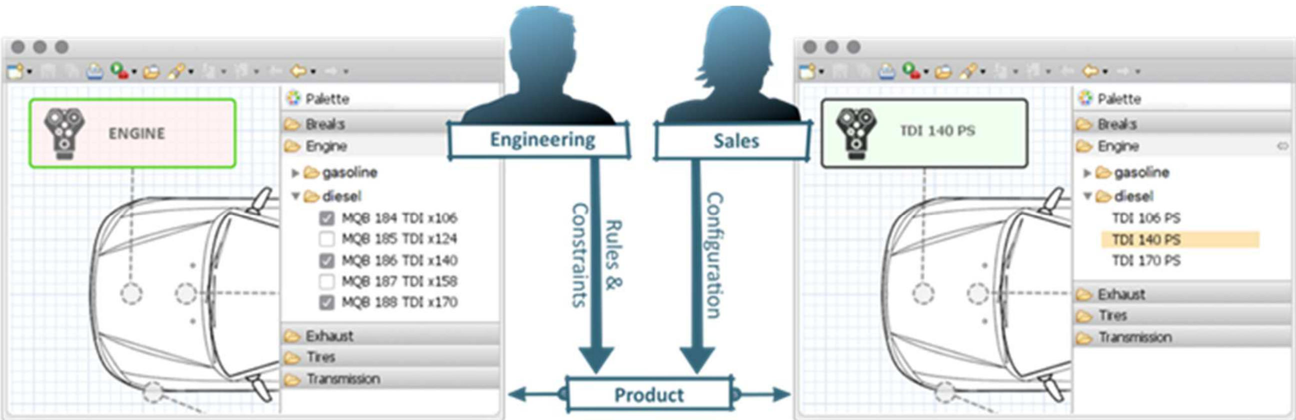

Figure 2: Product Structure and Product Configuration
(Steffen et al., 2016)

Providing these views in a fashion adequate for SUS configuration is not as easy as it appears at first sight. E.g. the feature-oriented view for the sales force cannot be done at the component level alone, as important features depend on partial product configurations, i.e. specific combinations of components with appropriate characteristics. As an example, the throughput of a liquid processing machine does not solely depend on the size of its outlet, but also on the size of installed pipes and the power of its engine. A realization of this concept can build on the product structure and enable the specification of partial configurations to be linked to respective feature descriptions. More complicated is to guarantee the consistency between the different views, i.e., that the role-based translation is correct. However, according to the Professor of computer science and IT consultant all this is technically well feasible and mainly fails due to organizational limitations.

If a configuration attempt fails due to a lacking component or an unforeseen combination, sales staff may trigger a feasibility assessment workflow involving engineering experts in order to clarify whether the solution can be built or not (cf. **Requirement 4**). If triggered, the configuration framework translates the feature-centric view regarding the proposed configuration into a component-centric view with technical details to be presented to an engineer. Based on the own expertise, the engineer decides on the feasibility. The answer should be structured and comprise the decision, possible restrictions and supplementary requirements. If not feasible, the engineer should be able to justify the decision (e.g. by naming incompatible components) and should be supported to propose alternatives that are feasible and fulfil the requested features, if existent. The alternative-finding task again should be supported by a recommendation system that induces possible configurations that might fit the requirements according to composition rules and constraints.

The envisioned SUS product configurator explicitly supports this inter-departmental communication process in order to avoid media gaps and to enable subsequent processing and storing of the actual assessment. Even more importantly, if consequently used the SUS configurator helps to avoid misconceptions during the product generation, which cost money and negatively impact reputation (cf. R4, R5, R9, R10 and R12).

7.2.3 Continuous Improvement Cycle

The continuous maintenance and extension of the configuration knowledge as described in **Requirement 2** is seen as a continuous improvement cycle.

