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Knowledge Reuse – The Forgotten Piece of Knowledge Management

A knowledge management system design at Volvo Cars Corporation

Master of Science Thesis
in the Quality and Operations Management Programme

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Abstract

Knowledge management has been climbing fast on the corporate business agenda for the last couple of decades and many companies are trying to figure out how to manage knowledge within their organizations. As customers demand more and shorter lead times are expected, it becomes important for organizations to be able to utilize the knowledge that exists within the company in order to avoid late product changes and unnecessary spending. This issue is especially pressing in the product development industry where the competition is growing fiercer by the day. One company that has acknowledged this need is Volvo Cars Corporation who is looking for ways to reuse their gained knowledge in order to prevent mistakes from being repeated.

The purpose of this master thesis has been to investigate how knowledge should be handled in order to enable for the reuse of knowledge at the R&D department at Volvo Cars Corporation. Four major obstacles were found that hinders knowledge reuse, including a strong project orientation, high internal staff turnover, knowledge inaccessibility and insufficient routines for the information systems in place. As an effort to mitigate these issues, a knowledge management system was designed, including processes and routines to support the use of a software enabling knowledge reuse. The system design based on a qualitative study of the R&D department at Volvo Cars Corporation including a literature research, extensive observations, interviews with employees and benchmarking companies as well as a testing sessions of the designed knowledge management system.

From the design and testing of the system it was concluded that the four obstacles for knowledge reuse could be overcome by providing a solid process for the knowledge from creation to reuse where the knowledge was consolidated into fewer systems that are pushing the most important knowledge to the users. By pushing thin-slices of the knowledge a pull flow from more knowledge is triggered. It was also concluded that in order for the knowledge to be reusable it needs to be stripped clean from information and structured in a way that allows for contextualizing. However, the major conclusion from the study and the contribution to research was the realization that it is of utmost importance to provide employees with a concrete process for *reusing* knowledge and to incorporate that process into the weekly work tasks. Many companies, and researchers underestimate the difficulty of the reuse phase of knowledge management and seem to believe that it is enough to capture learnings. However, in order for knowledge to be of value for any organization it needs to be reapplied, thus the reuse of knowledge should be the focus of knowledge management.

Keyword: knowledge management, knowledge reuse, knowledge value chain, thin slicing, checklists, knowledge management system, knowledge system design principles.

Table of contents

1 Introduction

For the last couple of decades the issue of "knowledge management" has climbed on the business agenda. The markets are fast changing, more global than ever before and the need for efficiency is increasing by the day. Efficient processes are essential for the survival of the companies, especially in the product development business where short lead times are a necessity for the ability to satisfy customer needs. However, efficient processes are almost redundant if mistakes in the processes are constantly repeated. Mistakes and problems are high costs for companies, and by repeating mistakes, the companies are not only spending unnecessary money but also prolonging the time to market for their products. Therefore, there is a need for capturing the learnings made from previous mistakes and re-apply them in new projects. Volvo Cars Corporation, hereafter referred to as Volvo, is a global automotive company and one of the companies in the product development industry that has acknowledged this matter and is working intensely to handle the increasing urgency of knowledge management. The following chapter will explain in more detail why this area is of importance to Volvo and how this thesis aims to investigate the area further.

1.1 Background

How to reuse knowledge throughout an organization has for long been a central issue for companies in order to avoid reinventing the wheel over and over again (Jansson, 2012). This led to, in the mid 90's, the concept of knowledge management, which can be viewed upon as an umbrella term for administering organizational learning (Jansson, 2012; Alvesson & Kärreman, 2004). Since then, the field of knowledge management has been extensively researched in order to find best practices to enable knowledge reuse, yet still no ground breaking truth has been found. Hence, companies are still facing a number of challenges that need to be overcome. Kipley et al. (2008) explain that even though knowledge management is reliant on technical systems, most of the challenges are actually non-technical in essence. According to Kipley et al. (2008) the challenges are partly related to time for knowledge management activities, the mindset and realization of importance for knowledge management. Knowledge is also difficult to quantify due to its intangibility, which often result in difficulties to create good incentives for knowledge management activities as well as managerial support of the matter. However, there are also challenges that are of more technical nature such as difficulty to access knowledge, lack of structure and context for knowledge (Maedche et al., 2015).

Companies all over the world have attempted to address these challenges by a number of different initiatives in order to gain efficiency and create a competitive advantage, Volvo along with them. Volvo has for a long time been experiencing that mistakes re-occur in different projects. They have tried to redeem this in many ways, but still, numerous problems occur along the way resulting in changes on the product (see Figure 1). Often, these problems are not recognized until rather late in the process when physical prototypes are created. This

results in a problem solving process that is often highly expensive due to pressing time to market demands and also because of the complexity of the problem area since all parts of the product at this point are connected to each other in one way or the other (Wheelwright & Clark, 1992).

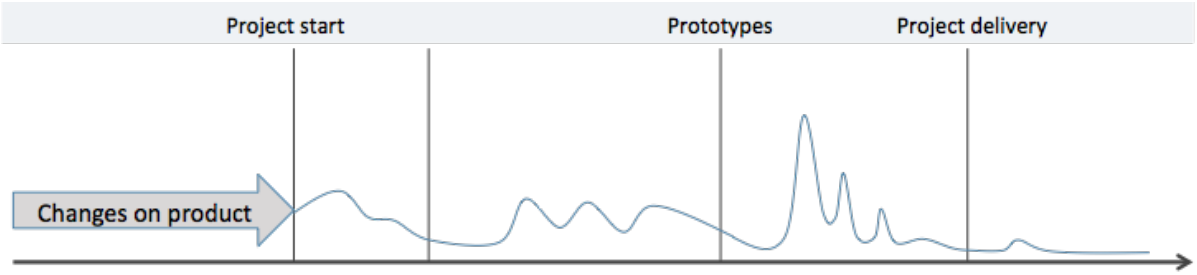

Figure 1 - Visualization of the number of changes in a product development process over time. The more changes the larger the knowledge creation and the later the changes the cost.

Sometimes these problems occur simply because the company is developing something new, that has never been tried before. However, too often, companies realize that the problem is not new to the organization, it has happened before in another project and could, most likely have been prevented if only the knowledge gained from that from earlier projects had been applied. In those cases the problem is not only costly due to lack of time and complexity, it is also completely unnecessary (Wheelwright & Clark, 1992). For a company as Volvo that is active in one of the most competitive industries in the world, they simply cannot afford such unnecessary costs, still the problems keep reoccurring.

As an effort to mitigate this problem, Volvo has recently launched an initiative called "Transformation 202020", which focus is to introduce knowledge based product development and ultimately be able to develop a new car model within 20 months by year 2020. One part of this initiative is to become better at utilizing the knowledge that exists within the company. Knowledge is constantly created within product development companies (Wheelwright & Clark, 1992), this is also true for Volvo. Problems are solved and new solutions are invented, thousands of calculations and tests are carried out for each project and the results are continuously communicated back to the concerned teams. Volvo has gateways containing requirements for product fulfillment, processes for documenting issues in projects as well as quality problem handling systems and Lessons learned. They have all these systems and processes to manage knowledge within the organization and still, they do not manage to apply the knowledge in future projects. Why is this? And what can Volvo do to overcome it?

In general, the common way to mitigate the difficulties related to knowledge reuse and avoid making mistakes is by the utilization of a knowledge management system (Alavi & Leidner, 1999). According to Alavi and Leidner (1999) a management system refers to one or several information systems with a focus to facilitate the sharing and integration of knowledge in an

organization. Connected to these knowledge focused information systems are processes and routines to support the entire value chain of knowledge, from creation to reuse (O'Dell and Grayson, 1998). Thus, the term knowledge management system can regarded as to include systems as well as process and routines to support these systems and will be throughout this thesis. Along with the growing need for knowledge reuse within organization, the area of knowledge management systems has been evolving for the last decades. Even so, a best practices for handling of knowledge, in order to be able to later apply it later reuse, is still to be found.

As a part of the Transformation 202020 initiative, Volvo has come in contact with a start-up company in Gothenburg, connected to Chalmers University of Technology. The start-up is developing a new software, called Checksheets, with knowledge reuse in focus. The software is currently used by Volvo Trucks and is based on theories of thin-slicing of knowledge in the form of checklists, which is about making small fragments of knowledge available to the user rather than the entire information base (Carney et al., 2007; Gawande, 2010). Volvo has acknowledged the potential of using such software to enable reuse of knowledge. However, they have not yet explored the use of Checksheets themselves but are interested in evaluating the benefits of the software in a knowledge management system context.

1.2 Purpose

The purpose of this master thesis is to investigate how knowledge should be handled in order to enable the knowledge to be reused. The investigation will focus on the requirements of a knowledge management system at the design engineering department at Volvo, in order to mitigate the underlying reasons to why knowledge is not being applied in later projects. During the master thesis, an evaluation will be performed of how the software Checksheets can be used in such knowledge management system. The aim is to provide Volvo with a recommendation for a design of a knowledge management system for technical knowledge at the design engineering department that with minor adjustments could be implemented throughout the different departments involved in the product development process.

1.3 Problem analysis and research questions

According to Alavi & Leidner (2001) it is not so much the existence of knowledge but the ability to apply it that creates a competitive advantage. Any knowledge management initiative is redundant as long as it does not result in the knowledge being reused. Many organizations are aware of this but are struggling obtain it as well as to understand what is needed from the organization to enable knowledge reuse. Hence, the first research question has been formulated accordingly.

RQ1: *What is required from a knowledge management system in order to enable knowledge reuse?*

As described in the background, Volvo has several systems in place to manage knowledge and there are several sources of knowledge creation at Volvo. However, as mentioned, they are not able to reuse the knowledge that is being created in the projects from learnings. It seems as if the systems and processes, in line with what Alavi and Leidner (2001) are arguing, are not able to support reuse of knowledge. How such support is to be obtained must be adapted to the specific context in which it is to be applied, leading down to second research question:

RQ2: *How should a knowledge management system at the design engineering department at Volvo be designed in order to enable knowledge reuse?*

As mentioned in the earlier, Volvo has been introduced to a new knowledge management software Checksheets. The software aims to facilitate the reuse of knowledge by providing a common platform in the form of a checklist that gathers the most important knowledge to consider throughout a project within an organization. The software can be used either as a complement to an already existing knowledge management system or as the core knowledge management system in the organization. However, in order for Volvo to invest in such software it needs to be able to support the suggested design of the knowledge management system, leading down to the third and last research question:

RQ3: *How can Checksheets be used to support the designed knowledge management system?*

1.4 Delimitations

This study is focused only on the knowledge management process of the R&D department at Volvo. Suggestions and recommendations will be made solely for the product development process at Volvo and specifically the design engineering department. Thus, knowledge created within pre-development will not be considered when designing the knowledge management system. The evaluation of the knowledge management software Checksheets will be delimited to two design engineering teams due to resource and time constraints. The study will also be delimited from implementation of a knowledge management system. Furthermore, the master thesis will not focus on transferring knowledge across the organization, but rather how to reuse knowledge for different subsystems of the car from project to project within the organization, in order to prevent mistakes from being repeated.

2 Methodology

In order to be able to answer the above presented research questions, a study has been conducted. The following chapter will explain the details on the performing of the research, including justifications for why this approach has been selected as well as important aspects that has been considered to make the study reliable.

2.1 Research strategy

Bryman & Bell (2011) brings up two frequently used strategies for conducting research, the quantitative and the qualitative approach. A quantitative approach has a strong focus on numerical data and can provide a fast and often statistically based understanding of a subject or an area (Bryman & Bell, 2011). However, a quantitative study makes it difficult to investigate the more intangible parts of the field of investigation and the approach is rather inflexible. In a qualitative approach on the other hand, the emphasis is put on the on words and the underlying meaning of what is spoken rather than on numerical data (Bryman & Bell, 2011). The approach can be changed as the research progresses and new conclusions are made along the way (Bryman & Bell, 2011). This research has been aiming to provide a deep understanding of knowledge management and the requirements needed to enable knowledge reuse, areas that are both of intangible nature. The study was decided to be both exploratory as well as iterative, meaning that the direction of the research changed successively throughout as the research progressed. Further, the research has also been aiming to combine the existing theory with empirical findings and uncover new ground by combining them, thus using an inductive method. According to Bryman & Bell (2011), the qualitative approach is suitable for the creation of new theories. The inductiveness of the research in combination with the need to be able to capture the intangibility of knowledge management, and the elements needed for answering the research questions as well as the exploratory and iterative manner of the study, resulted in that the qualitative approach was found to be most suitable.

2.2 Research design

To enable for a qualitative study that could provide the information necessary, a research design was chosen that to some extent is a hybrid model of an action research and a cross-case study. The reasoning behind this decision was based on the purpose of the study. To a large extent, the research aims is to deliver value to a specific company by providing them with a suggestion for a design of a knowledge management system. Such strong company focus makes the study similar to the action research approach described by Bryman & Bell (2011). However, in an action research, the research group should include company employees, something that has not been the case in this study. Instead the study was broadened through a cross-case analysis of other companies in the product development industry to provide input on how a knowledge management system should be designed a Volvo. A cross-case analysis is a way in a qualitative research to mobilize knowledge through

the accumulation and comparison of input from different cases (Khan & VanWynsberghe, 2008). In this research, the input was collected through qualitative interviews at four other companies. The focus of the interviews was to provide input on different aspects of knowledge management with the purpose to understand gain knowledge in how other companies work with knowledge management. All interviews have been carried out in a semi-structured format as suggested by Bryman & Bell (2011) when performing qualitative studies.

2.3 Research process

The research has included seven methodological parts, all of which have been performed concurrently and collectively contributed to answering the formulated research questions. The seven parts include: a literature study, exploratory interviews, observations, benchmarking interviews, survey, testing of the system and in-depth team member interviews. In one way, this master thesis can be compared to a product development project. The practical approach has been rather agile, where prototypes were presented at an early stage and Volvo employees has been given the opportunity to influence both the knowledge management system and the software directly. In addition, the focus has been to quickly get the software developed and ready for testing. This approach has been inspired by the theory of creating early hypotheses and prototypes, that is of importance in order to obtain a customer satisfying final product (Wheelwright & Clark, 1992). However, such agile approach is difficult to present in written form, thus the structure of the report does not completely reflect the methodology of the study. All three research questions have been answered in parallel, see Figure 2 below for which of the methodological parts that answers which question.

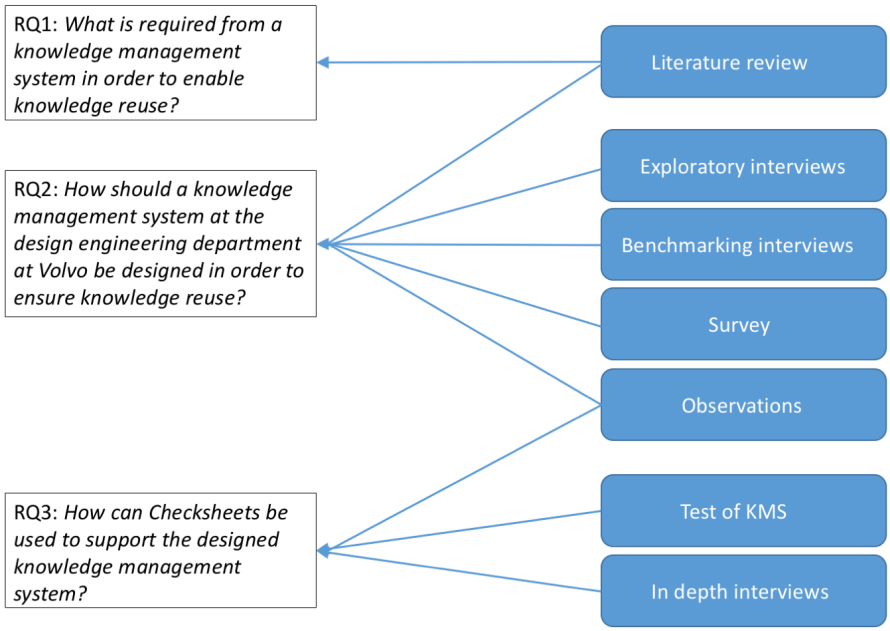

Figure 2 - Visualization of which methodological parts contributing to which research question.

The first research question, "*What is required from a knowledge management system in order to enable knowledge reuse?"* has mainly been addressed through a literature review. The literature review created a fundamental understanding of knowledge management and what is demanded of a knowledge management system. One article in particular provided the basic foundation for the requirements of a knowledge management system, the article "*The Evolution of Design Principles Enabling Knowledge Reuse for Projects: An Action Design Research Project"* by Maedche et al. (2015). This article has provided the study with the main basis for the answer to research question one (see Section 2.3.1). The level of influence from this particular article was a conscious choice based on the fact that authors had made a thorough investigation as basis for the article. Not to build on such extensive research would have been directly in conflict with the theories of knowledge management (Alavi & Leidner, 2001).

Research question two, *"How should a knowledge management system at the design engineering department at Volvo be designed in order to ensure knowledge reuse?"* was focused on during the exploratory interviews, benchmarking interviews and general observations. The exploratory interviews were performed in order to get familiar with work procedures, create a perception of how knowledge management fits in at Volvo and to raise possible questions. As a greater understanding of both knowledge management and the organization at Volvo was gained, the exploratory interviews became more and more focused on answering the research question and thus converting into discussions regarding a knowledge management system. In addition to the exploratory interviews, a survey was sent out to different groups in the R&D business unit. The answers of the survey served as guidance for what areas to investigate further in order to understand how the knowledge management system should be design in order to enable knowledge reuse.

In parallel with the interviews, a prototype of the design of the knowledge management system was developed. During the more focused interviews, the interviewees were offered a chance to give feedback on the system in order to provide the most possible input to the system design. Simultaneously, discussions were held with the start-up developing the software Checksheets with the intention to specify the requirements of Checksheets needed to fit with the Volvo organization. As the research progressed the discussions became more focused on specific functions needed in the software to enable the possibility of knowledge reuse. During these discussions, input from stakeholders, benchmarking companies and researchers from Chalmers have been gathered and thus influenced the software. The benchmarking interviews was conducted to gain awareness of how other organizations work with knowledge management and different information systems, thus serving as inspiration for designing the knowledge management system at Volvo Cars. During the later stages of the design process of the knowledge management system, the benchmarking interviews were also used to gain feedback on the system design. The companies participating in the benchmarking interviews were SKF, SCA, Autoliv and Volvo Trucks. In essence, there has been three major parts contributing to the design of the knowledge management system at Volvo, visualized in Figure 3 below. The three parts were; the literature review performed, all the knowledge gained from exploratory interviews and observations about knowledge related issues at Volvo

such as organizational structure, systems handling knowledge, work procedures, and challenges with knowledge management, as well as the benchmarking interviews.

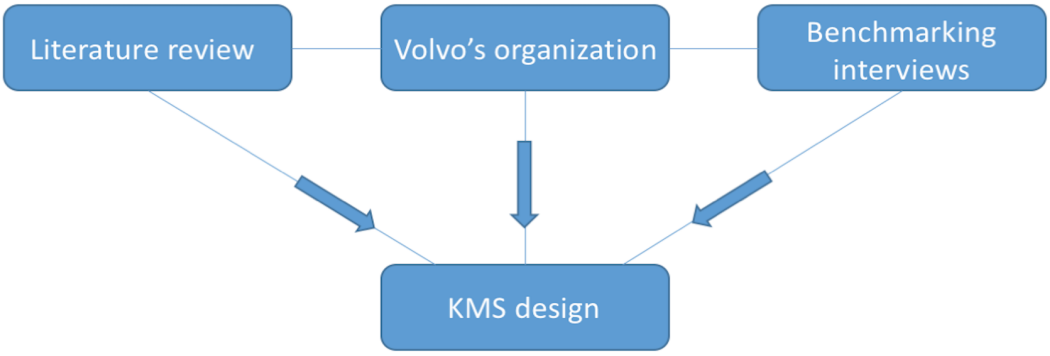

Figure 3 - Visualization of the three parts that has influenced the design of the knowledge management system.

The last research question, *"How can Checksheets be used to support the knowledge management system at Volvo Cars?",* has first and foremost been answered by a testing of the knowledge management system and by additional in-depth interviews. When a thorough research of academia and the Volvo Cars corporation as well as when benchmarking interviews had been performed, the input from those three sources collectively resulted in the complete design of the knowledge management system. In order to realize how this knowledge management system could contribute to knowledge reuse, 8 workshops were conducted and two tests were performed. The first step was to lead and facilitate the workshops with the selected test groups, two design engineering groups, in order to gather important knowledge for each design group respectively. This was done by gathering 4-5 employees from a group at Volvo for an off-loading process. The employees had been asked to prepare previous quality issues with solutions to bring up at the workshops. These quality issues were discussed within between the 4-5 employees and how to formulate the preventive action was collectively decided. Once the software was filled with the most important knowledge to take into consideration during the design phase it was ready for testing. The testing consisted of two different simulated use-cases of the knowledge management system: individual use, where different group members worked with the software as intended in the system design, and a knowledge meeting, where the entire group was gathered to provide knowledge input to the knowledge management system. After the use-cases, in-depth interviews were conducted during 20 minutes in order to qualitatively evaluate how the use of the software as part of the knowledge management system but also to provide input on how the knowledge management system design overall could be improved. The questions during the in-depth interviews were formulated and divided into three categories, software, quality of knowledge and the knowledge management system.

2.3.1 Literature study

The literature study served, as mentioned, as the basis for answering the first research question in the thesis. In order to create a holistic understanding of the subject, research was made regarding knowledge as a concept, knowledge management, the most common

challenges with knowledge management and finally potential solution for handling knowledge in order to enable reuse. The areas were not investigated in that order but in parallel to each other as a way to create a general understanding without being biased due to the literature absorbed hitherto. The universal search engine at the library of Chalmers University was used to locate the literature as well as Google Scholar and recommended literature from supervisor and industrial PhD in knowledge management at Volvo Trucks. As mentioned, one article in particular was used as a basis to answer research question one, "*The Evolution of Design Principles Enabling Knowledge Reuse for Projects: An Action Design Research Project"* by Maedche et al. (2015). The authors of the article present an extensive literature research and a designed knowledge management system through an action research resulting in six design principles for a knowledge management system. The design principles are based on requirements of a knowledge management system and underlying difficulties with such system.

2.3.2 Exploratory interviews

As part of answering research question two exploratory interviews were, as mentioned, conducted with different employees at Volvo. The interviews consisted of 45-60 minutes meetings with Volvo 11 employees from different areas involved throughout the product development process (see Table 1).

Table 1 - The roles and departments that were represented in the exploratory interviews

Role	**Department**
Group Design Leader	Vehicle Hardware - Design
Director Design	Design Engineering
Senior manager	Vehicle Hardware - Vehicle Concept Development
Technical Leader	Vehicle Hardware - Predevelopment
Annual program Manager	Manufacturing Engineering - Strategic Planning & Control
Technical Expert	Design Engineering - Exterior design
Group Design Leader	Vehicle Hardware - Design
Design engineer	Vehicle Hardware - Design
Manager	Vehicle Hardware - Mechanical Integration
Manager	Complete Vehicle Engineering - Crash analysis
Manager	Complete Vehicle Engineering - Durability

The departments ranged from Styling in the beginning of the product development process to Manufacturing Engineering that are active in the very end of the product development process with a focus to make sure the designed cars are able to be manufactured. Regarding the roles, they vary from Director and Senior Manager that work on higher strategic level all the way to Design Engineers designing the actual parts of the cars.

During the first interviews the aim was to get an understanding of the product development process, how different units and departments were tied together as well as how knowledge was managed throughout the process. Thus, questions regarding the work in the current department and contact with other departments where in focus as well as examples of knowledge management were posed (see Appendix 1). In the later interviews, the focus turned more towards input for the design of a knowledge management system and the interviewees were, in addition to the interview questions also presented with conceptual model of a knowledge management system aiming to answer research question two. They were asked to give their feedback on the initial thoughts on the system than how they thought it could be improved to better fit with the Volvo organization. Based on the feedback provided during these late interviews, the knowledge management system was iteratively adjusted. The feedback in combination with the survey provided input to understand the underlying difficulties ta enable knowledge reuse at Volvo and how these possibly could be mitigated.

2.3.3 Observations

During the master thesis a close collaboration and insight to the Volvo organization has been in an important in order to gain a holistic understanding of the knowledge setting and input to research question two and three. Observations have continuously been carried out through attending formal meetings, leading workshops, using Volvo's information systems and intranet as well as less having informal conversations with employees. On average four days a week have been spent at Volvo to create opportunities for quickly meeting with employees when necessary. The observations have mainly been centered around the understanding of how the organization works, what systems that are handling knowledge and how these are related to each other as well as challenges of knowledge reuse. They have been captured by an oral discussion between the researchers as well as company supervisors followed by the development or adjustment of illustrations and flowcharts visualizing the different observational aspects. The visualization that has been in particular focus is the design of the knowledge management system that has been adjusted iteratively during the research.

2.3.4 Survey

To further gather knowledge about how the employees' perceive knowledge management within the organization, a survey was conducted with employees at all different hierarchical levels within the R&D business unit. 98 employees answered the survey and there were two main questions that were in focus, "*Why do you think mistakes that have been acknowledged and resolved in earlier projects at Volvo are repeated?"* and *"What are your general thoughts on knowledge management at Volvo?"*. In addition, the survey included 12 questions regarding current information systems and how they are used in order to find out if any information system works very well or not good at all. Each of these 12 questions were thus connected to a specific information system, including two separate questions, "*How often do you use this information system to store knowledge?"* and *"How often do you use this information system to reuse knowledge?"*. Altogether, the survey served several purposes:

1. Triangulate data by confirming the observations made and interviews conducted
2. Direction on what problem areas connected to knowledge reuse to further investigate
3. Get an overview of how well the current information systems work

2.3.5 Benchmarking

To gain credibility and put more weight into general statements regarding knowledge management, benchmarking interviews were performed with a focus to understand how other product development companies work with knowledge management, which problems they experience and how those problems are solved. This provided the researchers with the possibility to validate the findings at Volvo and to acknowledge that the area of investigation and conclusions drawn were not only applicable to the main case company but partly generalizable. The interviews also broadened the input on knowledge management for the researched and provided new perspective on the matter. In total, seven interviews were conducted with four different companies: Volvo Trucks, SCA, SKF and Autoliv. In order to narrow down the focus of the interview towards concrete activities for knowledge management, all interviewees were introduced the master thesis in the beginning of each interview. The questions asked were open and based on 8 main questions (see Appendix 2). Depending how each company worked with knowledge management, the follow-up questions were different in order to dig deeper into those specific problems or solutions. The findings of the benchmarking interviews will be presented individually for each company within these reports, however with the names of the companies coded in order to reduce readers bias and respect the privacy of the benchmarking companies.

2.3.6 Testing and in-depth interviews

Due to the fact that this master thesis has similarities to a product development project, testing that the knowledge management system actually could work and that it satisfies the employees' expectations was necessary. As mentioned, two different tests were performed, one that focused on the individual use of the software and the other was a knowledge meeting moderated by an employee within the test group. The individual tests were performed on three employees for 40 minutes each, where 20 minutes consisted of using the software and 20 minutes were used for interviewing. At the beginning of the test, each test person was introduced to the knowledge management system and the intended use of Checksheets. Thereafter, a short walk through of how to navigate within Checksheets was performed followed up by asking the test person to create their own checklist for their specific component and project phase. During the use of the software, the researchers were present, however not looking over the test person's shoulder. Thus, stress created from continuously being watched could be avoided, and the researchers were available for instant feedback. The test persons also took notes regarding the knowledge to be used as input for the test of the knowledge meeting. Once the test was completed, the test person was interviewed regarding the software, the knowledge and the knowledge management system, see interview questions in Appendix 3.

The test of the knowledge meeting was conducted with only one of the test groups due to time constraints of the employees at Volvo. The test performed in the same way as the workshops were conducted, only the knowledge meeting was entirely moderated by an employee instead of the researchers. Thus, the moderator was responsible to ask for new input to the knowledge base, navigate within the software and revise the knowledge within Checksheets. The researchers, who were only observing the knowledge meeting in order to collect data, appointed the moderator.

2.4 Quality of research

In order to provide the reader with a sense of the quality of this research, trustworthiness and ethics will be discussed within this chapter.

2.4.1 Trustworthiness

When conducting research one must consider the reliability and validity of the study. In qualitative research, reliability and validity is equivalent to trustworthiness and authenticity (Bryman and Bell, 2015). According to Bryman and Bell (2015) trustworthiness can be divided into four subcategories: credibility, transferability, dependability and confirmability. In order to ensure credibility, it is important to make sure that different aspects of the subject are all highlighted. Triangulation has been performed using multiple interviewers; cross-referencing notes in order to avoid biased judgments, and by comparing qualitative interpretations to documented data when possible.

Regarding the transferability aspect, the main purpose is to enable generalization of the study. According to Bryman & Bell (2015) this is most efficiently done by providing a thick description to the context of the study in order for others to make a judgment of what can be generalized for their own purposes. In this study, the transferability has also been enhanced through the benchmarking study of other companies' knowledge management systems. The dependability of the study has been strengthened by documenting all phases of the process and continuously maintaining these records in order to keep them accessible (Bryman & Bell, 2015). As for conformability, the purpose is to ensure objectivity in the study. Complete objectivity is almost impossible to obtain in a qualitative research since all answers and question from all interviews will contain bias to some degree due to person to person interaction. However, the bias can be reduced by acknowledging the possible subjectivism as well as by assuring a minimum of two interviewers at all interviews to at least balance out some of the subjectivism.

In addition to the different aspects of trustworthiness, Bryman & Bell (2011) also suggests that the *authenticity* should be regarded. Authenticity concerns the more political issues related to a research study and a reasoning on the subject should, according to Bryman & Bell (p. 399, 2011) include the following questions:

- Does the research help members to arrive at a better understanding of their social milieu?
- Does the research help better appreciate the perspectives of other members of their social setting?
- Has the research acted as an impetus to members to engage in action to change their circumstances?
- Has the research empowered members to take the step necessary for engaging in action?

All of these questions have been taken into consideration throughout the study by being part of the ongoing dialogue with the team members in the two design engineering groups. The questions have also been post-research evaluated, by giving the participants in the study the possibility to give oral feedback on the impact of the study for them personally. In each of the groups, the employees have uncompelled taken responsibility to involve and engage the group. These groups have also continued to work with the methods to encourage knowledge reuse after the researchers left Volvo.

2.4.2 Ethics

In any type of research study but especially in qualitative studies such as this one, ethical issues are of great importance. According to Bryman & Bell (2015) there are generally four different issues that should be regarded when aiming to uphold an ethical standard in a research study; (1) harm to participant, (2) lack of informed consent, (3) invasion of privacy and (4) deception. Harm to participants occurs if any of the people or companies involved in the study experience that they are being harmed in any way, either emotionally or professionally. In order to avoid this, a copy of the final report has been sent to interviewees for confirmation of accuracy. The assurance of anonymousness is also an important factor in order to avoid the participants feeling harmed. Interviewees should be given the information that no specific information will be included in the report that could be traced back to them personally. Company secrets have been handled under confidentiality agreements and the final report has excluded material that, if made official, could cause harm to the companies being a part of this study.

Lack of informed consent is an issue to take into consideration during the interviews with any personnel outside of the thesis supervisors. However, this could be avoided by thoroughly informing interviewees about the background and purpose of the project, as well as what their contribution will be and how the results of the project will be used. This also decreases the possibility of the participants feeling deceived.

Regarding invasion of privacy, one of the main aspects to regard here is the free will of the participants' to contribute to the study. They have been informed that at any given point in time during an interview they have the right to refuse to answer or choose to opt out of the study completely. All interviewees or people being observed was also informed of when any type of recording devices was be used, with the right to refusal of being recorded. Further, the

results from the study have been communicated to the participants and a final copy of the report has been sent for confirmation of agreed participation before publication.

3 Theoretical framework

In order to create an understanding for the knowledge management in general as well as the empirical data later in this report, this chapter will include an introduction to subject of knowledge management. The chapter will also address the most common difficulties related to knowledge management as well as how to mitigate these and hence the theoretical suggestions for the requirements of a knowledge management system.

3.1 Introducing knowledge management

The area of knowledge management has been given a substantial amount of attention the last couple of decades and the general impression associated with the term is that it is highly complicated and incredibly difficult for companies to accomplish knowledge reuse. Although, the basic concept of knowledge management is not complicated, knowledge management is simply a mindset of trying to build a company's future actions on past experience (O'Dell & Grayson, 1998). However, even though the concept is easy to grasp, the processes supporting it are not. In order to understand knowledge management and the difficulties related to the area, one needs to have a fundamental understanding of what knowledge really is, as well as the different ways it can be expressed and handled.

3.1.1 Definitions, views and hierarchies of knowledge

Jonsson (2012) advocates the importance of defining the expressions and choosing words carefully when discussing the management of knowledge. Not necessarily because the words themselves are important, but in order to clarify what is actually meant. Due to the fact that the concepts within knowledge management flourish nowadays, it becomes difficult to understand differences between different terms and expressions. Alavi and Leidner (2001) also acknowledged this risk related to the view of knowledge and made an effort to gather the different perspectives presented in academia:

1. A state of mind - The sum of what one has experienced, perceived and learned
2. An object - An item to be stored and shaped
3. A process - A procedure of simultaneously knowing and acting, focused on applying expertise
4. A condition of having access to information - Similar to the view of knowledge being an object, but focused on the accessibility
5. A capability - A means of having the possibility to influence future actions

Until today, these views on what knowledge is, have still not been surpassed by new definitions, and are therefore used to explain that knowledge may be looked upon very differently. Depending on what view one adheres to, it could affect the understanding and communication regarding what knowledge management is (Alavi & Leidner, 2001).

Another aspect that contributes to confusion around the subject of knowledge management is the difference between knowledge, information and data, since there is a remarkable distinction between the concepts but they are often mixed up. Alavi and Leidner (2001, p. 109), argue that "knowledge is information possessed in the mind of individuals: it is personalized information related to facts, procedures, concepts, interpretations, ideas, observations and judgments". Furthermore, the hierarchy of the above mentioned concepts are often explained accordingly: data is viewed upon as facts and raw numbers, information is processed data and knowledge is authenticated information (Alavi and Leidner, 2001). This definition is sued by Maedche et al. (2015) as well and actually suits well with the definition of knowledge provided by Volvo. According to Nyström (2017), manager of knowledge based engineering at Volvo, "knowledge is understanding gained through experience or study". Thus, one could argue that knowledge is personal since the definition is focused towards the understanding of a specific event, which may vary from person to person.

As an effort to make the definition of knowledge more concrete yet capturing the focal point of Volvo's definition, a combination of these two is presented accordingly: knowledge is the understanding of information gained through facts, procedures, concepts, experiences, interpretations, ideas, observations, judgments and studies. In order to make the purpose of the study clear and avoid confusion as described by Alavi and Leidner, this is the definition that will, be used throughout the continuing of the thesis since it captures the core of Volvo's view, which is the understanding, and still it becomes concrete by explicating experiences and studies.

3.1.2 Dimensions of knowledge

In addition to the definition of knowledge, the concept also includes different dimensions. The literature generally refers to two main dimensions of knowledge within organizations; explicit and tacit knowledge (Nonaka & Takeuchi, 1995; Alavi & Leidner, 2001; Jonsson, 2012; Markus, 2001). Nonaka and Takeuchi (1995) explain the explicit dimension as knowledge that is formal and can be systematized by being expressed in words, numbers and statistics. Such type of knowledge is easy to communicate and transferred since it is easily interpreted and can be codified into hard data. Tacit knowledge on the other hand, is the type of knowledge that is not obvious, hence, cannot easily be expressed nor visualized (Alavi & Leidner, 2001). This is a more subjective kind of knowledge such as insights and intuitions. Those things that are rooted within the core of a person and entangled with the emotions, values and ideals of each individual (Nonaka & Takeuchi, 1995). In addition to this, tacit knowledge consists of two sub-dimensions; technical and cognitive. The technical dimension is the informal skills and know-how that is hard to express but that people are aware of exists while the cognitive dimension reflects every person's perception of the reality. It constitutes of mental model and beliefs that are so deeply rooted in people that they are most often taken for granted or disregarded.

The concept of knowledge management and in particular knowledge reuse is highly affected by these dimensions since knowledge exist in both forms in any company (Nonaka et al.

2000). In order to enable knowledge reuse, a company needs to require knowledge in both dimensions, otherwise only fragments of the gathered knowledge base will be available for reuse. In order to do so, one needs to understand the relationship between tacit and explicit knowledge.

3.1.3 Knowledge conversion

Even though there is a difference between tacit and explicit knowledge by definition, the two dimensions are strongly linked to each other. According to Alavi and Leidner (2001) tacit knowledge forms the underlying basis that is needed in order to be able to interpret and understand explicit knowledge. If two people are presented with the same exact explicit knowledge, they can still interpret it completely different depending on the tacit knowledge they possess. However, if the people possess the same tacit knowledge to some extent, it is more likely that they will interpret and understand explicit knowledge in a similar way. Hence, the greater the shared knowledge base is, the more of the explicit knowledge can the utilized (Alavi & Leidner, 2001). This relationship is sometimes illustrated by the use of a model showing the conversion of knowledge between the two dimensions, the SECI-model (see Figure 4). According to Nonaka et al. (2000) the model consists of four different modes explaining different forms of conversion of knowledge.

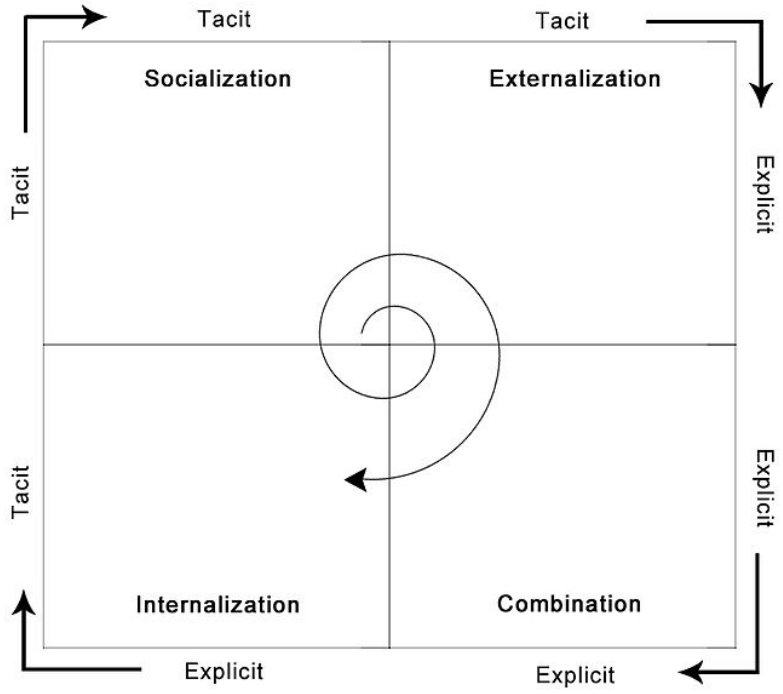

Figure 4 - Visualization of the SECI-model, explaining the different modes in the knowledge conversion spiral (Nonaka & Takeuchi, 1995).

- *Socialization* - The process of converting tacit knowledge into tacit. Since tacit knowledge is hard to formalize the conversion of tacit knowledge is most easily made through the sharing of experiences or environmental conditions where there is potential for sharing knowledge through continuous interaction.

- *Externalization* - When tacit knowledge needs to be shared in a broader environment than socialization can obtain, tacit knowledge needs to be converted into explicit. By articulating tacit knowledge it can be crystallized and made communicable. This is a crucial process for enabling dissemination of knowledge within a company and it is also the most difficult of the four modes in the SECI-model. Since tacit knowledge is hard to formulize, precise use of models, analogies and metaphors need to play a large role in the externalization in order to obtain a correct interpretation of the tacit knowledge.

- *Combination* - Once the knowledge has been externalized it can be further systematized, turning the models and concepts into details and hence, conversion of explicit knowledge to more explicit knowledge.

- *Internalization* - The explicit knowledge can then, after externalization and combination, be communicated out in an organization and applied in different situations. By turning the knowledge into actions, the knowledge will through a learning process become integrated into the people's personal know-how and soon enough a natural part of the process. Hence the knowledge has converted back into tacit knowledge.

Often in organizations, knowledge is tacit when first created. In smaller organizations this is not normally a problem regarding the reusability of the knowledge since the room for externalization is large due to the close connections within the company. However, in large companies or in companies that have rather high staff turnover it is more difficult to share knowledge and make it reusable through socialization since people do not interact as easily. Instead there is need to make the knowledge explicit through externalization in order to enable for it to be communicated to other parties in the organization whom can then internalizing it to be able to re-apply it correctly.

3.1.4 The knowledge value chain

The process of transferring knowledge from where it has been created to where it is to be reused is a common topic for the research on knowledge management. In the literature there are different definitions of this process and often companies has a definition of their own. For example, O'Dell and Grayson (1998) present a framework named *"steps in the knowledge transfer process"* (see Figure 5). They identified eight phases within the knowledge transfer process including: create, use, identify, collect, organize, share, adapt, and use.

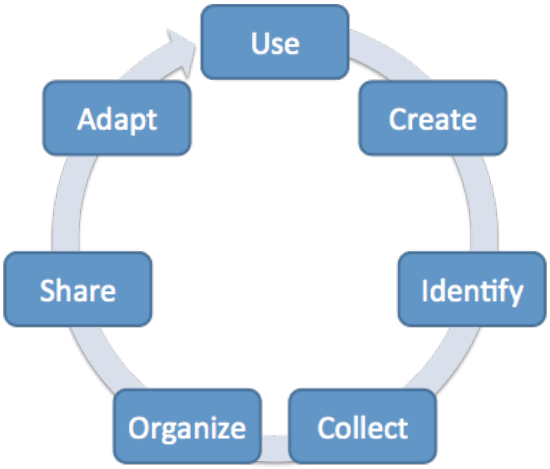

Figure 5 - O'Dell and Grayson's (1998) framework for steps in the knowledge transfer process.

Alavi and Leidner (2001) present a process that can be regarded as a less detailed version of the above illustrated process, including the phases: creating, storing, transfer, and application.

Creating - The creation of knowledge can be related to the definition of knowledge, where knowledge is created in the process of understanding information gained through facts, procedures, concepts, experiences, interpretations, ideas, observations, judgments and studies. Thus, knowledge is created when the above aspects are processed by a person's own thoughts and interpretation of the information.

Storing - In order for the created knowledge to become applicable it needs to be captured and stored in a manner where it will be able to be retrieved later. Much knowledge is initially stored within the mind and memory of each person involved in the creation process. However, the memory is highly selective and people have a tendency to forget what they know (Alavi & Leidner, 2001). In order to prevent such organizational knowledge loss, three things need to be in place. Firstly, there must be an organizational structure and culture that support knowledge management and storage (Alavi & Leidner, 2001). Such structure could be interaction points, networks and meetings that help segmenting gained knowledge by socialization and discussion. Secondly, there must be a solid process for externalization and combination of knowledge in order to make it understandably expressed (Nonaka & Takeuchi, 1995). Finally, storage systems are needed that can organize, sort and store the explicit knowledge effectively in a way that makes it retrievable for anyone in need of the knowledge later (Alavi & Leidner, 2001).

Transferring - Transfer of knowledge occur on different levels in organization but generally refers to either inter-human transfer or transfer of knowledge between an explicit source and a group of people or single individuals (Alavi & Leidner, 2001). Similar to the storing the inter-human transfer process is dependent on interaction points between individuals or groups of some kind. For the transfer related to explicit sources there is a need for storage intermediaries, as aforementioned, that enable knowledge to be expressed, stored and later

retrieved by the knowledge user. IT-systems and structured processes plays an important role for this transfer process especially when the transfer is occurring with a time difference, that is that the moment of creation is much earlier than the knowledge application moment (Alavi & Leidner, 2001).

Application - The application of knowledge is the last step in the process and the very core of knowledge management since it is a firm's ability to effectively apply the knowledge that forms the basis for obtaining a competitive advantage, not the pure existence of knowledge (Alavi & Leidner, 2001). In order for the knowledge to be applicable, it needs to be retrievable from the storage location and packaged in a manner that is understandable for whoever is using it (Markus, 2001). Once the knowledge is retrieved, it can be applied and new knowledge created by observation of the results of the application.

Reviewing the literature, it seems that a common ground for the process can be summaries to the steps: creation, capture, store, transfer and reuse of knowledge (see Figure 6). This definition can be regarded as a slightly altered version of the framework presented by Alavi and Leidner (2001). Capture is a step in between *create* and *store* in the Alavi & Leidner (2001) framework, where the essence of what actually is usable knowledge is defined in order to determine what should be stored and how it should be packaged. As for *store* and *transfer* the order change depending on whether the knowledge is applicable for the creator only or other teams and employees as well. And the reuse step is what is referred to as *application,* when the created knowledge is actually applied again. In this thesis this process will be referred to as the knowledge value chain and used as the baseline for knowledge travel through an organization.