Sales staff start the requirement specification at the customer site by defining the product category, determining some important primary parameters (step 1), and query the configurator for matching configurations. As can be seen in Figure 3, the configurator answers the sales queries with a prioritized list where potential alternatives are highlighted using a color code according to their fit. In the SUS context, this querying step will typically result in a dialogue with the configurator and, where necessary, with the engineering expert where the sales staff alters the original specification according to the feedback until a satisfactory solution is found (cf. R6).

After the subsequent product implementation in step 3 the knowledge gained during the production process is entered into the knowledge base (step 4). Also this final step is quite elaborated. In fact, creating adequate configuration knowledge is a recent research approach (Felfering et al., 2013). It tackles the major challenge to overcome the difficult and tedious transfer of expert knowledge into a knowledge base, which is known as the knowledge acquisition bottleneck (Hoekstra, 2010).

From the IT perspective, there are no severe technical hurdles to build such a SUS configurator. An example is the Holistic in the Loop Configurator (HiLC) which adequately addresses the technical and (most of) the semantic KMBs (Steffen et al., 2016). This configuration tool is further intended to be used by all employees requiring workshops teaching how to work with it (cf. R20).

7.3 Integration and Summary

Enterprise-wide enhancements of stimulating and facilitating collaboration are more effective than their decentralized counterparts at the departmental level. This indicates that the global approach described throughout Chapter 7 is the right way to go (Lee et al., 2012).

Figure 3: Continuous Improvement Cycle

(Hessenkämper et al., 2015)

For an organization aiming at an overarching solution, a mix of organizational and technical implications will be most successful. The top-management needs to make KM one of the top priorities and adapt the internal structure and culture to clear the way for a successful change. Here, it is important to guide the employees and free resources to carefully develop and introduce comprehensive support in terms of an overarching configuration tool, like the above described HiLC.

The employees' behavior and perception are highly dependent on the given situation and atmosphere, directly impacting their willingness to contribute. This concerns in particular the IT infrastructure. The top-management needs to recognize that an unsatisfactory solution here is counterproductive, with uncontrollable costs in the long term. The tool must be able to fit into the processes, provide an overview of the projects' status, of similar projects and contracts, of product configurations and of components at all times in order to allow more accurate estimations and provide an up-to-date overview. This includes the requirement that the tool must be user friendly, e.g., providing the user with tailored views, and that it does not require the employees to have to (precisely) know what to search for and where. Only this way it is possible to overcome the inherent semantic KMBs.

More generally, a KM system should allow stakeholders to directly interact with it at their level of expertise, without requiring any artificial encoding. This directness does not only reduce potential misconception but also lowers the entry hurdle for new employees. Using the proprietary KM system tackles the problem that it takes typically up to one to two years before a newly hired employee is able to independently take over a project, and even five years of experience until they can independently take over SUS projects as was mentioned by a Product Sales Manager.

8. DISCUSSION: SEMANTIC KMBS

During a one year internship and along the empirical study one theme continuously reappeared and led to the introduction of the category of **semantic KMBs**, a category previously enjoying little emphasis in the literature and subsumed by the personal KMBs. Actually, the importance of semantic KMBs and their causes seems to grow the longer one thinks about them. The following discussion of two non-manufacturing scenarios where semantic KMBs are particularly addressed, in fact, even particular exploited, is illustrative.

The first example concerns an Emergency Room department in Hamburg-Altona (Germany) where patients typically endured hours of waiting time before their case was treated. The root reason was the complicated classification of the patients, who were first interviewed and triaged, then treated by a nurse, then saw an assistant doctor who often initiated numerous (often unnecessary) tests, before they reached the required expert. The chief physician of this ER therefore decided to optimize the workflow by essentially turning it upside down. In the new organization, the patients were promised to see a senior physician within fifteen minutes from arrival. The idea was to place a 'gatekeeper', the senior physician, right at the beginning to steer the treatment in the correct direction as soon as possible. This avoided wrong classifications by unexperienced staff, unnecessary tests, treatments and other major cost factors, with the consequence that with the same staff more patients could be treated with increased quality. As a side effect, this optimization improved the reputation of the hospital increasing the number of patients choosing this hospital not only for the ER but also for more severe illnesses (Steffen, 2012(a)).