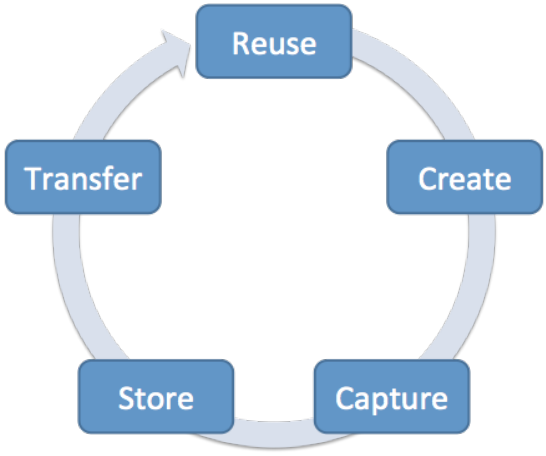

Figure 6 - The by literature commonly agreed knowledge value chain.

What is important to address regarding the knowledge value chain, independently of what definition one is using, is that in order for knowledge to be reusable, all stages of the value chain needs to be addressed and managed (O'Dell and Grayson, 1998). Basically this is what

the concept of knowledge management is evolving around, to enable the knowledge to travel through all different stages of the value chain in order to be reused. Thus, a knowledge management system should include all part of the knowledge value chain. However, how a company does this can differ, in other words they can have different strategies for enabling the addressing of the entire knowledge value chain.

3.1.5 Knowledge management strategy

According to Hansen et al. (1999) there are two common strategies for taking knowledge through the value chain, *codification* and *personalization*. Codification refers to the use of documentation and coding of knowledge in order to be able to store and transfer the knowledge for later reuse. When using codification for the knowledge value stream process it is crucial to strip the documentation of experiences from project specific knowledge (Hansen et al., 1999). Unique knowledge will not be useful for future projects and should therefore not be coded. To understand what is generic knowledge and not difficult for someone that is unfamiliar with the codification process and experience in project process. According to Maedche et al. (2012) and Markus (2001), intermediaries can play an important role as specialists in finding the essence of knowledge within the often large amount of information and data that projects generate. Once the knowledge has been captured from the projects and coded into documents a codification strategy is often in need of some kind of common knowledge storage in order for future projects to know where to look for the coded knowledge (Hansen et al., 1999; Markus, 2001).

Codification makes it possible to retrieve and reuse knowledge without having direct contact with the knowledge creator (Hansen et al. 1999). As a result, knowledge economies of scale are obtainable. However, since the knowledge is coded down to number, figures and letters, some knowledge might end up being missed, forgotten or overlooked in the process. It also makes it hard to apply on highly unique projects and is more suitable for projects that are more standardized (Hansen et al., 1999). Another difficult aspect of the codification strategy is that it is using push of knowledge instead of pull (Alavi & Leidner, 2001). This means that one needs to foresee the future knowledge need since the knowledge is externalized and put in print sometimes years ahead of the reuse moment.

When having a personalization strategy on the other hand, the knowledge transfer is not made through people-to-document processes but through people-to-people processes. Personalization focuses on the dialog between people, the socialization part of the knowledge SECI-model (Nonaka & Takeuchi, 1995). When knowledge has been created it is stored within the mind of the creator and transferred to others through brainstorming sessions and one-to-one conversations. The knowledge is in most cases retrieved from the knowledge creator upon request by either being asked to give input to a project in his or her area or, as in most cases, when help is needed within a subsequent project to solve a situation. The first scenario is proactive and the second one reactive.

Personalization makes it possible to store, transfer and reuse created knowledge that is not

suitable for printed externalization. By storing the knowledge at the source of creation, details of knowledge can be kept intact and the reuse of knowledge can be adapted to the current situation at the moment of reuse. This gives personalization strategy the possibility to reuse knowledge even when addressing unique situations and problems since the knowledge creator can process the knowledge and bring it forward in a way that allows the project to build on it in a new context. However, since the knowledge is stored within the mind of a person there is a risk of misleading knowledge due to the mind's ability to forget and recreate situations based on later information and circumstances.

3.2 Knowledge management in product development

Every company is in some way influenced by the setting they are working in. This also affects how they can handle knowledge and it is therefore important to understand the context of a company in order to be able to understand how they best should handle knowledge. In this section such context will be provided for organizations in the product development industry.

3.2.1 The project focus in product development

In product development industry, the main focus is to provide the market with order-winning products to the market in time. The products are often developed in a stepwise process where each new product in the process is regarded as one individual project. Many times the organization is handling several different projects concurrently. The purpose of each project is to meet the deliver a product in time that will appeal to the customers (Wheelwright & Clark, 1992). The competition on the market has been increasing and along with that so has the importance of the "in time"-aspect of the delivery since the window of opportunity is diminishing (Wheelwright & Clark, 1992). As a result all activities within each project are focused on this goal and all personnel involved are working hard to obtain it, thus a strong project focus in product development companies is natural (Alavi & Leidner, 2001).

In theory a strong project focus is not a problematic matter, it means that everyone is working hard to bring in revenue to the company. However, the effects of a strong project focus in reality are often that activities that are not driving the current projects forward are neglected and put aside. The urgency of solving the problems in the current project is much stronger and the effects of non-delivery are direct and pressing, resulting in a down-prioritization of anything that is not within the scope of the project. One of the things that often gets down-prioritized, is building knowledge to create a more favorable outset for the product development in the next project (Radeka, 2013). Both capturing, storing and transfer of learnings from projects are rarely done since it will not bring any value to the current project. As for the reuse of former learnings, this would bring value to the projects and could provide helpful insight to an ongoing problem. However, most often the pressing time aspect in the projects is hindering such learning seek-out as well as the lack of available learnings due to the earlier mentioned problematic with the first steps of the value chain (Alavi & Leidner, 2001).

As a result, knowledge is neither captured nor reused in projects as an effect of the strong project orientation and companies find themselves constantly reinventing the wheel (Jansson, 2012). However, since this is a rather well-known condition for the product development business, research on how to handle this matter has been made. One of the major theories regarding the subject is called Lean Product Development.

3.2.2 Lean product development

Lean as a term is most often associated with waste elimination of all kinds in order to create value for the end product (Liker & Meier, 2013). In lean production this is often translated into removal of all non-value adding activities such as unnecessary transport, overproduction and unnecessary waiting time. In Lean product development the waste elimination is not as simple. One needs to consider the bigger picture in order to identify the non-value adding activities. In the short term perspective that is of focus in the individual projects, it is easy to see all activities that not directly drive the project forward as non-value adding. Such activities are often root cause analysis of problems and testing in early phases or almost anything the concerns the line function of the company. However, by shortcutting such processes, one often ends up with a product needing severe alterations late in the development process when they are very expensive. In addition, knowledge gets lost along the way since there is no time or place to capture the created knowledge.

What lean product development has done to address these difficulties is to streamline the projects to focus the non-interruption of the main activities. Such perspective gives a different set of non-value adding activities that the seven wastes in lean production. According to Radeka (2013) the seven wastes of lean product development are instead:

- Design loopbacks
- Reinvention
- Unproductive meetings
- Insufficient knowledge of customer needs
- Excess requirements and specifications
- Excess project management overhead
- Overloaded resources

Instead they focus their time on activities that: build knowledge of their customers, product technology or the integration of the two. Everything else is waste according to the lean product development philosophy. This often means that solving problems thoroughly and to capture the knowledge they create in order to build for the next projects are recognized as main activities. The knowledge capturing is one of the most important parts of the lean product development concept since it provides the foundation for a company to actually reuse the knowledge. In most product development companies the creation of knowledge is not a problem, but there is however rarely time to learn and the knowledge ends up being unused and the same mistakes constantly repeated. The idea of Lean product development is that by

streamlining the rest of the process, time is made available for knowledge capture and the possibility to simply build on that knowledge in the next project is presented and thereby also the possibility to reduce both cost and lead time of the product development process.

However, as mentioned earlier, capture of knowledge is only one part of the knowledge value chain. In order for the knowledge to actually be reused, it needs to be stored and transferred to the right place in a suitable way. And as has also been mentioned, companies are struggling to manage this entire process.

3.3 Problems related to Knowledge management

All companies are different and hence, so are the reasons to why they are not able to find effective ways of managing knowledge within the company. However, reviewing the literature there seem to be some areas that are troublesome for almost all companies. The most common ones are related to the characteristics of knowledge, organizational aspects and the IT structures in companies and will be addressed in this section.

3.3.1 Characteristic of knowledge

As mentioned in Section 3.1, knowledge is a complex matter including not only several different definitions but also a distinction between knowledge and information as well as different dimensions and a complex value chain where knowledge travels. Due to these characteristics there are some problems occurring when companies are managing knowledge and trying to make it reusable.

Intangibility of knowledge
The definition of knowledge is scattered, as mentioned, it can be regarded as both a state of mind, an object, a process, a condition of having access to information, or a capability (Alavi & Leidner, 2001). Companies also often have their own definition of knowledge in addition to this. Due to its in conclusive definition and the dimensional aspect of knowledge where most is first created as tacit knowledge within the mind of a person, knowledge becomes a rather fuzzy subject (Nonaka & Takeuchi, 1995). It is viewed upon as intangible, which in turn makes is difficult to quality control (Kipley et al., 2008). The intangibility of knowledge also makes it hard to demonstrate the benefits of the knowledge initiatives and thus the benefits of a well-functioning knowledge management system. As a result, the financial benefits of knowledge become hard to demonstrate and the support for knowledge related work is down-prioritized (Kipley et al., 2008).

Information vs. knowledge
As for the distinction between knowledge and information, Jonsson (2012) brings up an interesting explanation to why so many knowledge management efforts fail. It is simply due to the fact that these efforts have dealt with information management rather than knowledge management and thus, the effects of knowledge have been left out. According to Jonsson

(2012), knowledge management is about being able to distinguish knowledge from data and information, where the difference between the concepts is that knowledge can be put into practical use while information and data cannot. Thus, if the employees working with knowledge management do not have the ability to make this distinction, the effort is doomed to fail from the start. It is also reasonable to believe that the many unsuccessful knowledge management efforts are results of the fact that too many knowledge concepts have been used without a proper definition, it is hard to define knowledge, and people view knowledge differently. Altogether, this could have created confusion, making it intractable to get a knowledge management system functioning across the organization.

General vs. specific knowledge

Related to the above aspect is the difference between and the difficulty of distinguishing general knowledge from specific knowledge. Alfredsson and Söderberg (2009) refers to this as unexploited transferability and emphasize the fact that it is usually not obvious what knowledge can be used and how within other projects. That of course influences the above mentioned problems with finding out if knowledge exists, locating and applying it. If it is hard to determine what that is general and what is specific knowledge, it will be troublesome to understand who needs this knowledge. Then in turn, it is even harder to realize how to contextualize knowledge and separate the general from the specific knowledge. This means, even if the knowledge would find its way to the right person it would be hard to apply it. In addition, Alavi and Leidner (2001) mention that people often are oblivious of what they do not know, which of course makes it difficult to ask the right questions, find the right people or search for the knowledge. Thus, this would especially become a hindrance if one were to rely too much on a pulling knowledge management system, which means that a certain amount of push needs to be incorporated within the system.

3.3.2 Organizational aspects

In order for a knowledge management system to work, it needs to be adjusted to the environment or the organization it is to function within (Maedche et al, 2015). That might seem fairly easy to understand; however in order to get there, there are a few barriers that need to be addressed.

Managerial support

One of the strongest barriers for companies to overcome in order to enable knowledge reuse is the lack of managerial support for the matter (Maedche et al., 2015). Managers are generally responsible for the capturing and documentation of knowledge. However, according to Maedche et al. (2015), the capturing managers are often reluctant to take care of the knowledge since rarely "these reports never reached the places in the organization where they could be utilized and transformed into (new) organizational practices" (Kautz & Hansen, 2008, p. 98). Alfredsson and Söderberg (2009) state that leaders at all levels need to clearly prioritize knowledge management. Without the clear prioritization, knowledge reuse activities risk ending up as "tick in a box tasks" that are performed only because it says so somewhere. In order for a change to take place, another evaluation of managers will be needed. Alfredsson

and Söderberg (2009) claim that management needs to set different priorities and evaluate managers on long-term results instead of for example the financial results for this quarter, otherwise knowledge will not be properly managed and highly difficult to use and benefit from previous learnings.

Culture

Related to the issue of managerial support is the cultural aspect of knowledge management and the attitude towards learnings. Alfredsson and Söderberg (2009) discovered several attitudes within companies that could possibly be an obstacle for the reuse of knowledge. Firstly, a common opinion seems to be that people think learning is someone else's responsibility. It could either be a project leader or a knowledge management division that employees consider should do that kind of work. In addition, such activities are often, as mentioned, viewed upon as "tick in a box tasks", that are performed because it says so in a process description. Secondly, employees may use knowledge as a power tool, where keeping knowledge to oneself may be useful and thus avoid being exchangeable. Further, Alavi and Leidner (2001) found out that culture may be either a catalyst or a hindrance when it comes to knowledge creation and sharing, which is also why a common goal within knowledge management is to develop a knowledge intensive culture inspiring to proactive knowledge seeking, although the companies are struggling to obtain it.

Time

As mentioned earlier, the markets are becoming increasingly competitive and the pressure for shorter lead times and high quality is augmenting (Wheelwright & Clark, 1992). The processes in product development companies are streamlined and time is a more scarce resource than ever (Radeka, 2013). In combination with the project orientation in product development companies this results in down-prioritization of all activities that are not value adding for the ongoing project, including knowledge management (Radeka, 2013)

According to Kipley et al. (2008), time is of essence in order to be able to create a mindset for knowledge management within an organization. Knowledge management is as mentioned a complex subject and in order to understand it the right mindset is of essence. Further, without time for managing knowledge, the knowledge will be created but not managed further throughout the knowledge value chain, resulting in knowledge not being applied (O'Dell & Grayson, 1998).

Employee turnover

One general factor that that is brought up by Alavi and Leidner (2001) is the problem of employee turnovers. Many companies suffer substantial setbacks when key individuals quit, which obviously justifies the importance of storing knowledge within the company to avoid competence loss. However, it is not uncomplicated even if employees would decide to stay within the company for a longer period of time. Although companies believe that the knowledge remains within the company, it is still hard to know if it exists, most likely also difficult to locate and then it may be easier said than done to apply the knowledge when retrieved Alavi and Leidner (2001).

Incentives

Incentives and KPIs are commonly used for supporting a desired behavior in companies (Schneider, 1994). Alavi and Leidner (2001) as well as Kipley et al. argue that incentives are important to overcome other barriers, such as time and culture. Companies rarely reward employees focused on generating and sharing knowledge within the organization. Instead, the general notion among companies is that incentives and rewards are normally encouraging short term benefits and fire-fighting behavior. If a company is to implement such incentives it is important that they are adapted to the knowledge management strategy (Hansen et al., 1999). For instance, depending on if the knowledge management strategy is focused on person to person transfer or transfer through databases and documents, the incentive systems should be designed differently. It is also important to not only focus on external rewards and incentives such as salary, but instead encourage a will to work with knowledge related activities from an intrinsic perspective as well (Maedche et al., 2015). Important to remember is also that, in order for a knowledge related incentive to work, the benefits must be greater than the cost of managing knowledge. Feedback and ranking systems for knowledge is two incentives that fulfill these aspects and can contribute to knowledge being prioritized.

3.3.3 IT-related barriers

Even though knowledge is created within the minds of a person through the understanding and interpretation of different facts and situations it is often highly dependent on some kind of systems or databases to be able to travel through the knowledge value chain. However, even though the systems are intended to facilitate the managing of knowledge, this is not always the case.

Knowledge access

The general notion when knowledge databases are discussed is related to Jonsson's (2012) notion of information versus knowledge. Looking at databases that aim to provide the users with knowledge, they often include information rather than knowledge (Alavi & Leidner, 2001). In addition, these systems often lack structure and the information is difficult to access. Since the system contains information rather than knowledge, there is often massive amounts of information within them creating an overflow (Alavi and Leidner, 2001) making it even harder to access the knowledge. Another problem experienced is the searchability (Alavi & Leidner, 2001). The databases often have a rather malfunctioning search algorithm resulting in that in cases where the knowledge itself might be fairly well-structured, it is hard find because there is a need to sentence words just right to locate what you are looking for.

Processes for knowledge

There is an absence of systematic approaches to benefit from knowledge within organizations. Alfredsson and Söderberg (2009) mention that most companies probably do not document some technical solutions due to the fact that there are no sufficient systems for doing it. Maedche et al. (2015) also describe an interesting behavior of users related to IT-systems for managing knowledge. Supposedly 10% of the users actively contribute to creating and building knowledge base, whereas 90% of the users are actually fetchers, meaning they only

retrieve knowledge from the IT-system. Therefore, it is reasonable to believe that it is important to design robust processes and routines or provide incentives for collective contribution to the knowledge base.

3.5 Solutions for problems in Knowledge management

As can be understood from the previous section, there are several challenges to overcome regarding knowledge management for companies. However, even though they have been struggling for a long time to do so, there is some light in the tunnel. As knowledge management has become an increasingly important topic for organizations, the research on solutions for overcoming the challenges has developed. In this section, theories of such solutions will be discussed, with the main focus being on the design principles presented by Maedche et al. (2015). Additional theories will also be presented to introduce the reader to concepts that are expected to be of benefit for a knowledge management system design.

3.5.1 Design principles

The design principles origins from a research conducted by Maedche et al. (2015). Within their research four main challenges with knowledge were established including: access to the knowledge and experiences documented within a company, the support needed by project teams to manage knowledge, the way knowledge is structured, contextualized and packaged, and incentives for reusing knowledge as well as contributing to organizational learning. Based on these challenges four design principles for the design of a knowledge management system were formulated. The design principles include:

- *DP1: Ensure access to experts and expertise*
- *DP2: Extend project teams with knowledge intermediaries to support project knowledge management*
- *DP3: Provide contextual and packaged knowledge in structured documents, using a terminology appropriate to both novices and experts*
- *DP4: Enable project insight maintenance based on feedback concerning its usefulness and actuality*

One major finding was that intermediaries should be introduced to unburden project teams from spending time on knowledge management activities. Therefore, the design principles generated were categorized into technical and intermediary principles. The technical principles refer directly to the characteristics and functions of the software used, whereas the intermediary principles concern the behavior of the intermediary and specific tasks that should be performed. The technical principles include DP1, DP3 and DP4 including sub-criteria (see Table 2) (Maedche et al., 2015 pp. 16).

Table 2 - Technical design principles according to Maedche et al. (2015).

Design decision	Source
DP1: Ensure access to both experts and expertise	
• **Social networks and communities:** knowledge communities are an instantiation of communities of practice. By implementing communities, companies promote informal knowledge exchange, which facilitates knowledge reuse. Examples of technological implementations can be social networks, forums, or chatrooms.	Ardichvili, Page, & Wentling (2003), Julian (2008)
• **Search functionality:** today, many platforms have semantic search functionality. This allows users to find unstructured information captured in various documents or other knowledge documentation formats.	Markus (2001), Popov, Kiryakov, Ognyanoff, Manov, & Kirilov (2004)
• **Hyperlinking and tagging:** hyperlinking and tagging are mechanisms that ease knowledge documentation, search, and retrieval. Each time a document is stored on the platform, individuals provide some keywords or links relating to documents. This enables the development of an information network that eases the exploration of project insights.	Petter & Vaishnavi (2008), Wagner (2004), Yang, Hu, & Davison (2010)
• **Access control:** by implementing user authentication and authorization mechanisms, users with various roles may get different access rights to documents. Thus, project team members can share their knowledge in documents that are either open for all project KMS users, or for private for use by a project's team members.	Tolone, Ahn, Pai, & Hong (2005)
DP3: Provide contextual, packaged knowledge in structured documents, using a terminology appropriate to both novices and experts	
• **Project characteristic questionnaire:** a questionnaire on project characteristics is a structured way to enable the provision of project's contextual information. The questionnaire supports the standardization of processes, is easy to complete, and provides some metrics that ease the comparability of various projects.	Interview study
• **Project overview:** using the project characterization conducted in the starting phase and stored in a central database, a project KMS can be enriched by a project overview, which visually relates projects to other projects based on its characteristics.	Interview study
• **Project insights overview:** in addition to an appropriate search engine, the provision of an overview on the project insights that relate to another project eases knowledge search and retrieval. Here, a rating mechanism can be used to display insights perceived as most useful for other users.	Kautz & Hansen (2008), Markus (2001)
• **Variety of formats:** various projects possess varying complexities. Thus, full standardization of project insight documentation is unfeasible. The more complex a project, the more individuals should be able to include additional information, for instance by providing additional documentation formats (e.g., photos, videos, etc.).	Nielsen & Madsen (2006), Petter & Vaishnavi (2008)
DP4: Enable project insight maintenance based on feedback concerning its usefulness and actuality	
• **Rating:** the rating of products or services is intensively used in electronic markets. Rating mechanisms summarize the opinions of users and provide a brief overview of a product or service for potential users. By implementing a rating functionality in the project KMS, knowledge seekers get a quick overview of the usefulness and applicability of documented insights.	Dellarocas (2010)
• **Feedback provision:** if individuals receive constructive feedback on their work, they are more willing to share their knowledge. By implementing mechanisms that enable project teams to assess the received expertise or the knowledge providers, continuous learning owing to regular updates of existing, organizational knowledge can be facilitated.	Bartsch, Ebers, & Maurer (2012), Desouza & Evaristo (2004)
• **Automatically updating:** using the assessment functionality, project insights can be ranked according to their usefulness and applicability. The resulting ranking enables the identification of project insights that are no longer used because they are no longer useful.	Dellarocas (2010), King, Marks, & McCoy (2002)

The intermediary principles were formulated according to Table 3 (Maedche et al., 2015 pp. 18). They include the same principle headings as the technical design principle, however the sub criteria are different from the technical ones. Maedche et al. (2015) concludes in line with Marcus (2001) and many other researcher on knowledge management that role of an intermediary is highly important to a knowledge management system in order for it to enable reuse of knowledge. An intermediary can help in mitigating many of the challenges stated in Section 3.4 and thereby facilitate knowledge management extensively.

Table 3 - Intermediary design principles according to Maedche et al. (2015).

Design decision	Source
DP1: Ensure access to both experts and expertise	
• **Connect knowledge seekers and providers:** PKIs should form a central point of contact in order to help knowledge seekers to find expertise and experts.	Meyer (2010), Wong & Aspinwall (2006)
• **Support in knowledge needs formulation:** to find valuable knowledge, accurate questions should be formulated. Knowledge seekers find it difficult to formulate questions since they do not have the necessary vocabulary.	Lind & Persborn (2000), Wong & Aspinwall (2006)
• **Search for and finding of knowledge sources:** as a central knowledge base, PKIs should provide an overview of various knowledge storage locations to help knowledge seekers to find appropriate knowledge sources.	Lind & Persborn (2000), Wong & Aspinwall (2006)
• **Provide infrastructure to support knowledge exchange:** PKIs enable knowledge exchange, either by implementing an appropriate technology or by establishing communication structures.	Lind & Persborn (2000), Wong & Aspinwall (2006)
DP2: Extend project teams with knowledge intermediaries to support project knowledge management	
• **Prepare and organize knowledge collection:** to reuse project knowledge, such knowledge first needs to be collected. Knowledge collection often takes place in lessons learned sessions at the end of a project. The PKI should prepare the sessions since they have the knowledge about appropriate methodologies.	Blessing, Goerk, & Bach (2001), Meyer (2010)

• **Moderate knowledge collection:** PKIs should ensure the gathering of reusable knowledge and should support problem-solving by asking questions related to the project insights. They should also act as neutral actors to guide and, if needed, to calm heated discussions and render them productive.	Blessing et al. (2001(, Tan et al. (2007)
• **Draw attention to useful knowledge:** since the PKI attends many sessions where knowledge is gathered and discussed within teams, he or she can draw attention to valuable knowledge and can provide guidance.	Blessing et al. (2001), Wong & Aspinwall (2006)
DP3: Provide contextual and packaged knowledge in structured documents, using a terminology appropriate to both novices and experts	
• **Prepare knowledge for its reuse:** PKIs should prepare the knowledge by eliciting, indexing, summarizing, sanitizing, and packaging it.	Markus (2001), Tan et al. (2007)
• **Translate knowledge: k**nowledge documented by experts is often difficult to understand for non-professionals. PKIs have to translate the gathered knowledge using a terminology appropriate for every employee.	Blessing et al. (2001), Surridge & Harris (2007)
• **Collect and document contextual information:** to decide whether knowledge can solve a problem, one needs background information. PKIs should link the contextual information to project insights, easing decision-making on whether and how to apply knowledge.	Tan et al. (2007)
DP4: Enable project insight maintenance based on feedback concerning its usefulness and actuality	
• **Maintain knowledge base:** the knowledge gathered in projects should be stored in a central knowledge base. The PKI should assess the stored knowledge, keep it up-to-date, and maintain the knowledge base.	Blessing et al. (2001), Tan et al. (2007), Wong & Aspinwall (2006)
• **Identify questions for knowledge reuse:** based on existing and requested knowledge, PKIs should be able to identify knowledge that may become important and valuable for future projects.	Lind & Persborn (2000), Wong & Aspinwall (2006)
• **Maintain links to knowledge sources:** PKIs should know the relationships between knowledge and knowledge sources. When knowledge seekers request a specific knowledge, PKIs should be able to connect them to the according source.	Meyer (2010), Surridge & Harris (2007)
• **Collect feedback on knowledge from knowledge consumers:** knowledge consumers should be encouraged to give feedback on whether or not knowledge provided by PKIs is useful. Based on this feedback, PKIs should be able to maintain the knowledge base concerning its actuality and usefulness.	Geister (2006), Jarvenpaa & Leidner (1999)

As can be seen within both tables, all four the design principles are rooted in an extensive literature review and in the case where additional information was needed interviews were conducted. That provides a fairly strong case and these design principles could be considered important to other knowledge management systems in general, not only in the action research of Maedche et al. (2015). In addition to the literature review Maedche et al. (2015) also performed a pilot study and generated Lessons learned, which resulted in two more design principles:

- *DP5 - Document and reuse knowledge in all project phases*
- *DP6 - Motivate knowledge management in projects by including emotional, affective functionalities.*

The reason for the addition of these design principles were that the test group agreed that knowledge reuse would have a greater impact when Lessons learned sessions are performed regularly instead of only at the end of a project. Further, since only 10% of the users in a knowledge management system are providing knowledge, a need for additional motivation was experienced. As also Hwang (2005) and Venkatesh & Bala (2008) have indicated through their research, experiencing usefulness and enjoyment related to the knowledge management system are potent factors influencing the willingness to participate and

contribute. These six presented design principles provide a rather stable foundation for the design of a knowledge management system. However, there are other solutions for knowledge management mentioned in the literature that can be used as part of or additions to the Maedche et al. (2015) framework.

3.5.2 Thin-slicing

The term thin-slicing origins from psychology and refers to the ability to making prediction of events and patterns from a very small and fragmented piece of information, such as first impressions for example (Carney et al., 2007). However, since the term was introduced in the early 90s, the areas of utilization have expanded rapidly. Although, the main idea is to make predictions with a small amount of information remains. In recent years, the concept has started to enter the product development business, most likely due to many studies showing that thin-sliced judgments are often more accurate and as well as far less expensive than a detailed evaluation (Gladwell, 2005).

However, the concept of thin-slicing cannot be directly transferred to the business world but is in need of adaptation to fit within the organizations (Gladwell, 2005). Product development companies are as mentioned generally struggling to make decisions based on knowledge. This is partly due to the enormous amounts of information that is contained within the organization (Alavi & Leidner, 2001). All of this information creates an overflow causing both exhaustion, unwillingness to grasp the knowledge and has a negative effect on the decision-making process (Alavi & Leidner, 2001; Gladwell, 2005). Instead thin-slicing can be used to extract a smaller amount of the most useful knowledge from the total amount of information in a company that will not only make your decision-making easier, but also improve the quality of the outcome. These slices should contain the knowledge that a highly senior and experienced worker has in mind when he or she makes decisions throughout a project. By capturing these knowledge points, the entire organization can make quick and similar judgments of a situation and make close to the same decision independently of the seniority of the employee.

3.5.3 Push and pull

Two models commonly discussed regarding to retrieval of knowledge is push or pull (Alavi and Leidner, 2001). The major difference between the models is whether the knowledge is automatically steered towards and received by the user or if the user has a need creating an urge to locate the knowledge herself. Thus, if the knowledge is automatically steered towards the user, it is a push model and if the user has to search for the knowledge when there is a need, it is a pull model. Maier (2007) defines the concept in more detail, presenting push-functions and pull-functions. The pull-functions are typically search functions actively used by the user, but can also be navigating tools or a thesaurus that help to access the knowledge. The push-functions are only turned on once, and provides the user with the appropriate knowledge, for example through list servers, smart systems that identify who needs what knowledge and when or simply a regular information subscription.

Alavi and Leidner (2001) further explains that the challenge in picking a design for sharing

organizational knowledge, is to provide the users with the right amount of knowledge at the correct time. Thus, the knowledge should be provided when the user needs it and in an amount that does not cause an overflow. According to Helms and Buijsrogge (2005), if one picks the push model, it is important to know who the user is, whereas if the pull model is chosen, the user needs to know where to access the knowledge. Maier (2007) proposes a balance between push and pull of knowledge, which should be done by using tools and systems that can connect the knowledge providers and knowledge seekers. However, the system should be slightly swayed towards a pull of knowledge, since a push system is likely to micro-manage employees by giving too much directions of how to perform tasks.

In relation to the decision of using a push system or a pull system and more importantly codification or personalization for managing knowledge there is also an interesting trade-off called knowledge viscosity. Knowledge viscosity concerns the richness of the knowledge that has been shared (Davenport and Prusak, 1998). In essence, how much of the knowledge intended for transfer has actually been comprehended. Davenport and Prusak (1998) explains that a number of factors impact the knowledge viscosity, however it is mainly the method of transfer. If the knowledge is transferred through teaching and coaching chances are better that the knowledge is richer than if the novice has read an article or retrieved knowledge from a database.

3.5.4 Checklists

According to Gorovitz and Macintyre (1976) there are two main reasons to failure, ignorance and ineptitude. Ignorance in this case means that one have not yet been given the appropriate knowledge in order to make the right decisions, one have the wrong perception of the world, and hence risk failure as a result. Ineptitude on the other hand, is when on is provided with the correct knowledge but fails to apply it as one should (Gawande, 2010). Recently, the later of the two has become more and more frequently occurring within all different kinds of fields including product development. According to Gawande (2010) there is a simple reason for this, the augmenting complexity. The number of aspects to take into account is simply too many to constantly remember, and mistakes are made, repeatedly. So the question to ask is, how can this be fixed?

The answer, according to Gawande (2010) is shockingly simple, checklists. With the complexity the world is facing, the human mind is simply not capable of ensuring that everything is always remembered, there is need for support (Gawande, 2010). A checklist can provide such support by being a reminder of the basic and most important things to always keep in mind in order not to fail. Relating back to the different types of failures, the first one is actually the basic foundation for a checklist. By ignorance, one fails and thus uncovers new ground. This gained experience through the failure, will provide the input needed to create a checklist and the checklist will prevent us from ineptitude.

4 Findings

In order to determine how a knowledge management system at Volvo should be designed, a study of the company was performed including interviews, observations and a survey as well as interviews with benchmarking companies. In this chapter, the findings from that study will be presented to provide an overall picture of the company related to knowledge management. These finding will serve as the baseline for the analysis in Chapter 5 to determine the requirements of the knowledge management system design. This chapter will first present the findings from the study at Volvo, then continue on to the findings from the benchmarking interviews. Due to the fact that data has been collected from different sources in parallel, all of which contributed to an overall picture of Volvo's organization, the findings will be presented in logical structure based on the type of finding, rather than a structure based on which type of data collection method that has been used. This will be the case for all findings except for a categorization of the survey conducted at Volvo that will be presented in the end of the findings related to Volvo.

4.1 Volvo

Volvo is a large company with many different departments and levels within the organization. There are also several different types of systems and procedures in place at the company, some more related to knowledge management than others. In this section, the knowledge related findings from the study at the Research and Development business function, that has been the subject of the research, will be presented. The findings include the overall setting for knowledge as well as an overview of the information systems related to knowledge currently in place at the business unit.

4.1.1 The knowledge setting

Bringing new products or, more often new generations of the same product to the market and a constant ambition to innovate, is the basic business that drives Volvo forward as a company. In any innovative process, knowledge is constantly created as a natural part of the business, but in order to understand how this knowledge is managed within Volvo one needs to understand the context in which the knowledge moves.

Organizational structure

The new products at Volvo are created within separate projects, each with the purpose to deliver a specific type of car that will meet and at best exceed the customer expectations. However, like many other companies, Volvo also has functional areas that need to be handled alongside the projects. In order to obtain efficiency in both functional areas as well as the projects, Volvo is structured in a matrix organization where the different functions (also called the line organization) in the company are on one side and the different car projects on the other (see Figure 9). For both parts of the matrix organization, Volvo has an internal organizational structure as well.

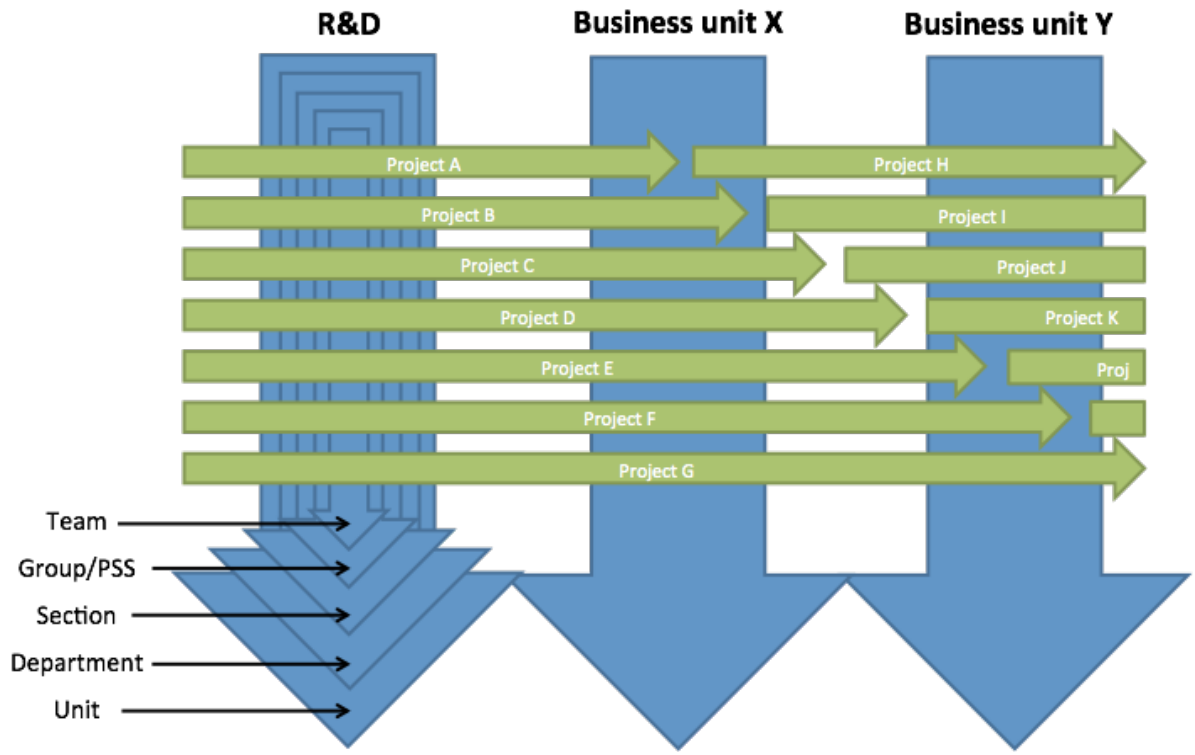

Figure 9 - Visualization of the Volvo matrix organization.

The line organization is divided into functions on different hierarchical levels. Volvo's entire organization includes 16 different business functions. For this master thesis, as mentioned, the focus is on the Research and Development business function. The R&D function is divided into units, departments, sections, groups and teams. Most often one group is equal to one subsystem in the car, but some groups include two or three subsystems. These subsystems are referred to as PSSes, where each PSS is responsible for a certain part, approximately five components, of the car in all projects. As for the projects' organizational structure, there is no formal structure, but in general a project is managed at several levels by project leaders ranging from the overall project leader, responsible for managing cost, time and quality of the entire project, to group design leaders responsible for the design engineers in a team within a PSS. Typically, one team in a PSS is responsible for the subsystem in a specific project and another team within the PSS is responsible for the subsystem in a different project. For each team there is a group design leader that is responsible for coordination with other PSSes as well as status reporting to the project management.

Project process

As for the project process itself, Volvo uses a process, often referred to as a stage gate process (Cooper, 1990), divided into three different phases: pre-development, conceptualizing & engineering, and industrializing. In the pre-development phase, the focus is on new technology and materials that in the long-term will be beneficial for the projects on an overall level. The conceptualizing & engineering phase is where the styling of the cars is made into concepts. Those concepts are broken down and designed in detail in the different PSSes. Once all details of the car are designed, they are released and the industrializing phase is initiated.

In this phase the different build series of the car are performed as well as tests on the different built cars. These builds are performed three times before the production is started. The design engineers are mostly involved in the conceptualizing & engineering phase as well as the first part of the industrializing phase.

Normally, a project extends over roughly three years and there are approximately seven different car projects ongoing at the same time. The projects are often in different sub phases of the project process in order to keep an even flow of new car releases on the market (see Figure 10). In general, there is little collaboration between the different projects and a rather strict separation regarding file access, documentation and status reports. There is a small amount of communication between the projects, except for a project coordinator on the different PSSes that keeps track of the overall project progress for the PSS. Beside that connection, the interaction between people working in different projects occurs first and foremost in the line organization during group meetings (read more about this in the following paragraph).

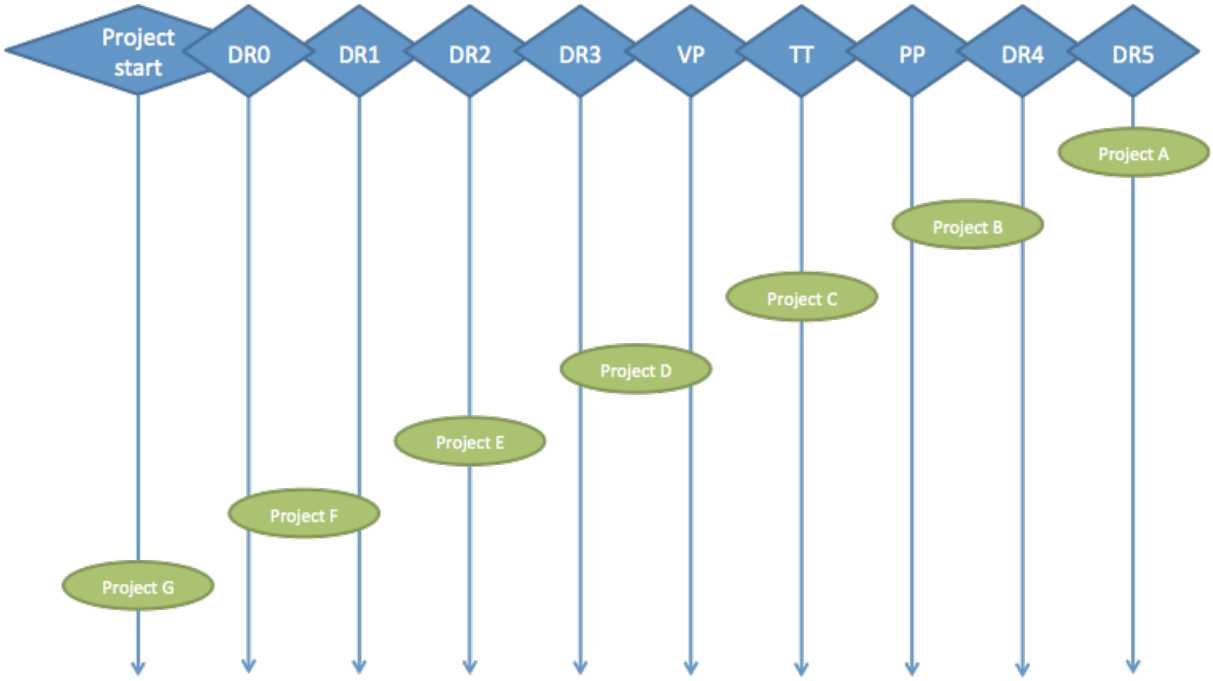

Figure 10 - Illustration of where different project are in the project process at a certain point in time.

Meeting structure

During the projects, there are gates where the projects need to have reached certain criteria in order to pass to the next stage in the process. In order to have the information necessary to make the decision at the gate, status meetings called Design reviews (DRs) are conducted in connection to the gates. During these meetings a checklist is used, where the purpose of the DRs is to give the project management insight of the overall progress for the project in time to still have the possibility to influence the project before the gate. Risk areas are evaluated and gaps in terms of fulfilling customer requirements are discussed in order to make decisions on what compromises that have to be made. However, even though the gate is supposed to be a

definite deadline for earlier activities in the process, changes frequently occur due to new information that emerges from previous stages. During an entire project, five separate DRs are conducted. In between the DRs, the design is iteratively looped with a release every 15 weeks, the entire car is tested to evaluate the integration between different subsystems and find problematic areas to correct during the next loop. The feedback from the release is communicated back to the design engineers and the problem areas are resolved within the loop.

In order to secure that the new design solutions meet requirements both for attributes, such as durability and security, as well as for manufacturing and suppliers, meetings are held with concerned attribute engineers as well as manufacturing on a weekly basis. If there is a conflict between requirements and design solution where a compromise has to be made affecting either quality, cost or the timeframe of the project, the solution needs to be approved on a higher project level and is sent for evaluation up in the project structure.

Alongside the project oriented meetings for the design engineers, meetings are also held on group level in the line organization on a weekly basis. During these meetings, general matters concerning the entire group, independent of the projects, are discussed. This is also a place where the group manager is updated on the progress in each project, in order to be able to support the design engineers with extra resources if needed or simply guide the employees to resolve an issue that is difficult to solve in within the project itself. Since all personnel at the group meeting are working within the same sub system they can often help each other by sharing knowledge gained through earlier projects. Some groups have also taken this time to focus on knowledge sharing both internally within the group as well as externally with other groups or attributes.

This process of continuous problem solving, meetings along with the stage gate process and the requirements for each gate is what drives the day-to-day work for the design engineers. It is also where the largest amount of knowledge is created, by finding problems, working to fulfill criteria and coming up with a solution that works. In order to maintain control over this knowledge process, different support systems have been implemented with the purposes to store, transfer and eventually reuse the knowledge created, some better than others in serving their purpose (see Section 4.1.2).

Cultural aspects

A culture is built on many tiny things; norms and routines that together shape the way employees in general behave in a company (Schneider, 1994). Since the average Volvo employee stays within the company for 17 years, the culture is observed to be distinct across the company. As mentioned earlier, Volvo is a strongly project-oriented company like many other product development companies. The project orientation is deeply rooted within the organization and guides much of the daily work for the employees. The project focus is also confirmed by several employees expressing that seniors are often managing resources based on deliveries in projects rather than long-term results. The general approach is always to prioritize the project assignments since these are what in the end drives the revenue and also

where the urgency often lies. If work such as updating CAD-templates or documenting a learning is set aside, it will not disturb the rest of the entire organization since the ongoing product development projects can continue independently of the such updates. Solving a problem in a project on the other hand, if such assignment if postponed, the entire release of a new car might be delayed, customers will be disappointed and revenue potentially lost. This has been the common notion at Volvo for a long time and is what guides the behavior of the personnel. However, even though such culture is great to possess in times of urgency, it occasionally takes away time for reflection, learning and hence also improvement initiatives that in the long run will affect the quality of the products and there is a risk of losing customers.

This dilemma has been recognized by the top management at Volvo that has made an official statement to focus on *Knowledge Based Product Development*. Since then, several initiatives have been launched in different parts of the organization. In manufacturing engineering, a search-based knowledge base was developed, in the R&D business unit the Closed loop initiative has been launched and in the collision department load case and system responsible have been appointed in order to ensure access to experts. Time and effort has been dedicated to enforce this new strategy and an overall transformation project named Transformation 202020 was started, involving employees throughout the organization to pursue this.

Top management commitment is important, and in the case of Volvo this commitment have enabled deployment of this message; knowledge based engineering is of long-term importance for the organization. However, in order to change a culture, one needs to change the natural way people act in an organization and that takes time, effort and often also supporting tools and processes to make an organization behave differently. Examples of such tools and processes are KPIs and rewards that enforce a wanted behavior. At Volvo they are using personal goals directly related to salary to guide changes as the one described above. The aim of such change is to move away from the controlling culture that has been a natural part of the organization for a long time and towards a more trusting organization but where behavior can still be guided with external rewards such as a raise.

4.1.2 Information system

In addition to the general setting of the daily work, knowledge management at Volvo is also to a large extent dependent on, and guided by different tools, systems and processes. Much of the daily work is documented in logs; status reports and meeting minutes are stored into different systems. For this master thesis, some of the systems, tools and processes have been identified as more important for the purpose of the report and will be described below.