The point of this case is that this optimization directly addresses the problem of semantic-based uncertainty. An unexperienced person, often with a wrong specialization and insufficient confidence to take adequate decisions is replaced by an expert, with the consequence that the overall process is radically improved. In the SUS context, this would correlate to a technical expert with broad knowledge accompanying the salesforce to bridge the semantic gap from inception, this way, in particular reducing from early on the uncertainty of SUS projects.

The second example colourfully illustrates the effect of understanding the impact of semantic KMBs in a way that recognizes and uses the different strengths of the individual employees.

Asperger-autists are typically considered disabled because of their high sensitivity to change and their inability to classify emotions correctly. Thorkil Sonne, the father of an Asperger autist, did not accept this negatively biased judgement for his son and founded a company specifically designed to employ Asperger autists leveraging abilities they distinctively have. His idea was to build on other traits widespread among Asperger autists: their characteristic sense of detail, exact perception, and brilliant memory. These exceptional skill are of high value for a number of data processing tasks which are too complicated to be easily automated. Thorkil Sonne succeeded to turn these autists from disabled people living on social security to IT experts (easily) able to live on their own. Key for this success was the creation of a tailored working environment which allowed the autists to stay in a familiar setting, accurately stick to their routines without much noise and contact to others, and follow their own schedule (Steffen, 2012 (b)). In the meantime, this company has subsidiaries in more than ten countries on two continents.

This example stresses the importance for an organization to take the employees' semantic KMBs into account. Identifying and exploiting the differences as individual strength of employees does not only lead to much better results but also to much better motivation.

9. CONCLUSION

This thesis analyzed, to my knowledge for the first time, inter- & intradepartmental KMBs in the context of SUSs, which today constitute a major bottleneck when offering customer-specific solutions. In particular in the Business-to-Business market SUSs are gaining increasing importance as customers require solutions fitting to their infrastructure while satisfying specific functional requirements. It is the high frequency of SUSs projects together with the unpredictable and often very specific customer requests which makes KM a challenge of highest importance: for mass customization it is less critical because of the predictability of variation, and for new product development there is a much lower time and resource pressure. In fact, despite the comparatively high margins and the tighter customer relationship combined with a closer link to market trends, SUS projects are high risk because of unpredictability, as sometimes seemingly simple adaptations may require an unforeseen major effort which overthrows the entire project calculation. Such problems are typically rooted in miscommunication between the sales and the engineering department - the reason for this thesis to mainly focus on KMBs between these two departments in its empirical study.

The investigation, which has started with a systematic literature review about KMBs in general has led to a four category classification (organizational, technology, individual and semantic) which has then been concretized and refined by means of an empirical study that focuses on the SUS perspective.

The thesis has revealed interdependencies between (the four categories of) the KMBs and identified three measures for overcoming them in order to establish a culture of knowledge sharing providing:

S*tandardized processes* that guide and coordinate the stakeholders from a global perspective. In particular, each stakeholder should be guided to clearly conform to their level of expertise in order to avoid misconception like smattering.

Transparent managerial communication and organization-oriented incentives in order to establish a global culture of trust and common goals which, in particular, overcomes most individual communication barriers and avoids uncertainty.

IT-based knowledge management to provide up-to-date knowledge and bridge the semantic barriers, e.g. by providing role specific views and process-oriented guiding.

Addressing the stakeholders in their 'language' is of major importance to avoid misunderstandings and to establish a smooth cross departmental dialogue. Only this way, misconceptions, like the confusion of the characteristics of water way and land way in the illustrative example of Chapter 6.1.5 can be avoided. An adequate KM system has the potential to overcome the need for a human gatekeeper that is able to translate between, e.g., the sales and the engineering languages (cf. also the discussion in Chapter 8).