Flow

One of the recently implemented IT-systems is called Flow, which is a handling system for issues. The purpose of Flow is to support the process of dealing with specific matters immediately when emerged, involve the concerned people, perform a root-cause analysis, solve the problem and make corrections in steering documents or processes in order for this

problem to not emerge again. Thus, Flow does not work as a database; it is strictly an IT-system where issues are open for the period of time it takes to solve the problem. It is also possible to create learnings related to the issue, which can be both tagged and searched for. The progress of the issue is possible to track and follow, but once a solution has been reached, the issue is closed. Subsequently to the closing of issues, a list of them is generated in an Excel file to be used for assessment of what may be useful in future projects. Although it is still possible to search for old issues within the system, the idea is that one should not have to, since corrected actions have been put in place for the problem to not appear again.

The implementation of flow has been an extensive project at Volvo where the employees are educated through trainings, both in larger groups and individual exercises. The courses in larger groups aim to explain the purpose of the IT-system as well as provide an overview of what the software looks like and how it works, whereas the individual exercises focus on getting the employee ready for using the software within the daily activities. The aim of this company-wide education is to create a clear purpose as well as consistent way of using Flow. In addition it is designed to decrease the amount of alternative methods to perform the same task, intended support a consistent use and thus preserve structure.

Flow is replacing an Excel-based issue handling system called VQDC. Flow has been replacing VQDC successively as new projects are started, with the first project using Flow was started in 2016. The general opinion of the issue handling systems at Volvo is that they work well and could be a way to support knowledge reuse when used as intended but not all groups are using them as part of the daily work. Some groups are not using the systems at all; others are using them only as a status reporting tool for issues. Few groups are looking at the issue handling system as a source to create knowledge but simply as the issue handling system that it is.

Closed loop

As a support to Flow and VQDC, and an attempt to make the learnings from the issue handling system reusable, Volvo has initiated a process called *Closed loop*. This is a process that is using issues in the projects to transfer potential learnings to the line organization. Closed issues are extracted from the systems and looped back to the PSS involved in the issue. The extraction is performed in the line organization and the group design leader in the line organization is responsible for reviewing the issues and evaluating whether they contain knowledge that can be used in future projects. The learnings should be incorporated into the project process or steering documents in order to enable knowledge to be reused. At the moment the process is Excel-driven and manually handled and the thought is that the learnings should result in an update of Design Guidelines or CAD templates.

The Closed loop initiative is a rather new initiative at Volvo and has not been implemented at all PSSes. The general notion among the employees using Closed loop, is that it works rather well for technical learnings that can be transferred directly into design guidelines or requirements specification. However, learnings that fall outside of the existing storage systems intended for reuse are often disregarded because they do not belong to any of those

documentation systems. Also, for many of the issues, the group that is receiving the loop backs is not always directly affected by the learnings. Instead, the preventive actions for the learning are often to be introduced at another group or department. In that case, there is a lack of routines and processes for how to direct the issue to another group. Employees also express that there is a lack of forum for handling the Closed loop initiative since it often needs to be discussed in a larger group but people are unwilling to take time away from the projects.

Lessons learned

Lessons learned was introduced at Volvo to secure that learnings and knowledge from experiences are reused. In Figure 11 below, the framework for Lessons learned is presented. As visualized in the figure, the framework is divided into three parts, identify potential Lessons learned items, root cause analysis and document and reuse. There are also five steps within the framework, each of which includes instructions for what to perform in each step.

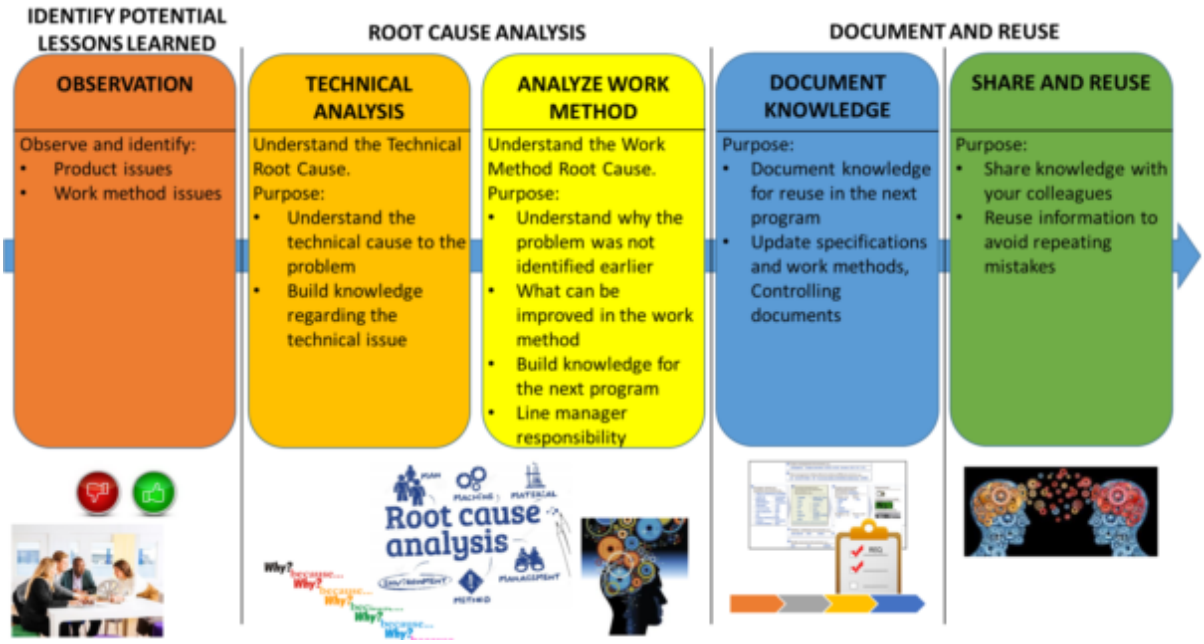

Figure 11 - Lessons learned framework.

The reasoning behind the process of Lessons learned is to force the user to perform a thorough analysis of the problem and not document the solution until that is done. This analysis is supposed to be performed on problems that are or could be affecting the quality, time or cost of current project that have a high potential of recurring in the future. The group manager is in charge of making sure that Lessons learned are performed throughout the project. The structure of the process is held on a general level in order to be applicable on all parts of the Volvo organization. There is no detailed explanation available for what exact methods to use in each step nor instructions for how to structure documentation of the Lessons learned, all in order to enable a company wide application of the process.

Regarding the actual use of Lessons learned, it is not totally in line with the intended process described above. In many cases root cause analysis are not performed since the employees

feel that is takes time away from the projects. Instead, many of the Lessons learned documentations are descriptions of the symptomatic problem and do not include descriptions of preventive actions. This is not always the case but many examples could be found at Volvo. The general opinion is also that it is more important to deliver in the project than to document learnings for the future, which then leads to that Lessons learned is not prioritized until the end and then, it is often only the largest issues during the entire project that are investigated. In the cases where a Lessons learned is performed, the end result is normally in the form of a PowerPoint or a PDF file that is placed in the project documentation or at company wide documentation system.

As for the use of Lessons learned, the documentation files are experienced to be rather hard to locate and therefore not always used in later projects. Further, if they are located, they are according to employees in many cases very project specific as well as unclear in their explanation of what the problem was and how to prevent it from happening again.

Design guidelines

Design guidelines is used for documenting experiences and technical knowledge to provide a base for the design work performed by the design engineers at a component level. Usually, it is new technical solutions on quality issues or Lessons learned that go into this document to define best practice. The guidelines include requirements, directions for what components should look like and visual pictures for clarification. The document is often in form of a printed booklet or a PDF document that is stored at group level in the PSS's internal systems. Further, the Design guidelines are often rather extensive and all of the content is given the same level of importance.

A system manager (official project role at Volvo) is the owner of the Design guidelines and is responsible for collecting input at system and subsystem level. A component responsible is responsible for updating design guidelines at component level. In Figure 12 below, the logical map and intended use of design guidelines is visualized. It is used as a starting point at concept level to stake out product directive documents that in turn is used to develop the product defining documents, eventually resulting in the physical part. Once the physical part is prototyped and produced it should be used to provide feedback on the design, which should be looped back into design guidelines for use in future projects.

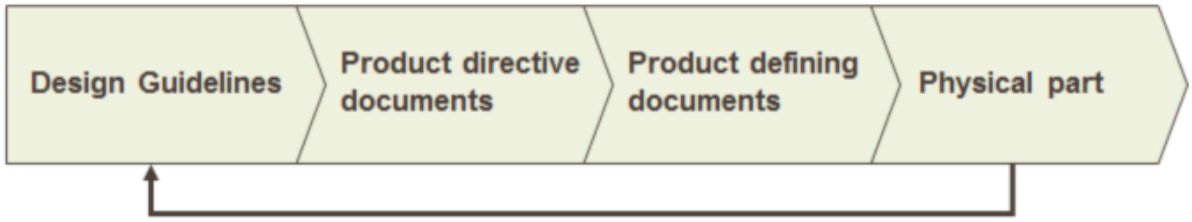

Figure 12 - Logical map of design guidelines.

The intention of Design Guidelines is that they should work as a technical support for the design process throughout the entire projects. However, the frequency of use differs between

the PSSes. Most of the groups are not using the document for retrieving of knowledge other than in the beginning of projects or by new design engineers that want a complete guide for how to start a design of a component. It is not generally regarded as a place to find important learnings from former projects, but rather as a start-up tool for a design when one is unsure of how to make the general design of the component. As for the quality of the Design guidelines that also differs somewhat between the PSSes. Some have newly updated Design guidelines with detailed instructions of best practices for the component design, while others are less updated and the content is more educational about what the component is, rather than an instruction for how to design it. Overall Design guidelines contain little contextual knowledge about the background to the instructions provided, instead the focus is on the technical solutions independent of the context.

As for the updating of Design guidelines, that task is as mentioned assigned to the component responsible. However, according to the employees at Volvo that assignment is not always prioritized due to time constraints, and Design guidelines are often found to contain old solution suggestions for component designs. It is expressed by several employees that it is too time consuming to keep a design guideline completely up to date.

CAD templates

A more live form of technical knowledge tool is CAD-templates. The CAD-templates are virtual 3D-models of components in the design software used at Volvo, which can be used as a starting point when the component is created virtually. The models are not designed in detail but are aimed to guide the design engineers in their work of designing the component. The templates include technical restrictions that automatically adjust the design to fulfill the requirements that has been fed into the system based on Lessons learned, quality requirements, etc. The templates can also in theory contain knowledge messages such as important trade-offs for a particular part of a component based on learnings from former projects. However, this function of the templates is not normally used at Volvo at the moment.

The aim of CAD templates is to enable for an automatic reuse of new solutions based on learnings from former projects and it is the mechanical integration department at Volvo that is responsible for the update of the templates. Thus, if a new solution for a component is found, the CAD-template can be adjusted according to that solution in order to reuse it in future projects for that specific component.

As for the use of CAD-templates they are integrated in the daily work at Volvo and used by almost all of the design engineers. The design engineers in general appreciate them as a tool for knowledge reuse since they are not taking time away from their daily work but instead are helping them. However, if the Design guidelines are lacking contextual knowledge the CAD-templates are doing so even more. They are used only to show the technical specification given by a certain solution without explanations to why a specific component looks the way it does, how it can be changed or the trade-offs linked to it.

General documentation systems

Besides the above-mentioned systems, there are several other systems in place at Volvo, handling information and knowledge. A few of these systems include SharePoint, Lotus Notes, Quality history files and White books. In SharePoint the projects sites are setup and that is where information about the specific projects are uploaded. Each project is free to build their own site logic and types of application on the site. Lotus Notes is used to log meeting notes and decisions etcetera. Some of this information overlaps with the SharePoint content, but while SharePoint is web based Lotus Notes is a database. White books was the old Lessons learned, but are still used in some departments although they were officially abandoned around 10 years ago. Quality history files are documentation made of problems in former projects that has caused quality issues for the end user. The documents are restricted to contain all quality issues occurring 15 years after the car model has stopped being produced. As a result the Quality history files contain very large amounts of information. The documents are intended to be used in the early phases of a project to hinder quality related mistakes to be repeated.

All of these systems are aiming to provide the entire Volvo organization with the necessary information for whatever they are in need of. However, the common notion at Volvo, according to employees, is that it is difficult to locate documents, files or knowledge within these systems. There is also a general notion among Volvo employees is that there are many systems in place and therefore hard to locate knowledge quickly. Further the purpose of each system is often stated but not always interpreted in the same way and the systems are often used in different manners as well as structured differently. Several employees have expressed that the benefits regarding knowledge reuse do not compensate for the time of finding the knowledge. The access to the systems is also limited due to access constraints. Different parts of the systems are often accessible for personnel within a certain functional area and/or a project. In order to extract knowledge from a site or folder, one needs to request access from the site/folder owner or an administrator. The restricted access is mostly a precaution to avoid changes being made by people unfamiliar with the area or process as well as to minimize the dissemination of confidential records.

4.1.3 Reasons for repeated mistakes

In order to map out the current view on knowledge management, experienced problems and the use frequency of current information systems, a survey was sent out to the R&D business function. The survey also included an investigation of why mistakes are being repeated. The 98 respondents were asked state which reasons that caused mistakes to occur more than once and the result is presented in Figure 13 below.

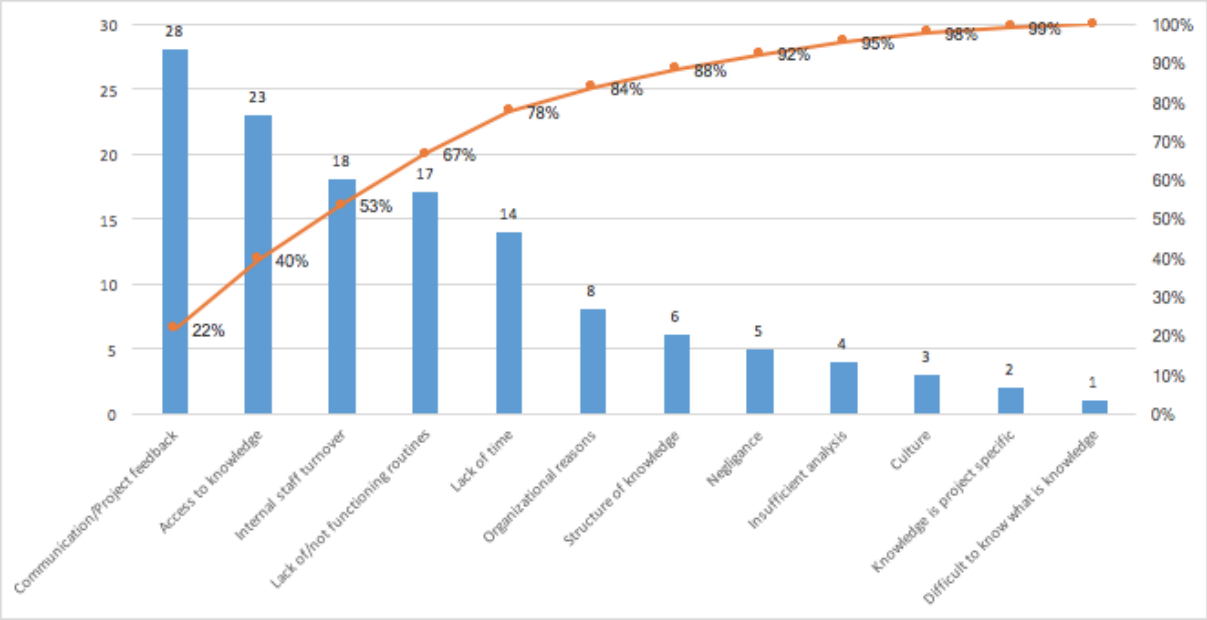

Figure 13 - Reasons for repeated mistakes according to employees at the R&D business unit.

4.2 Benchmarking companies

To broaden the perspective on how others work with knowledge management, which problems they experience and how they solve them, benchmarking interviews have been performed. Two of the companies are connected to the automotive industry, one of them with the truck business and the other with safety components in cars. The other two companies are working with hygiene products and roll and ball bearings solutions. The purpose of the interviews has been explored how other companies work with knowledge management and compare it to the Volvo organization in order to build credibility for the design of the knowledge management system that will be presented in Chapter 6. In this section the findings for each company will be presented.

4.2.1 Company W

Two separate interviews were performed at Company W, the first with an employee at the pre-development department and the second interview with a manager within the product development process. Within pre-development there is one major system intended to store knowledge, which is the report database. A report is written according to a clear structure provided in a template after each project or test is performed, where the author puts her or his name on the report. The report includes, among other things, purpose, method, result and effects. Once the report is written, the final step is to share the generated knowledge through a distribution list. Whomever the author believes to be concerned by the generated knowledge should go on that list and will automatically receive the report. The distribution list also work as a reminder for other employees that the report database exists and is used, and is therefore believed to be a motivation for contributing to the report database. In order to make the knowledge more accessible throughout the organization, several restrictions have been eased up on. Thus, more employees have now access to a larger extent of the database than before,

especially seniors, however the database is not completely open. The abstracts of all reports are accessible for all employees, however it may sometimes be necessary to request access to the full report. In the report database it is possible to make a free-text search for anything that a report might include.

At the product development department, the manager expressed a different process for handling knowledge. There are knowledge owners at each and every large area of expertise within the company. The knowledge owner is an expert within the area and operates as a knowledge judge, determining what should be documented and stored. However, before every document release, there is a four-eyes-process to ensure the quality of the document before its release. The knowledge owner is fed with input from a consensus group at each area of expertise that has the responsibility to pick up learnings during the projects. Once a document is released, it goes into a database in Lotus Notes, which also contains scanned old documents from a standards & practices binder. Although there is a process for this, employees usually struggle to locate documents; both SharePoint and Lotus Notes are viewed upon as systems where files disappear. There are too many categories that are not mutually exclusive, which result in that there are several options to where the file may be located. Thus, the manager believes that the category structure for the database needs to be very strict. Databases are only experienced to work when the employee knows exactly what to look for and manages to find it through a free-text search. This is especially a problem for new employees who many times struggle with knowing exactly what to ask or look for. Another problem experienced at Company W, is that several databases are used, it would be better to have one database where everything is gathered so that employees can look for something and if not found, they be "sure" that it does not exist.

Further, the product development manager explains that the most important decision to make in regards to knowledge management is to pick a strategy, either personalization or codification. Personalization allows for a richer communication where one can provide a context, trade-offs, effects and so forth. Unfortunately the problem is that a newly hired employee does not possess a comprehensive network, which makes personalization difficult. Codification on the other hand does not provide the same kind of richness in communication as personalization. Therefore, it becomes challenging to explain a complex problem, with the right context on a sufficient detail level for others to understand, yet not overloading them with information. It is simply impossible to write enough about a problem to make sure that it does not appear again. As a result, the manager's opinion is that databases provide simple answers to simple questions and the more complex problems are therefore not dealt with.

Another issue mentioned by the manager is that it is challenging to get people to contribute within knowledge management activities according to a rational structure. Although employees learn new things every day, it is just not enough to generate a fruitful discussion. One such example that the manager refers to is Lessons learned sessions at the end of projects.

4.2.2 Company X

From Company X, two employees were interviewed simultaneously, both of them product development managers. Similarly to Company X, Company Y has processes for capturing learnings and several knowledge management initiatives have passed by without getting rooted within the organization. The process for capturing learnings start with a Lessons learned session after the project has ended. The project team has been asked to prepare a little bit before the session and collect some important matters to discuss. There is also a template provided by the moderator during the meeting to be filled out. This template includes questions such as what went well during the project, what did not go as planned, how was the project managed and so forth. The learnings are later uploaded to a SharePoint site and the most important learnings are also included in the final project report. One problem that often occur, and is believed to be the reason for that mistakes are being repeated, is that the learnings found are not concrete and on a technical level. Instead, the learnings are often in regards to how leadership or communication was handled throughout the project. The most important benefit of Lessons learned sessions expressed by the managers is the individual learnings generated from discussions rather than what goes into the SharePoint site.

Before projects start, the first step is to log on to the learnings SharePoint site to read up on what has been done before. However, it seems like this step is often skipped and not really followed. One explanation mentioned is that it is truly difficult to navigate on the SharePoint site and files are often never found. That is also a reason for why Lessons learned moderators do not feel that it is inspiring to ask employees to perform Lessons learned, since the learnings most likely will not be used anyway. Another problem regarding the knowledge management is the current reward system. Today, time-to-market is prioritized and firefighters are generally rewarded and that is also many times the way to get promoted within Company X. It is also mentioned by the managers that the believed reason for why the initiatives never fully get implemented is due to the fact that top management do not give knowledge management enough attention and support. The focus also ends up on the software itself rather than the culture and the processes.

4.2.3 Company Y

The interview at Company Y was performed with a manager responsible for organizational development who is well familiar with knowledge management. The manager explains that product development is to large extent about innovating new products and creating new knowledge. Many times, customers also increase the demands from one product generation to another, which means that the product should be better, cheaper and lighter. In order to achieve this, one must reuse some components and knowledge, whereas other components must be innovated and developed. The strategy used by company Y is based on personalization, where personal communication is considered highly important. Meetings and checkpoints are big parts, however the discussions are quite often reactively oriented. Most often, knowledge is shared and problems are solved based on previous experiences, but the outcome is seldom related to how to prevent the problems in the first place. For the proactive measures, Company Y tries to use already completed FMEA documentation, which also

explains why a certain drawings looks the way it does. The manager explains that one major hindrance for knowledge management in product development is that the purpose is to innovate and use new ideas, which per definition, in one way, excludes the past and what has been done before. As a result, engineers often develop the following attitude:

"Engineers are driven by redoing things that already works because of a "not invented here-attitude". I do not want to use something that somebody else has developed, I want to do this myself instead."

On the other hand, the manager continues, it is exactly this mentality that drives development forward. This also contributes to the difficulty of asking somebody to reuse a solution without killing the joy of innovation possessed by many engineers. The culture also includes some extent of a disbelief in others' solutions, which results in that employees must be forced into such knowledge management activities. Company Y also has a program called Global Parts Management, which aims to get the knowledge from pre-development into the projects. This is done through personalization and recurring meetings. For each master component, there is a master component owner who work globally and is responsible for expert advise on the component. The recurring meetings are called upon by the projects, which invite the Global Part Owner as well as other employees who may contribute. The meetings often include checklists with questions such as have you considered this or that? However, according to the manger, checklists cannot cover everything, there must be opportunities for communication. Product development is an innovative and creative job. A checklist can set the bar as high as possible, but can never foresee future problems.

In order to make sure that knowledge is reused, one of Company Y's KPIs is to measure the number of reused components within a product. Global Part Owners work a lot with building onto the knowledge value stream in order for the company to be able to offer products to the customer on a long-term basis.