In fact, enabling the inter- & intradepartmental dialogue with such a KM system should automatically lead to a steep learning curve and a continuous improvement cycle which, in particular, also overcomes problems like re-invention of (often mediocre versions of) the wheel. This is a major competitive advantage, as it does not only accelerate the SUS project definition and development but also the later maintenance.

The interviews conducted in the empirical study also indicated that implementing intrusive changes as proposed above is a quite expensive long term effort which requires a careful change management (see also Chapter 10.2 below) and a step-wise introduction of new technology showing 'early wins'. This means in particular that attractive milestones have to be selected in order to keep the pace and the motivation. In fact, if the atmosphere and the time are right, the KM system should be extended to, eventually, comprise the entire supply chain. This would, e.g., help to also lower the customer/sales barrier with strong impact on the customer satisfaction.

Finally, from the scientific perspective, the thesis has investigated, apparently for the first time, an economically important research question: the impact of KMBs on the efficiency and effectiveness of SUS project handling in the Business-to-Business market. It has analyzed several general key concepts via a literature research and then put them in a practical context via an empirical study. This approach has revealed, a number of important requirements and identified in particular, the key role of the global level. Without top-management support, overcoming the KMBs - even with the best IT tooling - will hardly work. Similarly, the requirements for a supporting IT system systematically derived from the interviews clearly indicate how the technical barriers should be addressed. Particularly interesting in this context was the revealed importance of role-specific views. The thesis introduced the notion of semantic KMBs to better address this identified need.

10. LIMITATIONS AND NEXT STEPS

The results presented in this thesis have clear limitations regarding the scale, the scope, and the considered depth, in particular concerning solution approaches. These, as well as their imposed directions of future work are discussed in Chapter 10.1.

A completely different line of research concerns the required change management, which is particularly challenging when pursuing process innovations. Chapter 10.2 will elaborate on these challenges under the perspective of the proposed practical implications sketched in Chapter 7.

10.1 Limitations – Imposed Future Research

This thesis investigates KMBs in various dimensions in order to establish a global flavour of their character: as an abstract notion described in the literature, as a piece of personal experience revealed in interviews, and as a source of knowledge to deduce requirements for a potential KM system. This wide perspective inevitably leaves room for further investigation in three dimensions (as also depicted in Figure 4):

- to validate the findings by case studies,
- to investigate the generalizability to other industries, and
- to elaborate on the technological potential via a running prototype implementation and user feedback.

Whereas the first two items target to increase the reliability and validity of the findings (cf. Chapter 6), the third opens a story for itself, about small scale experimentation with proof of concept implementations, variations, incremental generalization, and, eventually, the implementation at a first mover, which comprises all aspects of change management as indicated in Chapter 10.2.

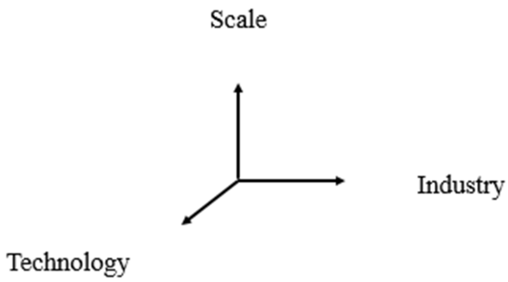

Figure 4: Directions for Future Work

10.2 Change Management

A factor not addressed in the scope of this bachelor thesis is the required change and innovation management if an organization actually wants to implement the described process innovation supported by technology described in Chapter 7. Especially in large manufacturing organizations (which typically follow a mechanistic organization structure) a powerful and widespread resistance to process innovation exists, as process innovation is particularly invasive and complex and affects the organization's culture and way of working accompanied by high levels of uncertainty (Hauschildt & Salomo, 2011). This also results from the fact that it is typically complicated to communicate the need and the resulting benefits. As the impact of process innovations like the introduction of KM systems translates only indirectly into a tangible advantage, it is difficult to calculate the benefits and estimate a return on investment. This in turn makes it difficult to obtain the required internal support, openness and willingness to change, explaining why many overarching process innovations fail despite the envisioned benefits. A fitting example is Sony, which struggled with its inability to internally communicate, cooperate and coordinate among its departments. These deficiencies ended up hampering new product developments that required interdepartmental support, eventually costing Sony its leadership image. Stringer, Sony's CEO, tried to counter this development by reorganizing the organization, aiming at enforcing the "Sony United" vision. However, his attempt failed due to internal obstruction, this way demonstrating the importance to carefully plan such radical changes without underestimating the power of the existing inhibitors (Indu & Gupta, 2010).

Accordingly, when planning and preparing organizational change it is of major importance to consider the change from the perspective of potential inhibitors, who will do everything in their power to prevent the change. A change team aiming at a successful implementation of the process innovation needs to be prepared to counter those allegations once they are voiced. Here, it is opportune to make a list of the most dangerous and probable motivations and arguments that might be used by inhibitors, and prepare strategies for each of those - either to foil them upfront or fight them when they appear. In the following some of the most likely arguments by the inhibitors are listed for which the management has to prepare itself:

Fear of uncertainty: People fear uncertainty as it does not allow planning and preparation. Therefore it is important that the management clearly communicates the envisioned change, the change's vision, the intended benefits and especially the likely consequences for the employees. This transparency increases the likelihood of achieving change and decreasing chaos in the operations and for each employee as they feel taken seriously and like being part of the change.

Existential fear/fear of disadvantages: Employees fear to become dispensable if processes become more effective and efficient, as organizations often focus on cost reductions. Here, it is crucial to stay transparent and prevent rumours. This means that the change's vision, the role the employees play and in which position they will find themselves afterwards must be clear.

Not-wanting barrier: Inhibitors dislike change as it is coupled with adaptations which often lead to learning dips. In the cases where encouragement and positive stimulation via incentives and rewards are not enough, the leadership has to push change onto the employees via sanctioning and punishing inhibitors if necessary.

Not knowing-barrier: Employees do not know what the changes imply and therefore are against it. Here, the process change, its goal and the implementation plan need to be explained to convey the inhibitors and win the employees' trust.

Technological arguments:

- ❖ Mistrust in feasibility/functional capabilities: Inhibitors want to proof that the proposed changes do not live up to the promises.
- ❖ Misfit with organization's culture: Change does not suit the organization's culture and therefore it is best to still wait.

To counter these technical arguments, it is important to have technical and provable arguments. Therefore, it is helpful if a proof-of-concept shows early wins/failures to demonstrate intended benefits. However, small scale projects unfortunately are typically not particularly impressive. In addition the urgency of the change implementation needs to be stated as it directly impacts the organization's competitive advantage.

Economic arguments.

- ❖ Satisfaction with current state
- ❖ Existing infrastructure becomes obsolete
- ❖ It costs too much time, money and resources

Here, the management has to demonstrate that the current processes are not adequate for competitively handling SUS projects. Also the creation of dissatisfaction with the status quo reduces resistance.

If an organization starts to recognize the need to actually implement the proposed process innovation it needs to carefully plan the adoption of the new internal processes. Here, the guideline provided by Hayes & Hyde's five step change process (1998) can be adopted as guiding support. To prevent that important variables and steps along the change process are neglected other theories should be applied simultaneously throughout the five steps (Cameron & Green, 2015).

1. Recognize need to change and start change process

Here the organization decides that it wants to change, what it wants to change and which impact it has on the organization. Further it needs to consider which additional resources it might need to successfully implement the change (Bullock & Batten, 1985). Besides, the team of promotors/guiding coalition pushing the project and countering the inhibitors must be established (Hauschildt, & Salomo, 2011; Kotter, 1995).

2. Diagnosis and Vision

Once the team is composed and the responsibilities and tasks distributed the vision for the change must be defined. Here it is important to review the present state and envision a preferred future state. This diagnosis will lead to a change vision which is required to persuade the employees and receive their support.