4.2.4 Company Z

At Company Z, the knowledge management manager has been interviewed several times. As Company Z has demonstrated to have numerous detailed processes for capturing, sharing, storing and reusing knowledge, it was considered valuable to revisit the manager at multiple occasions. Firstly, Company Z has two starting phases for the knowledge management system when implemented at a new team. The first phase is a start up the community phase; it includes appointing a knowledge owner, establishing the network and an off-loading process. The knowledge owner is responsible for capturing and packaging knowledge, making it visible as well as responsible for where it should be reused. The knowledge owner is also responsible for gathering the network for knowledge meetings. In the off-loading process, the current knowledge possessed by the team is captured and documented. The off-loading processes are performed in different ways, for example by interviewing the most experienced engineer in the team or using a workshop-like format with several members of the team. This process usually generates 20-30 knowledge posts organized in a web-based check sheet,

where the knowledge is structured according to know what, know why and know how. Excel sheets are also used for storing the knowledge, all of which are connected to the web-based version. Once the 20-30 checks are formulated, the check sheet is ready to be used by the team in a projects, which is the second phase within starting up the knowledge management system for a new team. The purpose is to continuously update the checklist during the knowledge meetings called upon by the knowledge owner. When the checklist are used within projects, employees will realize that some knowledge is obsolete, wrong or needs to be updated and sometimes a completely new check is necessary. The knowledge owner sends out the most recent version of the check sheet to all parties within the network, who are responsible to provide propositions of updates before the next knowledge meeting. At the knowledge meeting the proposed updates are discussed and agreed upon by the network. It is important that the knowledge owner does not act as a knowledge judge. What knowledge that will be necessary in the future and where it has the best chance of being reused, thus the location where it should be stored is for the network to determine collectively. The pace of which new checks are added usually stagnates when approximately 40 checks have been reached and commonly peaks at 50-60 checks. How often these knowledge meetings are performed vary depending on how fast the team generates knowledge. However, a reference point for network meetings is once a month, whereas it usually takes a quarter for the cyclic reuse to take place, from create, to capture and then finally reuse.

The knowledge meetings are split up in two parts, the first half of the meeting is spent on "meet and share" activities and the second half is used for capturing knowledge. During the meet and share session, Lessons learned are shared, quality issues are discussed and complex issues are discussed. This is a way for employees to ventilate their thoughts as well as to discuss solutions for issues in a less formal manner. During the capturing, updates for the knowledge base are proposed, previous proposals are reviewed and the work for updating the knowledge base is distributed. It is also of importance that the knowledge owner dares to challenge new updates if the knowledge is not crisp enough. In order for the knowledge to be beneficial, it needs to be detailed and formulated for primary users, meaning users that directly can apply this knowledge. The manager also mentions that there is a risk that inexperienced communities formulate knowledge for secondary users, meaning knowledge that concerns others but actually is too general for the own team to be used directly. Different methods for updating are used from one team to another, sometimes the updates are performed immediately and sometimes batch wise, in other teams it is always the most recently hired employee who is responsible for updating.

The manager further explains that it is fine if the knowledge in the checklist overlaps with other part of the knowledge base such as design guidelines. This is due to the fact that the knowledge base often contains educational content including information and data, which is not ready for reuse. The knowledge base is often very large and much of it is "good to know", but not considered "must know". The checklist contains thin-sliced knowledge with "must know" and is presented in an instructional manner, where the "good to know" have been separated and left out. For example, if one is to read a design guideline, you necessarily do not learn how to build a car, but you may understand how a car works and what components it

is made up of. But if one is to read the content of the check sheets, it provides the most critical instructions and what steps to perform in order to build the car. Thus, check sheets and other parts of the knowledge base complement each other.

Company Z also uses KPIs within their knowledge management system. For the first-year users of the knowledge management system, the team is supposed to reach what is called a "Green OK". That is done by providing an example of a fragment that has passed the whole knowledge loop, where a new check has been added or an existing one updated and in which project that knowledge has been used. After the first year of use, the team should show an increased flow of fragments that pass through the whole knowledge loop. In addition several soft factors are used as KPIs such as the usefulness of the knowledge and effects of the knowledge reuse.

It also happens that issues that are solved, but not yet root cause analyzed tries to find its way into the check sheets. However, the manager advocates the importance of having found the root cause before, in order for the correct knowledge to go into the check sheets. If such a matter emerges, it ends up in a backlog until a proper analysis is performed and the root cause is identified. By doing that, firefighting is avoided and the proper preventive action is then documented in check sheets in order for the problem to not appear again.

5 Analysis

Based on the above described situation at Volvo and the benchmarking companies an analysis has been conducted to narrow down the main difficulties regarding knowledge management as well as the needs required from a knowledge management system in order to mitigate the difficulties. The needs will serves as a basis input for the suggested knowledge management system that will be presented in the Chapter 6.

5.1 Volvo analysis

Looking at the described situation at Volvo is seems like there are structures, systems and processes in place that would be able to support knowledge management and the prevention of repeated mistakes. Knowledge is being created and there are systems and processes capable, at least in theory, to take care of this knowledge (see Figure 14). However, somehow mistakes continue to be repeated from project to project. Why is this?

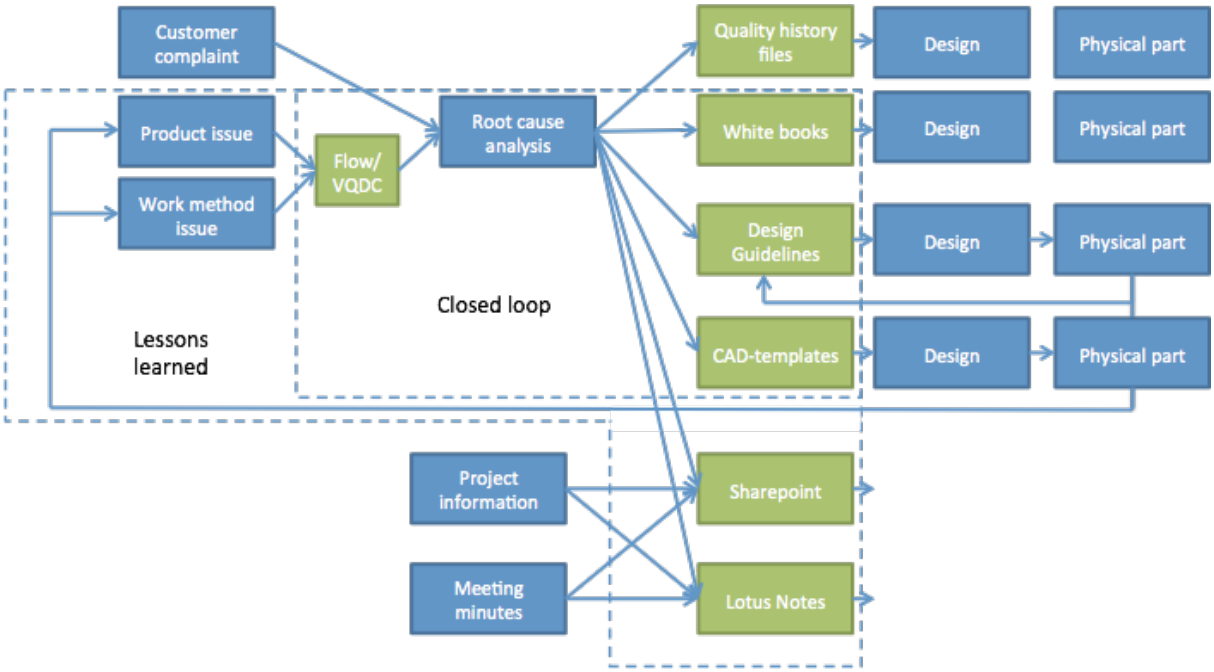

Figure 14 - Visualization of some of the systems, tools and processes used at Volvo and their correlation to each other as intended to work. Green box=tool or system, blue box=event or activity and lined box=process

In the following section, the underlying reasons for repeated mistakes at Volvo will be investigated and guided by the survey presented in Section 4.1.3 (Figure 13) where the top five most frequently occurring reasons for repeated mistakes make up almost 80% of the expressed opinions and can serve as a starting point for a further analysis.

5.1.1 Strong project orientation

One reason for Volvo's difficulty to enable knowledge reuse seems to be related to the strong project orientation and the difficulty to communicate between the projects. The knowledge that is in focus within this thesis, the knowledge on how to resolve and prevent mistakes from being repeated, is generally created in the different projects at Volvo. Since the projects are separated from each other with access restrictions and little direct communication between projects, the knowledge easily gets stuck within the individual projects. Once the projects have been delivered they are closed and the learnings captured are at high risk of being lost unless they are lifted out of the projects and transferred to another instance that is reachable outside of the project. Design reviews and the Lessons learned process are efforts from Volvo to mitigate this problem, although they seem to not be enough. One reason for this could be that they handle the issues within the projects. Design reviews are part of the project process and Lessons learned are performed within the project where the problem was encountered. Even though the result of the learnings are stored in organization-wide accessible sites, people outside of the specific project remain unaware of the knowledge that has been created and is unlikely that it will be reused.

Needs on KMS to mitigate of problems related to Strong project orientation

At Volvo the strongest link between the projects is the line organization, and maybe this is where the knowledge should be handled. However, the knowledge must be handled at an appropriate level in the line organization. One major drawback of the Design reviews is that they are too general according to employees at Volvo. In order for learnings to be reusable, it seems that they should be handled at the PSS-level where the learnings will be reused, rather than at project level. For the R&D business unit, the application of learnings are made by the individual design engineers, hence it is the design engineers that should be involved in the handling of learnings in the line organization. One way to do this is by making knowledge and learnings part of the weekly group meetings. Such solution would also possibly be able to mitigate the experienced difficulty to prioritize knowledge due to the constant focus on problem solving in projects. If the knowledge is handled in the line, at a meeting that is scheduled to take place independently of the knowledge part of it, it is likely that the staff will experience less stress due to lost project time.

5.1.2 Access to knowledge

In order for knowledge to be available for reuse in organization it needs to be accessible, and Lindlöf (2014) points out that accessibility is a major factor for reuse to take place. At Volvo, there are four different aspects that make the accessibility to the knowledge difficult; the number of different systems, access restrictions to sites, different site logic, and the amount of information in each system.

As mentioned earlier, there are many systems in place at Volvo where knowledge could be found, only a selection of the system were described in the previous section. Due to the large number of systems, employees find it difficult to identify in which system they should look for knowledge. To locate the right system, will then as a result regularly be a rather time

consuming activity. Further, even if the right system is found it is likely that it will be access restricted in some way. Many systems or sub units of systems at Volvo need to be access authorized either by a project or a central function. This access restriction results in both an entrance barrier to knowledge as well as more time spent on locating knowledge. The access restriction is especially problematic to new employees since they have not yet been authorized access to as many systems as an experienced employee.

In addition to these problems of accessing knowledge there is also a problem related to inner structure of the systems containing knowledge. As mentioned earlier, many of the sites at Volvo are allowed to create their own site logic; hence there could in theory be as many site logics as there are separate sites at Volvo. Having a great variation of site logics is beneficial for the internal efficiency of the site, but will make it difficult to navigate the site if one is not familiar with the logic. As a result, employees at Volvo find it hard to locate knowledge even if they are in the right system. The location of knowledge within sites is even more augmented due to the large amounts of information within each system. In order to find the knowledge one is looking for, the employees must know exactly what to ask for since there is simply too much information to have time to go through it all.

Needs on KMS to mitigate problems related to inaccessible knowledge
Based on the above reasoning is seems like the knowledge needs to be consolidated and open for everyone for everyone, independently of functional area or projects. Since Volvo has many different systems in place, containing and handling knowledge in different ways, a regular consolidation of systems will be hard to achieve since the systems most likely will not be able to be merged. A better solution would be to focus on the knowledge within the systems and consolidate that into one system that can gather the knowledge from the existing systems and put it in one common place that will be accessible for the entire Volvo organization. The system should also be separated from information and include only the most important aspects of knowledge to enable easy access and a smaller amount of knowledge. A long-term benefit of such solution would be that an employee can be convinced that the knowledge either exist or that it does not, as opposed to now, when an employee has no clue if the knowledge exists or not if failing to locate it in one system, because it could exist in several other places.

5.1.3 High internal staff turnover

Another problem that makes knowledge reuse difficult at Volvo is the high internal staff turnover. Many times, personnel are changing both functional area and PSS with a new position within the company. Considering that, a project lasts for about three years from concept to full production implementation, there are few people that stay more than one project within the same department or group. Since much of the knowledge is created during the problem solving process that is a part of the daily work within the projects, the internal staff turnover results in a lack of accumulated knowledge within people's minds since very few have experienced several projects within the same area of the company. If the knowledge is not documented it will be hard to build a knowledge base for any specific area of the

company and there will also be a risk of knowledge being lost in the staff transfer or at least hard to locate. The high internal staff turnover also creates a problem related to the accessibility of knowledge addressed in section 5.1.2, regarding knowing what to ask for. A highly experienced employee might be able to know exactly what to ask for, however, due to the internal staff turnover employees with such experience within the same area are rare at Volvo. Instead the regular employee at Volvo is in need of guidance to be able to ask the right question to locate the knowledge. However, when looking more into sharing knowledge across the company, rather than within the group, the internal staff turnover could potentially be used as an advantage as knowledge actually moves throughout the company.

Needs on KMS to mitigate problems related to high internal staff turnover

The conclusion to draw from the above described problematic is that a personalization strategy for knowledge management will be hard to apply at Volvo even though the product and organization fulfill some of the criteria, such as complexity of business and unique solutions to problems. Instead they are in need of document their knowledge in order to be able to maintain and reuse it later as well as to build a knowledge base. Such knowledge documentation should be able to guide the user to ask the right questions in search for further information and deeper knowledge if needed. In addition, the documented knowledge should be connected to the author, and thereby balance the codification strategy with a personalization to a certain extent. Thus, even though the employee has left the group, he or she could be contacted later and share experiences and knowledge.

5.1.4 Routines for system in place

The systems in place at Volvo supports different parts if the knowledge value chain (see Figure 15).

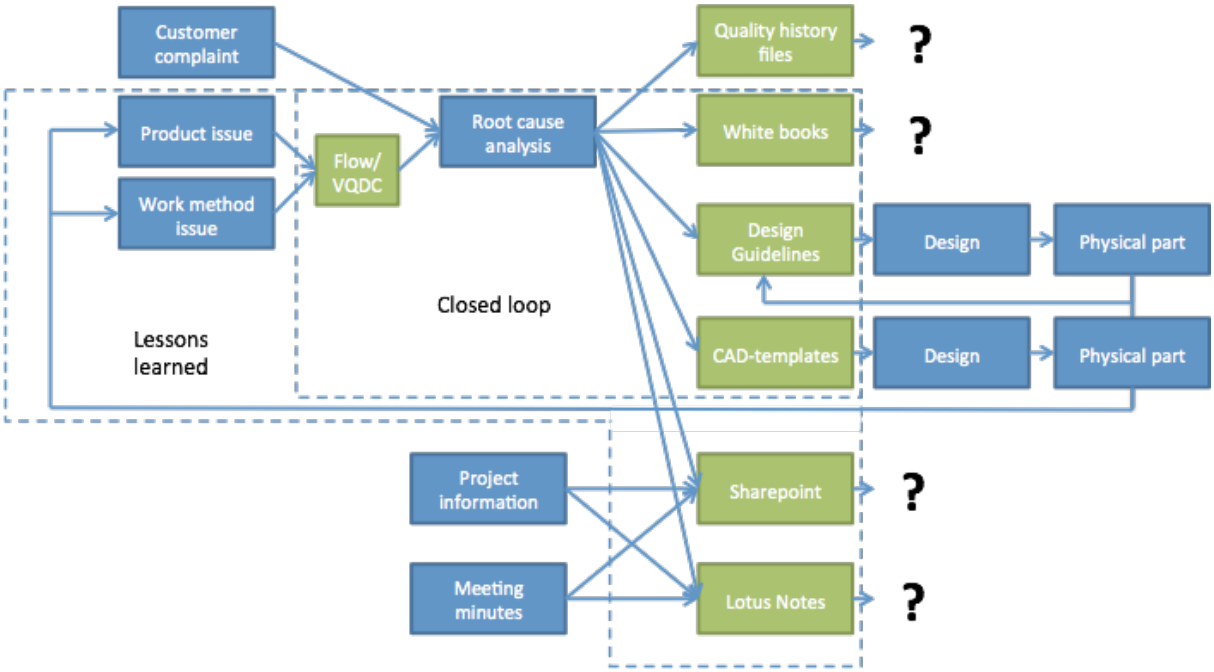

Figure 15 - Visualization of systems, tools, activities and processes within the knowledge value chain and their correlation to each other in reality. Green box=system, blue box=event or activity, and lined box=process

As can be seen from Figure 15 the systems which purpose is to provide knowledge reuse besides attribute requirements and specifications used to secure are CAD-templates, Design guidelines and Design review checklists. However, there are some aspects of the systems that are hindering knowledge reuse at the moment, namely lack the integration into the daily work, lack of contextual knowledge and the general level of the systems in some cases.

The integration into daily work becomes an issue due to the fact that Volvo, as mentioned, is a company with a naturally strong project focus and there is an unwillingness to prioritize any work outside of the projects. At the moment, knowledge management, both documentation and reuse of it, is seen as time stolen from the project time. One way to mitigate this is by putting knowledge management in the line organization as mentioned. However this will not completely enable for a natural reuse of the knowledge since that part needs to be handled by the design engineers in their daily work. Hence there is a need to make knowledge reuse a part of the daily work processes. Looking at the systems for reuse in place at Volvo today, this is particularly an issue for the Design guidelines. They are as mentioned normally used only in the beginning of projects and there is no continuous use of knowledge. This results in that large amounts of valuable knowledge are at risk of being forgotten since a project lasts for about three years. One potential reason for the lack of continuous use of Design guidelines is that they are extensive and contain very much knowledge on a detailed level that takes time to go through.

CAD-templates on the other hand are, as mentioned, well-used in the daily work at Volvo in the design engineering department. They however lack in terms of contextual knowledge that can put the knowledge user in the situation of the problem leading up to the CAD-template design. It is, as mentioned possible to incorporate this within the CAD-templates, but is not something that is used at Volvo as the moment. As a result of this, little knowledge can be transferred from the CAD-templates on to the reader. The knowledge remains explicit and is not converted into tacit again. Without a contextual understanding of the knowledge, the CAD-templates become almost impossible to transmit into a different setting and one could almost argue that the knowledge is no longer knowledge but information instead. Design guidelines also lack contextual knowledge since they contain technical instructions for how to design components, but little about why the different elements and methods are being used.

Design guidelines and CAD-templates both contain mostly highly detailed and direct technical knowledge. So do requirements and specifications that are used in the project process. However not all knowledge that is created in the projects is of that detail level that it fits within these systems. Moreover, there is also a general risk that other types of knowledge that are not technical requirements are created in the projects remain unused since there is no reuse system that covers those areas. With the Design reviews Volvo has made an attempt to close this gap. However, Design reviews on the other hand are too general. The questions are on a company-wide level that makes it difficult to apply on the specific area one is in, or at least a highly time consuming activity to translate the general questions and demands into group level knowledge. This results in Design reviews taking a tick-in-the-box role that only take time away from the project and without providing value for the product nor applying any

knowledge.

Needs on KMS to mitigate problems related to routines for systems in place
It is clear that the existing systems are not capable of managing knowledge reuse. Volvo is in need of systems and processes that can drive a continuous use of knowledge throughout the projects. The reuse of knowledge must take a natural part of the daily work for the design engineers and there is a need to find a system that is able to support different types of knowledge that cannot be absorbed by the existing systems at Volvo. There is also a need for technical knowledge supported by contextual knowledge in order to be able to build on the knowledge, and that knowledge needs to be on the level where it is to be applied.

5.2 Benchmarking analysis

Based on the described situations at the benchmarking companies in Section 4.2 a categorization of the problems experienced by the benchmarking companies has been conducted (see Table 4).

Table 4 - Summary of problems and mitigations for benchmarking companies

Problem areas				
Company	**Strong project orientation**	**Access to knowledge**	**High staff turnover**	**Routines for systems**
W	Not expressed during interviews but implied.	*Learnings are created, captured and put in a database where they are difficult to locate. *If one do not know what exactly what to ask for, it cannot be found.	*Difficult with personalization strategy	*No continuous process for knowledge activity.
X	*Problems of prioritization. *Reactive approach to problems. *Knowledge on technical level is lacking only on project level.	*Learnings are created, captured and put in a database where they are difficult to locate.	Not mentioned	*Lessons learned only in the end of projects and put in database, hard to remember. *Routines for reuse of Lessons learned not followed.
Y	Not expressed during interviews but implied and preventive actions taken on the to mitigate issue.		Not mentioned	*General problems of reuse with systems.
Z	Not expressed during interviews but implied and preventive actions taken on the to mitigate issue.	Not expressed during interviews but implied and preventive actions taken on the to mitigate issue.	Not mentioned	*General problems of reuse with systems.

Mitigation	
Company	
W	*Abstract of report only *Push of knowledge to receiver *Knowledge owners *Four eyes process to make sure only knowledge is documented
X	*Personalization to avoid documentation
Y	*KPI to promote a more proactive culture *Education on proactive behaviors *Knowledge owner *Personalization of knowledge in the GPM that is part of the product process
Z	*KPI to promote a more proactive culture *Report of KM related work *Knowledge owner *Thin-slicing of knowledge *Checklists *Knowledge process in place including the above

From the table and within the presented data for the benchmarking companies it is clear that they are experiencing similar problems to the once at Volvo. The strong project orientation is causing problems of prioritization and a knowledge friendly culture, due to the focus on problem solving in projects. Several of the benchmarking companies are also experiencing difficulties to access knowledge and thereby to locate knowledge in the databases where it is stored. There are also difficulties related to the routines around the existing process around the systems handling knowledge at the benchmarking companies. Especially a continuous work with the whole knowledge value chain is missing through the project process and routines for reuse are not followed. Overall, the reuse of knowledge is experienced as a difficult issue to handle by the benchmarking companies. They have attempted to mitigate this by solutions such as KPIs for promoting knowledge reuse, education on desired behaviors, thin-sliced knowledge in checklists, push of knowledge and personalization of knowledge.

All of these issues have been addressed in the analysis regarding the Volvo findings, except one, knowledge owner. The concept of knowledge owner is interesting since is a way to maintain knowledge initiative in organization while maintaining a knowledge focus. With one person responsible for knowledge work, the organization can maintain the knowledge processes while the rest of the organization can keep focus on the project. This can allow for knowledge to be updated and available for reuse without being in conflict with the project orientation. However, there is a risk that the knowledge get centralized around that person which is something that Volvo and the other companies do not want, instead the knowledge owner must work to make the knowledge available on a local level where it can be applied. This is something that Maedche et al. (2015), with their role of intermediary, are attempting

as well, arguing for even more advantages in a knowledge management system. Thus, it is likely that this could potentially be of benefit for a knowledge management system at Volvo as well. Further, based on the findings it is clear that Company Z is the only company working in a structured way with knowledge management. They are in the product development business, like Volvo, the system has been in place for some time and currently seem to be working well. Thus, there is reason to believe that their way of working can be of use to the design of a knowledge management system at Volvo as well.