3. Plan and prepare to change

Based on the defined vision, the organization has to plan and prepare the change incorporating implementation strategies and interventions which reach top-down to the employees. This plan depicts a crucial step for the change's success as it represents a guideline which shall reduce the felt uncertainty of everyone involved as it has the power to reduce the internal resistance.

Especially when planning such invasive changes like process innovations it is beneficial to "start small" and "to grow steadily" and to "not plan the whole thing" (Senge et al., 1999). This is in line with planning for early and short-term wins (e.g. proof of concepts). It makes sense to plan into the future, but to keep the outline rough so that it stays adaptable (Cameron & Green, 2015).

4. Implement the change

To change the status quo a clear end must be marked rendering old tools and routines obsolete and enabling the movement to the desired state. Here, the leadership has to carefully guide the changes to actually address the employees correctly so that they are open and enthusiastic about the change as they realize that something is going to change to the better. Very important is to state the direct and clear advantages for the employee so that they also see their personal advantage.

5. Sustain the change

To ensure that the change is successfully implemented the leadership has to emphasise the new beginning and refreeze the new state to prevent that employees fall back into old habits. (Bridges, 1991; Lewin, 1951, 1952).

To conclude when implementing organizational change the top-management has to especially be careful to keep possible inhibitors in mind as changes can fail, if faced by too strong inhibitors even if the management supports it. In addition, the rough outline of potential steps guiding the change implementation just gives an indication of the aspects top-management has to consider when addressing change. Here, further research is required to develop a change plan tailored to a specific scenario.

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14. APPENDIX

As stated in Chapter 6 the German interview outline was used to conduct the interviews. Important to note is that the interviewer used this outline as guideline ensuring that no important aspects are forgotten rather than actually asking every question and using exact phrasing of the questions. This method supported that the employees engaged in the interviews by providing e.g. experiences and examples.

14.1 English Interview Outline

14.1.1 Working context

1. Do you mostly handle standard, mass customization or single unit solution (SUS) projects?
2. How do you allocate the projects to one of the abovementioned categories?
3. What are the main differences among those three categories?
4. What are the main differences between new product development and SUS?
5. How does the SUS handling process look like?
6. To which extent does the customer know what he wants?
7. Who is present during the customer negotiations?
8. To which extent are these processes standardized?
9. With which other departments do you frequently work together in this context?

14.1.2 Existing internal KMBs

10. How satisfied are you with the cooperation within and among departments?
11. With which departments is the cooperation and alignment particularly difficult?
12. Which challenges regarding knowledge management do you frequently encounter throughout the SUS project processes?
13. What are knowledge management barriers you encounter when working on SUS projects?
14. Which organizational knowledge management barriers do you regularly encounter?
15. Which technology barriers do you regularly encounter?
16. Which individual barriers do you regularly encounter?
17. Which semantic barriers regarding e.g. miscommunication and misunderstandings do you regularly encounter?
18. Which barriers would you rate the most harmful to the internal processes? Why?
19. What are the main barriers hampering your processes?
20. What are the negative consequences?

14.1.3 Satisfaction with current internal processes

21. How satisfied are you with the current knowledge management?
22. What are the organization's efforts/measures to counter the knowledge management barriers?
23. How satisfied are you with the organization's efforts to overcome those?
24. What would you do differently if you could change everything?
25. What would be the direct benefits if these barriers could be overcome?

14.1.4 Proposed changes

26. Which knowledge management barriers could be overcome by standardized internal processes guiding everyone involved in the SUS projects?
27. What might be new knowledge management barriers, if the organization standardizes the processes?
28. How helpful would access to knowledge and experiences from prior projects be?
29. Which data would be the most supportive from your perspective?
30. What are the requirements a knowledge management system would need to fulfil to actually be of use to the organization?
31. Where do you see the main impact of internal knowledge management to quality and time to market?
32. What are the pros and cons of the processes and their execution you are encountering in the organization?
33. What do you like? What could be improved? What do you miss in the processes in place (e.g. supportive tools, clearer processes, and clearer overview)?
34. What are your main concerns?