However, taking the complete picture of the benchmarking companies into consideration, one thing in particular is of interest. A majority of the companies are, like Volvo, struggling to find a way to enable for knowledge gained from experience to be reused in projects. This struggle itself might not be so interesting, apart from the fact that it gives more credibility to the situation at Volvo. However, what is of high interest related to this is the fact that, even though the benchmarking companies were asked questions regarding knowledge management in general and the entire value change, the focus of the answers seems to be on the early parts of the value change, such as create, capture and store, possibly transfer. However, the actual reuse of knowledge is seldom in focus. The general impression is that the companies are continually forgetting this piece of the chain and thus making their knowledge management initiatives excluded of the only piece of the value chain that actually brings value to the business. This can be considered the main takeaway from the benchmarking analysis and a possible indicator of the general situation in the product development business.

5.3 Literature analysis

Regarding the literature, the main problem areas related to knowledge management concerns the characteristics of knowledge, organizational aspects as well as IT-related barriers. These difficulties pose different requirements on a knowledge management system in order to enable reuse of knowledge. Regarding characteristics of knowledge the general notion is that in order to be able to handle knowledge at all it needs to be clear to the organization what knowledge is and its nature. However, there is no clear requirement on a knowledge management system for this issue, only an overall understanding with the people using the system. As for the organizational aspects and IT-related barriers, the framework Maedche et al. (2015) present seems to mitigate these problems with the six design principles. The organizational aspects are mainly addressed by the second design principle including the intermediary, while the IT-related barriers are addressed by almost all of the other design principles in different ways. Thus, the design principles of Maedche et al. (2015) can be regarded as a solid foundation for the requirements of a knowledge management system.

Further, based on the above analysis of requirement it is of interest for the design of the knowledge management system to discuss the relation between the literature and findings at Volvo. The general notion when making the comparison is that Volvo is experiencing many of the problems that the literature is acknowledging. The project orientation is strongly related to the time and culture issues mentioned as part of the organizational aspects Section 3.4.2.

The theory is also recognizing access to knowledge and employee turnover as problem areas for enabling knowledge reuse, which are two main challenges found in the case study. As for the routines around process, that is also directly addressed in the section presenting IT-related barriers (Section 3.3.3). However, looking at the content of the analysis of Volvo (Section 5.1.4) it is can also be seen that the characteristics of knowledge play a part of the problems for Volvo to enable knowledge reuse.

Overall it seems as if the problems recognized by researchers in general also are a reality at Volvo. That in turn implies that the solution suggested by research for mitigation of the problems or challenges related to knowledge management also can be applied or at least serve as great inspiration to the knowledge management system design at Volvo. Thus, the concepts of thin-slicing, checklists (including the software Checksheets), the concepts of push and pull as well as the design principles from Maedche et al. (2015) are likely to be applicable to the design of the knowledge management system.

5.3.1 Impact of design principles for the KMS at Volvo

Since the design principles presented by Maedche et al. (2015) can function as a baseline for the knowledge management system design it is important to understand in which way the research might influence the knowledge management system, Table 5 below is presented. Several of the ideas presented by Maedche et al. (2015) are straight off applicable to Volvo's organization while some ideas have also been modified due to resource capabilities, organizational reasons or simply that the concept is not applicable to the working methods at Volvo. A few of the design principles have also generated completely new ideas to the knowledge management system designed for Volvo.

Table 5 - Adaption of design principles to the Volvo organization

Design principle	**Theoretical recommendation**	**Adaption to Volvo's organization**
DP1 (technical)	Social networks and communities	Each PSS could work as a knowledge community, responsible to manage the group's knowledge as well as communicate with other PSSes knowledge concerning others.
DP1 (technical)	Search functionality	Provide sortable knowledge for the PSS internally, and searchable keywords when looking for knowledge existing at another PSS.
DP1 (technical)	Hyperlinking and tagging	Make it possible to hyperlink to steering documents within the software as well as tag all knowledge posts.
DP1 (technical)	Access control	Remove all access restrictions, making it possible for everyone to reach the knowledge.

DP3 (technical)	Project characteristics questionnaire	For certain knowledge posts with a need for further contextual explanations, the knowledge post should include contextual knowledge, an example of a previous issue and links to documents providing a project overview.
DP4 (technical)	Rating of knowledge	Discuss the usefulness of knowledge within a knowledge meeting.
DP1 (intermediary)	Connect knowledge seekers and providers	Create an activity field within the software in order to register and make visible who created the knowledge post.
DP1 (intermediary)	Provide infrastructure to support knowledge exchange	Use a knowledge meeting for exchanging knowledge within the PSS as well as creating a time slot on group meetings for supporting knowledge sharing between groups.
DP2	Extend project teams with a knowledge intermediary	Introduce a knowledge meeting within the line to not take time from the projects.
DP2 (intermediary)	Draw attention to useful knowledge	Appoint a knowledge owner responsible for feeding a knowledge meeting with input, potential knowledge, from issue handling systems and Lessons learned.
DP3 (intermediary)	Prepare knowledge for its reuse	Discuss the formulation of knowledge during a knowledge meeting to be both contextual and understandable for novices.
DP4 (intermediary)	Maintain knowledge base	Use a knowledge meeting as a forum for discussing old or miss formulated knowledge.
DP4 (intermediary)	Collect feedback on knowledge from knowledge consumers	A knowledge owner is responsible for asking employees about updates on already formulated knowledge.
DP5	Document and reuse knowledge in all project phases	Each individual knowledge post could be connected to a certain to the project phase where the knowledge is to be applied it is to be applied. The knowledge could then be pushed out in the beginning of each project phase. As for the continuous documentation of knowledge this could be maintained as part of the mentioned knowledge meeting that is held weekly in the line organization.

5.4 Concluding analysis

Looking at the overall picture of problems related to knowledge management, how the benchmarking companies have tackled these difficulties as well as the overall setting at Volvo and the solutions provided by the literature, there are some important aspects that should be included in the design of the knowledge management system.

The first thing to bring into the knowledge management system for Volvo should be to apply a codification strategy, rather than relying on personalization of knowledge due to the high internal staff turnover (Hansen et al., 1999). However, since the learnings in projects often are of highly complex nature the knowledge management system should provide some possibility for personalization of knowledge as well. Secondly, there is need for a mitigation of the project orientation by moving the handling of knowledge from the projects into the line organization. The knowledge should also be handled locally at the level where it is to be reused later, thus the individual design engineers needs to be involved in the knowledge management process.

Further, Volvo needs to facilitate the access to knowledge throughout their systems. A consolidation into one system that pushes the most important knowledge in a thin-sliced format (Gladwell, 2005) and making it be accessible for the entire organization seems to be a solution that fits well with the Volvo organization. It is also the way several of the benchmarking companies have chosen to handle their systems or think is why they should do it at least. The system should also be able to handle both technical knowledge as well as more contextual knowledge and provide knowledge to an extent that a new employee at least will understand what questions to ask. Such system should also be integrated into the daily work at Volvo and be supported by processes and routines that drive a continuous use in order to make the knowledge reuse as easy as possible. In order to make such system with the knowledge needed, routines for externalization of knowledge from the projects are needed.

In general a holistic view on the entire knowledge value chain should be applied to ensure that knowledge reuse is possible at Volvo. Several of the benchmarking companies are using KPIs as a way to maintain control of the process and encourage knowledge reuse. However, KPIs are highly associated with a controlling culture that Volvo is trying to move away from. Hence, it might be more effective to simply avoid KPIs for the system and instead work with internal incentives. Maybe simply the experience of feeling that the system is of use in the daily work will be incentive enough for wanting to contribute to the system. However, to rely completely on the system to work on its own puts Volvo at the risk of another knowledge management initiative just fading out. To avoid this, the system should include a knowledge owner that at least is responsible for the process, creating some external incentives for keeping the system running.

6 The knowledge management system

Based on the above analysis, different problem areas regarding knowledge management at Volvo has been identified. From these problem areas and the literature requirements, needs on the system has been formulated as input for the design of the knowledge management system (see Figure 16).

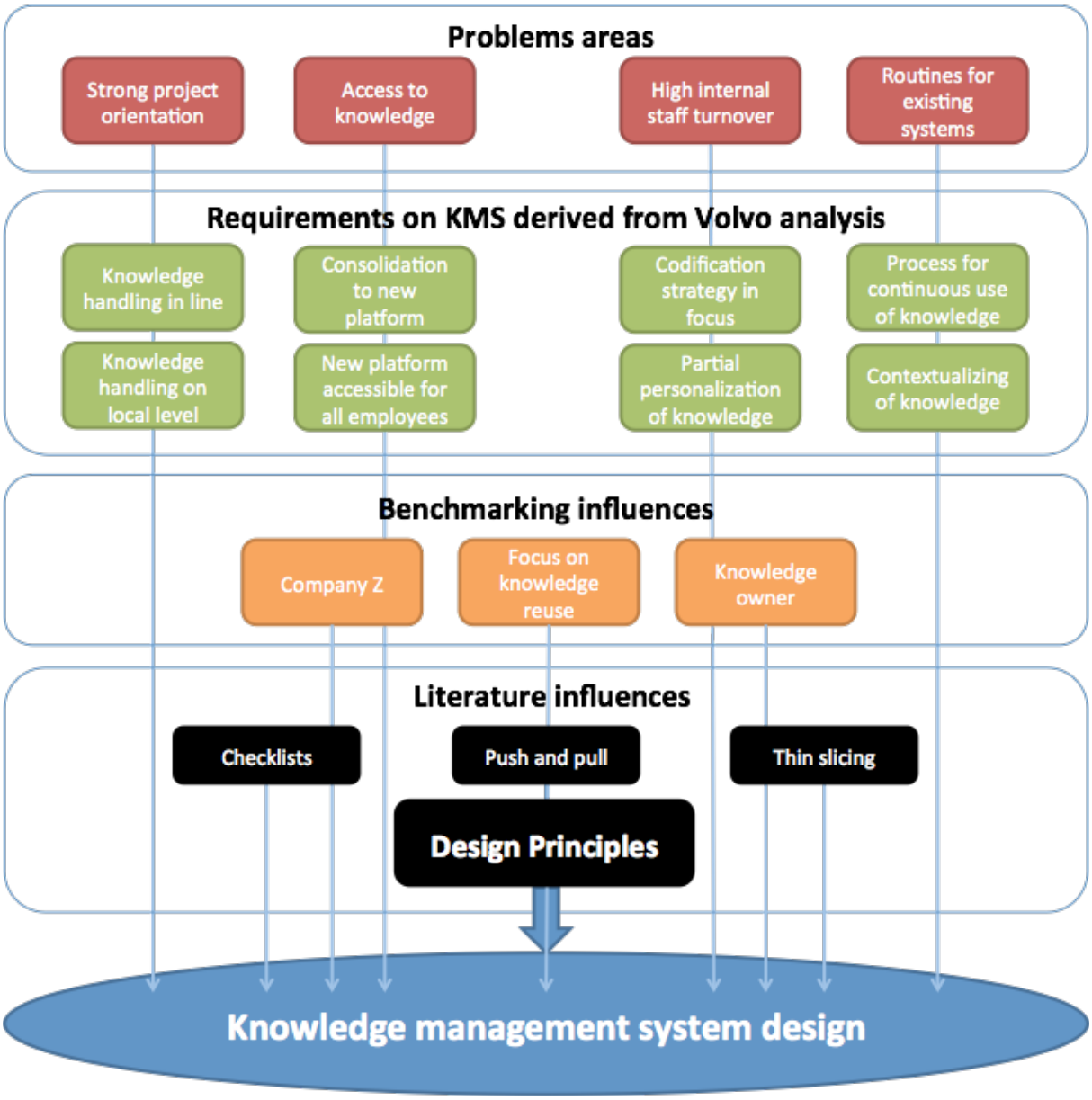

Figure 16 - Illustration of the different analyses and their correlation to each other as well as contribution to the knowledge management system.

This knowledge management system aims to include KM aspects from the theoretical research by and benchmarking companies by applying the design principles from Maedche et al. (2015), different aspects of theories regarding push and pull as well as parts of the process describes at Company Z. To include the aspects of thin-slicing and checklists, and to provide

a common platform for knowledge storage the software *Checksheets* is used. Finally, all of the above aspects are applied with the entire knowledge value chain in mind with an extra focus on knowledge reuse. By designing a knowledge management system that include these aspects, the underlying problems related to knowledge reuse is attempted to be mitigated, and the chance for reuse of knowledge at Volvo enhanced.

6.1 The system design

The system design is divided into four steps: collection of potential knowledge, decision of definitive knowledge, steering of definitive knowledge and reuse of knowledge within projects (see Figure 17). The system will be applied on a PSS level to enable for local involvement and application of the knowledge. In the following sections it will be described how each step is supposed to work and how the knowledge management system will overcome the existing challenges with knowledge management at Volvo. The specific use of Checksheets within the knowledge management system will also be described. The fundamental essence of the system design is to provide a process that supports the use of previous knowledge continuously throughout any project process in the R&D functional area based on the needs presented in the concluding analysis.

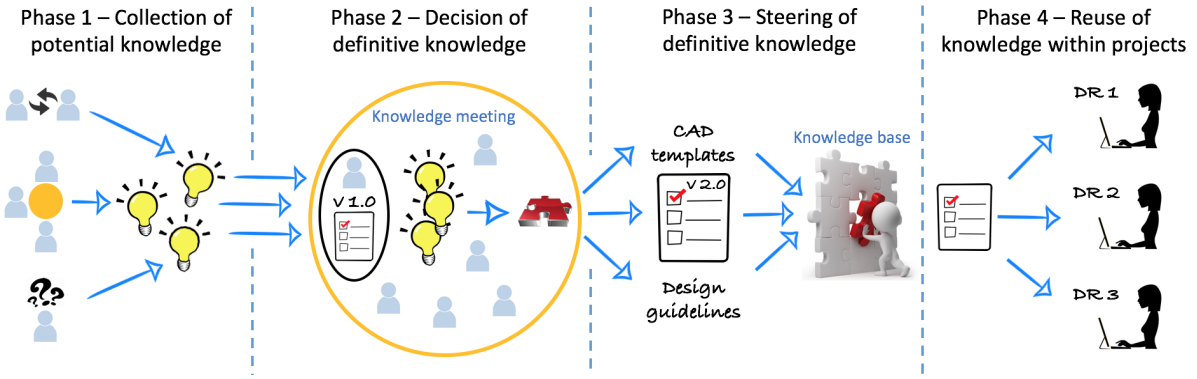

Figure 17 - Conceptual visualization of the knowledge management system.

6.1.1 Collecting knowledge

The initial phase of the system design is focused on the capturing of knowledge. Knowledge is, as mentioned, created in many different places in an organization and in different forms. Some of the knowledge created is project specific and will not be able to be used in the future, but some are learnings and knowledge that if absorbed in the organization could be reused in future projects. However in this stage of the process it is not clear what knowledge that will be used and what will not, therefore all of the knowledge is classified as potential knowledge. The purpose of Phase 1 is to capture and collect this potential knowledge for further assessment. To capture and structure that knowledge, Volvo has several systems in place such as Flow, Quality History Files and early phases of the Lessons learned process. These systems can hence be used as the baseline for the collection. It is suggested to generate a list all closed issues from the systems. The issues should be closed in order to be able to use the identified

root cause analysis as a basis for preventive actions to avoid prevention of symptoms to problems. This process is similar to the Closed loop initiative and there is potential to integrate that process into the system. However, Lessons learned and Quality history files are not included in the Closed loop initiative but should be in the new system design. Further, these systems are not capable of capturing all knowledge that is being created, much valuable knowledge is tacit or generated during informal circumstances. Thus, it is also important to collect the thoughts from employees in order to extract tacit knowledge or capture the knowledge generated in informal situations.

In the system design, an appointed Knowledge System Owner (read more in Section 6.1.5) within each PSS is responsible to collect the potential knowledge from the mentioned systems for how or hers PSS. Since the use of the systems differ between (see Chapter 4) the input sources of potential knowledge may emerge from various sources depending on which PSS the knowledge management system is implemented at. Thus, teams may use unofficial documents or programs to keep track of their issues within the projects, the system design has not been restricted to any specific input source from the knowledge collection phase but any place where knowledge is created can be included in the system.

6.1.2 Decision of definitive knowledge

In the second phase of the system design, the potential knowledge collected within the first phase of the knowledge management system is intended to serve as input to a knowledge meeting. This is where the assessment of which knowledge that is believed to be useful in future projects is made. In order to fit well with the established meeting structure at Volvo as well as to enable the connection between projects pointed out in the analysis, this knowledge meeting should be a part of the regular group meetings that are held weekly in each PSS. It is the knowledge owner who is responsible to convene for the knowledge meetings.

At this meeting, the potential knowledge from both each project team members and the capturing systems will be brought to the table and discussed in order to decide whether the knowledge is definitive or not. It is important to understand that definitive knowledge is not an absolute truth that never will become obsolete, definitive knowledge is rather knowledge that is believed, by the group, to be useful in future projects. What is important to keep in mind is that the potential knowledge that is assessed in terms of being definitive knowledge or not, should be a closed issues where root cause has been found. This is important in order to be able to take corrective actions and solve the problems, not the symptoms. Once the definitive knowledge has been decided upon, an action should be formulated by the group based on the root cause of the issue that proactively will hinder the problem from reoccurring. The knowledge should be structured according to what, why and how, which will be discussed in Section 5.1.4.

The knowledge meeting aims to capture the knowledge that can be of benefit for the future and directly transfer it to the rest of the PSS, thus functioning as an intermediary by having the group altogether decide upon the definitive knowledge and the proactive action. In that

way, the knowledge management will not require additional personnel, something that is necessary since Volvo is already stretching their limits regarding hiring new staff. Another possible way of managing the knowledge meetings would be for the knowledge owner to be responsible for distributing definitive knowledge to employees within the group for formulation until next week's meeting. The advantage with this approach is that the already formulated actions are used as a starting point for the discussion of how to formulate things, which gets the discussion going and also saves time. Since the knowledge meeting should be a part of the group meeting, which is in the line organization, the employees will hopefully not experience that the time is taken from the projects and a down-prioritization of the knowledge management can therefore be avoided.

6.1.3 Steering knowledge

When the definitive knowledge has been identified and proactive action has been formulated, it needs to be directed or steered to the right storage location in the organization, thus where the knowledge has the best chance to be reused. The right location is referring to the appropriate tool and/or the people affected by the knowledge. What the appropriate tool is should be decided upon at the knowledge meeting and could be either to update of design guidelines, CAD-templates, the Checksheets (see chapter 5.1.4) or other tools used within the organization. These tools and documents together constitute the accumulated knowledge base within the group.

Some knowledge will also have to be transferred to another PSS or functional area at Volvo. The knowledge owner in the original PSS is responsible for informing the concerned PSSes about the new/updated knowledge. It is therefore important that the PSSes using Checksheets always have 15 minutes reserved for knowledge meetings at the group meeting. This will create opportunities for knowledge owners to visit other PSSes and share knowledge. This will create a chance for the knowledge to reach the concerned people and secondly it gives other PSSes the freedom to package and contextualize the knowledge in a way that it is reusable for them.

6.1.4 Reuse of knowledge in projects

Once the knowledge has been steered into the right storage system in the organization, the last phase of the system design can be entered, the reuse of knowledge. This is were Volvo and other companies lack in routines and supporting systems. What is mostly lacking in the systems in place in order to enable reuse is the ability to:

- Provide contextual knowledge
- Store other types of knowledge than detailed technical learnings
- Support a continuous use
- Push thin-sliced knowledge
- Free access for everyone

Based on the above needs it is clear that the existing systems at Volvo are not able to provide

what is needed in the system. However, they are not ignorable, they are needed to provide Volvo with what they are intended for and to form the complete knowledge base. Although, there is a need to complement the existing systems with something new mentioned. This, based on the above mentioned needs at Volvo a software as been developed and included in the system, Checksheets. Checksheets can contain different types of knowledge, structured according to know what, know why and know how. The "what" should correspond to the proactive action formulated on the knowledge meeting. The "why" should explain why this needs to be done and why this is important to the organization. The how should explain how this action should be performed, and more precisely what activities to carry out as well as what to consider when performing them. The exact formulation of the "why" and the "how" should be decided during the knowledge meeting along with the action, however in order to guide the meeting the "why" and the "how" could answer the following questions:

Why?

- Why should this be done?
- What are the effects if this is not done?
- What problems may occur if this is not done?
- What has been the problem before and why did this action emerge?

How?

- What activities should be performed?
- Who needs to be communicated with?
- What should be considered when making these decisions or performing the activities?

It is the "why" in particular and also the how that contains the knowledge and should be formulated so that a person not familiar with the process or the PSS should at least understand what to ask for and thereby guide his or hers work in line with knowledge reuse. Within the "why" and the "how", links to other systems such as relevant Lessons learned, Quality history files, SharePoint documents, etc. The actions are tagged according to four different categories in order to structure the actions and make is searchable. The tagging categories are: PSS, phase, component and keyword. The PSS, component and phase tags are used to sort out the knowledge that is applicable for the individual during a certain phase in the project (see below for further explanation). By tagging the actions with keywords the transfer of knowledge within the organization will be facilitated since the software is open for everyone to use.

During the projects the Checksheets will be part of a continuous process for knowledge reuse (see Figure 18). In the beginning of each phase of a project, the team leader will be responsible for making sure that the team members create their own checklist for the specific component they are working with and the phase they are about to enter. This will allow for a push of the most important knowledge within each phase that can guide the design engineers in their work. The actions can also trigger a pull for more detailed knowledge and information from other systems at Volvo through the linking within the why and how, as well as by providing a guide for what to ask for.

To maintain a structure of the Checksheet software that is in line with the project organization at Volvo the phases are based on the different Design reviews as well as the prototyping gateways. Each team member should then continuously work with checking off the actions in the generated list throughout each phase and by the end of the project all actions for his or her component should be checked off. In this way, the knowledge is continuously used throughout the projects and the repeating of previous mistakes could be reduced.

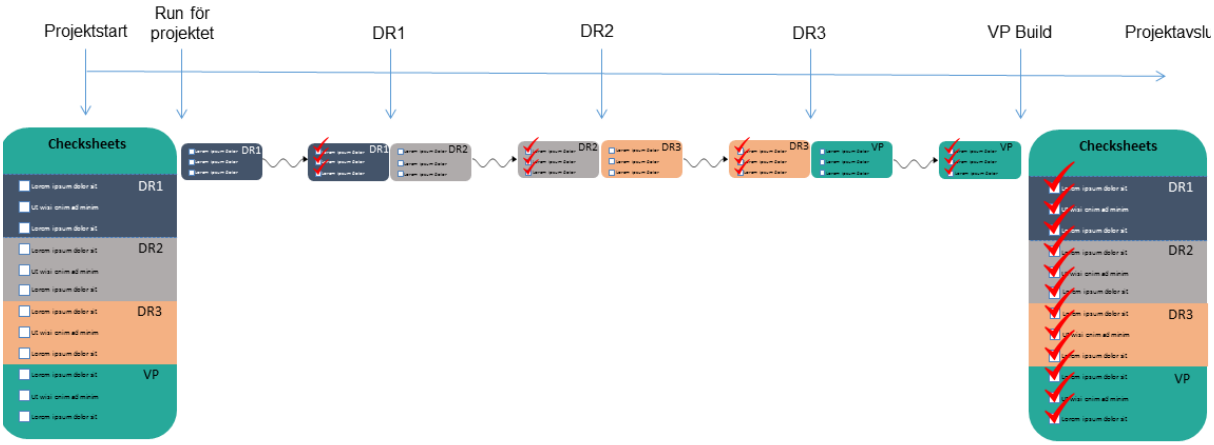

Figure 18 - The continuous use of Checksheets.

Further, Checksheets also has an editing history connected to each action that allows the users to see who created the action as well as who have made changes to it. This provides an opportunity for personalization of the knowledge as a complement to the documentation. Since some of the knowledge that will be formulated in the software is likely to be of highly complex origin, the thin-sliced knowledge within the action, why and how, might not always be sufficient, even with the complement the linkage provides. In such case, the editing history will guide the user to a person that has been first handedly involved in the underlying issue and the possibility to ask for more details about the case in person.

6.1.5 Knowledge system owner and its responsibilities

In order for this entire process to function properly in such large organization as Volvo and with the project orientation that is a fact, there is a need for somebody to be responsible for the knowledge management activities that is included within the system. A knowledge system owner should be appointed for each group using the system design. The responsibilities of the knowledge system owner is to:

1. *Summon the group for knowledge meetings and moderate these meetings*
2. *Bring up closed issues from Flow and ask co-workers for potential knowledge*
3. *Make sure that the knowledge is crisp and specific, thus, thin-sliced and instructional*
4. *Challenge knowledge actions formulations that are not sufficient according number 2*
5. *Make sure that action titles are assigned to group members for formulation until the*

next meeting and follow up that they have been done

6. *Bring up recently formulated knowledge actions for discussion*
7. *Responsible for communication regarding the knowledge with other PSSes*
8. *Responsible for inviting other PSSes to knowledge meetings and also informing at other PSSes about a new knowledge action that may concern them*

When looking at these responsibilities, it is important to remember that the knowledge system owner is not the judge of definitive knowledge or the person that necessarily has to perform all tasks regarding the knowledge. It is simply the person responsible for making sure that it gets done. In addition, it may be useful for the knowledge system owner to be straightforward to have the courage to challenge the formulations of knowledge actions, and also outgoing to be able to involve employees and get the discussions going. Something that should not be underestimated either is the general willingness, or often unwillingness, to participate in knowledge management activities. Therefore it is of great advantage if the knowledge system owner is excited about knowledge management, has the drive and energy to engage others and the ability to be persistent and get things done.

7 Test of the knowledge management system

As a part of forming a basis for a recommendation on the third research question, a test of the knowledge management system has been performed. The test consists of two different parts, individual use of the software and a knowledge meeting performed by the employees themselves under supervision of the researchers.

7.1 Individual use of the software Checksheets

The individual test was performed with the software Checksheets in focus, thus the reuse phase of the system design. The aim of the testing was to provide data on how the software was working as part of the system and along with the existing systems at Volvo. In addition, the employees that tested the software also evaluated the knowledge, thus generating feedback that will serve as input for a knowledge meeting, presented in Section 5.2.2. The test persons were asked to create their own checklist for their specific component within the current project phase that they were working within and go through the actions, no further information was given. However, most of the test persons have participated within the knowledge generating workshops and are therefore spatially familiar with the software.

During the test, the researchers were sitting nearby, being available for immediate feedback. A confusion experienced by the test persons were that it was not clear if one should make a search and thus narrowing down the number of actions and then create the checklist or to create the checklist first and then narrow down the actions for the specific component and project phase. It was also not obvious which of the project phases that had been used for tags within the software, and thus were available for the creation of a checklist. However, after some instructions the employees figured it out rather quickly.

It was also expected that the new checklist should pop up once created, instead of just ending up in the scroll down menu with the other checklists without notification. Another issue for the test persons was that when a checklist was created, one cannot add checks to that list thereafter, it is simply locked. This was experienced as frustrating and annoying since if one is to forget a tag in one's search, the checklist has to be remade from the start. It was believed that it is easy to forget to search for both the checks related to your component as well as component general checks. The test persons were generally concerned that this might create barriers of acceptance for the software.

Further, once a checklist had been created several of the employees developed an ownership of the created checklists, expressing a need for keeping others from being able to access to "their" list and possibly mess around in it. The test users also mentioned that it is hard to find your own checklist, since all checklists are gathered within a scroll down menu, which is not sorted. Several employees also were missing the possibility to track their own progress in the software. Currently, the project progress in not visualized within the software, therefore it is difficult to know if you are on falling behind or are on track. They expressed a desire to be

able to get an overview of “their” own ongoing and closed checklists.

Another comment received was that there might be a need for notifying other users when an update of a check has been performed, since that update directly feeds into already created checklists that are being used within projects. They also expressed a potential need for a field where one can propose a change to an action that is not sufficient. Since the knowledge documented is written in English, which might also become a barrier for some employees who feel less comfortable with spelling. The software also provides the option making an action non-applicable is perceived as good, however if that is done mistakenly, it is not possible to make it applicable again.

In general, the test persons did not experience the software as very easy to understand and the graphic interface was not appealing according to the interviewees. However, the concept itself, providing a checklist with the most necessary things to remember throughout each project phase is appealing to the test persons. The benefits expressed is that one does not have to ask your co-workers about everything and it also serves as a guide for asking the right question. The structure of arranging the knowledge according to know what, know why and know how is also perceived as concrete and easy to understand. If Checksheets become a part of the daily work activities, it there is a belief by the test persons that one would want to contribute in updating checks as long as there is a forum provided.

7.2 Knowledge meetings

In order to evaluate how the knowledge meetings should be improved, several knowledge meetings have been held. Firstly, the researchers themselves have moderated off-loading knowledge meetings where the employees are supposed to capture the current knowledge available within the team. Secondly, knowledge meetings have been held and moderated by Volvo employees, where the researchers only have been observing. In addition, interviews were held with employees to provide further feedback on the setup of the knowledge meeting.

During the startup meeting phase, when a new group is off loading the current knowledge into Checksheets several interesting observations was made. The employees found it difficult to, on top of their heads, present the most important aspects when designing a component. The ideas that were generated mostly concerned ongoing, unresolved issues without root cause, making the formulation of a correct preventive action difficult. The early knowledge meetings were performed without any creativity support or preparation and the meetings were staggered. In later meetings issues from previous projects were used, as intended in the system, as a starting point and inspiration for the knowledge meetings, as well as physical parts of previous car models. During those meeting the employees generated ideas of possible actions much faster than during the first meetings and the flow of was more natural. In addition, the knowledge shared regarding the issues from previous projects also raised ideas for other design questions that could be brought up for discussion.

Further, the structuring the knowledge according to know what, know why and know how appeared to be difficult during the first meetings. The employees occasionally had problems with separating why from how. Many times the "why" also resulted in a shallow explanation often related to the delivery itself, rather than the underlying knowledge. One such example is for the what - Secure bread board delivery: *Bread boards needed for electrical verification*. The "whats" were also repeatedly related to activities or deliveries in projects rather than design choices, concerns or material choices. Thirdly, on average it took 20-30 minutes to generate one action, thus a what, why and how. Hence, it was possible to generate approximately six actions in a two-hour long knowledge meeting with inexperienced participants, whom also expressed it was difficult to concentrate for more than two hours. For the later meetings the actions were formulated in group and then divided within the group to formulate potential whys and hows for the different actions to present in the next meeting. During these meetings the complete generation of an action (plus agreement of why and how) was about 10 minutes.

For the knowledge meetings held and moderated by the Volvo employees themselves, when the knowledge base was already established, several interesting observations were also made. These meetings were conducted in order to revise or add actions to Checksheets. Firstly, when employees came prepared with proposals (formulated actions) for new actions, the meetings ran more smoothly and were significantly more efficient. The actions were often well thought out and the discussions often concerned the knowledge itself rather than the formulation.

7.3 Analysis of test phase

Based on the above described testing phase a further analysis of the system has been conducted to identify possible improvements to the system design. The general impression is that the process as well as the use of the new software is working well and has the potential to actually enable knowledge reuse with the projects. However, minor adjustments can be made to the system based on the testing data. Within this section the adjustments and the underlying reasoning will be discussed and analyzed.

7.3.1 Individual use of the software Checksheets

Overall, the use of the software as part of the system design seems to be a working concept. Based on the test, it seems have the potential to fulfill the attempted purpose, to push out the most important knowledge continuously during the projects. However, in order to facilitate the integration of the software and thus the overall system design some adjustment might be of use.

Firstly, the search engine created some confusion. Due to the fact that the search engine does not work like Google, where one can type anything and thereafter get a number of hits, it may create confusion at first but instead provide effective locating abilities. Since it is based on a

tag system and the search is narrowed down for each tag that is added, the search engine is actually more sortable than searchable. In addition, there are currently four different types of tags used, which make the number of user choices in relation to searching very low. Therefore, when the user is working in a specific project phase with a certain component, he or she can be sure that it is the right location to look for the knowledge and thus be confident of that the knowledge either exist or that it does not exist. However, this information is not provided in the software at the moment when entering for the first time, thus confusion occurs. This confusion could most likely easily be managed by simply providing the user with instructions for how the software is structured and stepwise guidance for how to create a checklist.

The drawback with having such limited search engine is that it is more difficult to locate knowledge on a specific area from other PSSes. In order to locate knowledge from another PSS about a specific topic, the retriever of the knowledge must pinpoint the exact same keyword used by the author of the knowledge, which may sometimes be difficult. In order to mitigate this the search engine could suggest endings of phrases when typing as well as *"did you mean XXXX"*-suggestions based on the tags that are already in the system. Such search function facilitation would make the entire use of the Checksheets easier and it is most likely an important factor in order to make the system accepted by the employees. The difficulty to search for knowledge within the software can also be over bridged by personalization and puts more the importance of always setting off time on the group meetings for knowledge meetings to make it possible for PSSes to inform about learnings that may concern others.

The need for ownership was also pointed out as important for the users and as a way to make the software and system design easily a part of the Volvo organization. Ownership of knowledge has by several references been pointed out as the basic foundation for knowledge initiatives to work. By providing the employees with a personal homepage where they can overview their projects and progress with the checklists as well as the impossibility of others to make changes in checklists and actions, such ownership could potentially be achieved and knowledge reuse maintained in the organization without having to control it.

The concept itself with creating an own checklist in order to remember the most important things for each project phase to keep in mind when designing a component seems to be well accepted. Especially if Checksheets gets incorporated into the daily or weekly work activities as that appear to be a key factor for the willingness to contribute to and update the knowledge base. Thus, in order for the employees to want to use Checksheets, it should be important that the knowledge base provides significant benefits for the users, which is also advocated by Alavi and Leidner (2001) & Maedche et al. (2015) in order for contribution to take place.

Although there are relatively many feedback items regarding the user experience of the software to correct, the most interesting outcome of the test phase is that there seems to be support from the employees to use Checksheets. The best case scenario would be that fairly recently hired employees could make decisions at the same level, or close to, as experienced engineers by using Checksheets. If not, at least to be provided with enough knowledge to be

able to ask the right question and also understand from the software who to ask.

7.3.2 Knowledge meetings

The general impression during the knowledge meeting-tests was that the process as such is a working to bring learnings to the table. However, the process takes time and it is not always crystal clear how to formulate the “what”, “why” and “how”. The two difficulties are closely related since the difficulty to formulate actions makes the process time consuming. Another reason for the time consumption seems to be lack of idea generation due to lack of inspirational tools and concrete issues to address. Physical parts seemed to get the brainstorming process going and should preferably be used during knowledge meetings in an early stage where the need for idea generation is large in order to create a knowledge base. Further, the closed issues from issue handling system as well as former Lessons learned and Quality history files should be used as input to the knowledge meeting, as suggested by the system. Such input has probably a positive effect on both time consumption and will help the employees move away from ongoing issues without root cause and focus on the issues where true knowledge has been created.

Further, the employees seem to require a couple of knowledge meetings to start understanding what type of knowledge that should be captured and how to structure the knowledge according to what, why and how. The complete formulation of actions in a group also seems to take up too much time, which creates unwillingness, to contribute to the system. The attempt of the system is to reduce this unwillingness of contribution to knowledge reuse, not the opposite. Hence, it may be beneficial to utilize 20-30 minutes of the first knowledge meeting to simply educate the employees in the structure. The rest of the knowledge meeting can be used to formulate complete knowledge actions as well as the second workshop. As for the third workshop half of it can be used to formulate complete knowledge actions, whereas the other half is used only for generating action titles to be split up on the group members. For the next knowledge meeting the group members have then formulated the complete knowledge action, and that can be used as a baseline for the discussion. This setup will make the startup phase more effective, there is a better chance of getting the employees to participate throughout the discussions and avoid a slow and tiresome meeting.

Due to the fact that it is a little hard to understand how to thin-slice knowledge and structure it according to know what, know why and know how, introducing the concept to a new group may also require an experienced person. That person most likely needs to educate a knowledge system owner in order to generate crisp and specific knowledge rather than information. The knowledge system owner will also need to be outgoing and straightforward, to be able to keep the discussions going at times, but also challenge knowledge formulations when it is not crisp enough.

8 Conclusion

The purpose of this master thesis has been to investigate how knowledge should be handled in order to enable knowledge reuse. While conducting the research through an investigation including five large companies and a literature study, it was found that the knowledge reuse is many times a forgotten piece of knowledge management. Research is often focus on the means, processes or culture in which learnings are supposed be captured and stored. Four out of the five investigated companies fall into the same trap, not presenting a concrete process for retrieving and reusing the knowledge.

By revisiting the article of Maedche et al. (2015), and the answer to the first research question, "*What is required from a knowledge management system in order to enable knowledge reuse?*", the design principles of Maedche et al. (2015) are the most relevant current research has to offer. These design principles have been extremely useful for setting up the knowledge management system, preparing the knowledge, keeping it up to date and available. However, that is not enough for knowledge reuse to take place, there is also a need to incorporate knowledge reuse activities within the daily or weekly work tasks. Due to the fact that Maedche et al. (2015) lacks design principles for starting the process of reusing knowledge, a seventh design principle is proposed:

DP7: Provide employees with a concrete process to incorporate knowledge reuse with weekly work tasks during the complete project duration

The seventh design principle leads into the second research questions, *"How should a knowledge management system at the design engineering department at Volvo be designed in order to ensure knowledge reuse?"*, as it is the reason for the creation of the fourth phase of the designed knowledge management system, see Figure 19.

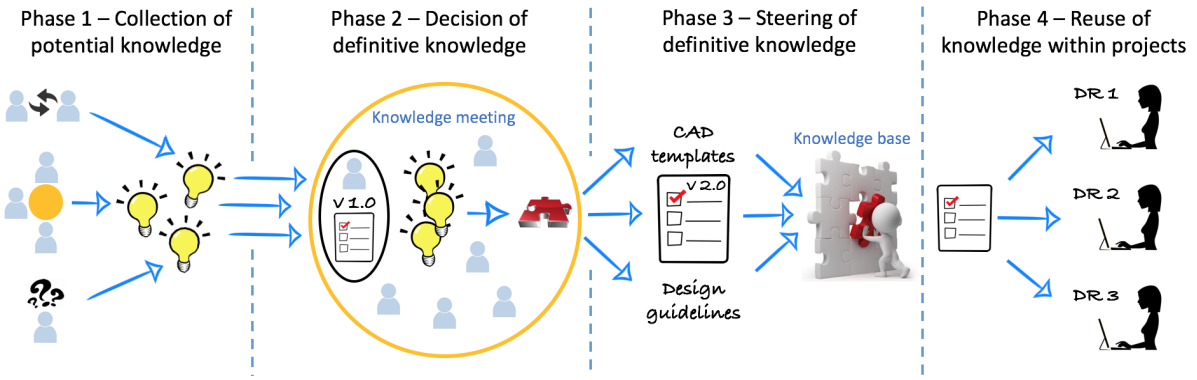

Figure 19 - The knowledge system.

Figure 19 is the conceptual visualization of the designed knowledge management system for Volvo. It is the result of three-way analysis, where three sources have been used as input: literature, benchmarking companies and the Volvo organization. The ideas from theory and benchmarking companies have been adapted in order to fit the organization at Volvo and thereby provide opportunities for knowledge reuse by translation of the design principles into

Volvo specifics (see Table 5) the role of knowledge system owner as an alteration of a knowledge owner. However, several parts of the system are also in line with what researchers conclude and benchmarking companies ideas. First of all, the structure of the knowledge is always the same and cannot be compromised. It is thin-sliced pieces of knowledge, avoiding an information overflow, that will always be structured according to know what, know why and know how. In addition, the process for reuse is setup to be incorporated into weekly work activities by including the currently used information systems at Volvo. The reuse is further supported within each project phase, where the employee generates a checklist for the specific component in a certain project phase. Thus, it is the continuous focus on reuse throughout this knowledge management system that will provide opportunities to make it work.

The answer to third and final research question, *"How can Checksheets be used to support the designed knowledge management system?",* include several interesting aspects. Firstly, Checksheets has the advantage of being able to provide the employee with the most important knowledge for each project phase and component. Secondly, it structures the knowledge, as mentioned, into know what know why and know how, which make the knowledge comprehensible, and instructional rather than educational. Thus, the employee will understand how to design a component or perform a work task and when it should be done. Thirdly, by utilizing current information systems as input and by connecting the software to steering documents, it has the opportunity to be incorporated into the weekly work tasks.

Relating back to the purpose once again, the system has the potential to provide Volvo with the support needed to enable knowledge reuse by making the knowledge accessible in thin-slices in a structured way. The first three phases of the system are valuable for keeping the knowledge up to date and available, which is also where other researchers and companies have focused their efforts. However, it is the fourth phase of the system that makes it unique and also serves as the main conclusion of this thesis. The fourth phase is the reuse part of the system. This part of the knowledge value chain should be in focus in any knowledge management system and knowledge should be handled in a concrete process evolving around that part of the chain, thus around knowledge reuse. That is how knowledge should be handled in order to prevent mistakes from being repeated.

9 Recommendations and Discussion

The recommendation for Volvo is to implement a knowledge management system as described in the previous chapter in order to enable for knowledge to be reused and mistakes from previous projects prevented. The actual implementation of such system is not within the scope of this thesis, however the designed knowledge management system entails a few implications for Volvo they need to consider.

The distinction between information and knowledge as well as the way to structure knowledge create a need for trainings of the employees responsible for rolling out the system. For the knowledge off-loading process with each new group, the responsible employees will need to be able to distinguish information from knowledge as well as be able to extract the knowledge from the engineers. Due to these two factors, it is also difficult to just let a new group access the software and believe that they can make it work themselves. The recommendation is to let educated employees moderate at least three workshops when starting up the knowledge management system with each a group.

Furthermore, there has been a large interest for knowledge management activities and many employees acknowledge the importance. However, there is a difference between expressing the importance of the work and to actually prioritize and contribute at knowledge management workshops. Therefore, it is considered to be important in the beginning, that line managers are brought on board to follow up on these activities and make sure employees prioritize it. The suggested way of enforcing that is to introduce the weekly 15-minute knowledge meetings as a part of the group meetings. Gradually, the frequency of these knowledge meetings can be adjusted according to how fast each group generates knowledge. As the knowledge management system starts to feed back benefits to the users, hopefully the employees will realize that it is worth to prioritize the knowledge management attended uncompelled.

Finally, in order to enable for a sufficient use of the designed knowledge management system and to be able to fully explore the benefits and potential drawbacks of the system, it needs to be broadly implemented on several interdependent groups at the R&D business unit at Volvo. It is also possible that the largest benefits of the system will show when upstream and downstream processes, thus when units outside of R&D, also have implemented the system with some minor adjustments. Therefore, it is recommended that a further testing of the system is conducted after scaling the system within the Volvo organization.

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Appendix 1 - Questions for exploratory interviews

1. What part of the product development process do you belong to?
2. Could you describe what the work tasks look like within this part of the product development process?
3. What other parts of the product development process do you work with or are in direct contact with?
4. What meetings for your group or department at Volvo are associated with knowledge management the most?
   Do you experience that learnings from previous projects are being used, if so when and how?
   a. Could you provide an example when this happened?
   b. Could you also provide an example of when a previous learning should have been used, but did not?

5. What do you think is the best way to manage learnings in order to be able to reuse them in future projects?
   What do you think is the best way to, during a project, retrieve knowledge from previous projects in order to be able to reuse it?

Appendix 2 - Questions for benchmarking interviews

1. What do your routines and processes look like for managing knowledge?
    a. How do you work with creating knowledge?
    b. How do you work with storing knowledge?
    c. How do you work with sharing knowledge?
    d. How do you work with reusing knowledge?

2. Which activities are included within each of these stages?
3. In what phases of the projects are these activities performed?
4. What information systems are used to support these activities?
5. Which responsibility roles are connected to these activities?
6. What are the difficulties with managing knowledge within your organization?
7. How do you ensure that the knowledge has been reused?
8. What feedback can you provide on our designed knowledge management system?

Appendix 3 - Interview questions for individual test of Checksheets

The software

1. What is your general impression of the software?
2. What do you believe will be the concrete benefits of using this software?
3. How did you perceive the search logic?
4. How did you perceive the interface?
5. What is your perception of creating a checklist?

The knowledge

6. How did you perceive the quality of the knowledge in Checksheets?
7. What new actions you would like to add to the knowledge base?
8. What actions would you like to revise within the knowledge base?
9. How do you experience structuring knowledge according to know what/why/how?

The knowledge management system

10. What would make you use this software within your daily work tasks?
11. What would make you want to contribute with new knowledge to Checksheets?
12. How would you like the setup for the knowledge meeting to be?
13. How can the use of Checksheets become a natural part of the Design reviews?