14.2 German Interview Outline

14.2.1 Arbeitskontext

1. Arbeiten Sie vor allem an Standard-, Customization- oder an Single Unit Lösungen (SUS)?
2. Wie ordnen Sie neue Kundenafragen einer der oben genannten Kategorien zu?
3. Was sind die Hauptunterschiede zwischen den drei Kategorien?
4. Was sind die Hauptunterschiede zwischen der Entwicklung neuer Produke und SUS?
5. Wie sieht der interne Prozess für SUS aus, nachdem eine neue Kundenanfrage Sie erreicht?
6. Inwiefern weiß der Kunde was er will?
7. Wer ist während der Kundenverhandlungen anwesend?
8. Inwiefern sind diese Prozesse standardisiert?
9. Mit welchen anderen Abteilungen arbeiten Sie in diesem Kontxt häufig zusammen?

14.2.2 Vorhandene Interne Wissensmanagementbarrieren

10. Wie zufireden sind Sie mit der Kooperation in den und zwischen den Abteilungen?
11. Mit welchen anderen Abteilungen stellt sich die Kooperation und Abstimmung besonders schwer dar?
12. Welche Herausforderungen in Bezug auf Wissensmanagement treten häufig in den internen Prozessen auf?
13. Was sind Wissensmanagementbarrieren die vor allem im Zusammenhang mit Single Unit Lösungen auftreten?
14. Welche organisationalen Wissensmanagementbarrieren treffen häufig auf?
15. Welche Technologiebarrieren treten häufig auf?
16. Welche Wissensmanagementbarrieren treten auf der zwischenmenschlichen Ebene auf?
17. Welche semantischen Wissensmanagementbarrieren die z.B. zu Missverständnissen führen treten häufig auf?
18. Welche Wissensmanagementbarrieren sind Ihrer Meinung nach die mit größtem negativen Einfluss auf die internen Prozesse?
19. Was sind die Hauptbarrieren, die die internen Prozesse negativ beeinflussen?
20. Was sind die negativen Folgen/Konsequenzen?

14.2.3 Zufriedenheit mit den vorhandenen internen Prozessen

21. Wie zufrieden sind Sie mit dem Wissensmanagement?
22. Was unternimmt die Organisation momentan, um die Wissensmanagementbarrieren zu ueberbrücken?
23. Wie zufrieden sind Sie mit den Anstregungen der Organisation, diese zu verhindern?
24. Was würden Sie anders machen, wenn Sie alle Freiheiten hätten?
25. Was wären die direkten Vorteile, wenn Sie Ihre Änderungsvorschläge durchsetzen könnten?

14.2.4 Vorgeschlagene Veraenderungen

26. Welche Wissensmanagementbarrieren könnten Ihrer Meinung nach mithilfe von standardisierten internen Prozessen, die alle Beteiligte leiten, überwunden werden?
27. Was könnten neue Wissensmanagementbarrieren sein, wenn die Organisation Ihre Prozesse standardisiert?
28. Wie hilfreich wäre es für Ihre Arbeit, wenn Sie Zugriff auf das Wissen und die Erfahrungen aus früheren Projekten hätten?
29. Welche Information/Wissen wäre Ihrer Meinung nach am hilfreichsten?
30. Was sind die Anforderungen, denen ein Wissensmanagementsystem gerecht werden müsste, um Sie wirklich unterstützen zu können?
31. Inwiefern denken Sie, dass diese Änderungen time-to-market und quality-to-market beeinflussen könnten?
32. Was sind die Vor- und Nachteile der organisationsinternen Prozesse and ihrer Ausführung?
33. Was gefällt Ihnen daran? Was könnte verbessert werden? Was vermissen Sie (e.g. unterstützende Systeme, klarere Prozesse etc.)?
34. Was sind Ihre Hauptsorgen?