PROCESS-BASED KNOWLEDGE CREATION

A master thesis in the approach to control the chaos of knowledge in the AEC-knowledge-based-consultant companies, to gain increased competiveness.

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TITLE PAGE

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PREAMBLE

This thesis is a product of the last semester on the education (Danish title) - Cand. Scient. Techn. in building informatics (English title) Master of Science and Technology in building informatics from Aalborg University, and is created provide a foundation for companies to improve practices with process based knowledge sharing. The main objective for the thesis is how to make internal processes in a construction consulting company tangible for everyone, and how it is possible to utilize the processes as a base for knowledge sharing, analyzing and improving. The thesis focuses on analyzing company and employee needs for a new IT system that supports current practice. The new system will be expressed as a functional model, where a list of possible existing solutions is presented to increase the company's total quality. The context is mainly based on the cooperation with the architectural company C.F. Møller (CFM). And an agreement between CFM and the author has created a foundation that provides for a mutual gain of knowledge in the fields of study. The thesis will provide internal surveys that are a part of the Quality-manager Lars Christiansen's work. Due to being newly appointed as the new Quality-manager for CFM, surveys will provide insight on how the level of quality is conducted within the company, and related to the current work-practices. Because of this, the surveys will be used in the future work to improve quality in CFM. Besides the Danish case, the thesis will also compare data from the Thailand-based architectural company, Whitespace. This data will contribute international context of issues and ways to approaches that render the thesis outcome international viable.

Keywords

Whitespace Knowledge creation Nonaka C.F. Møller Yammer Contextual Design Groupware Tibbr LFA Enterprise Social Network BPMN Usability Process mapping Business Process Reengineering Chatter Complexity in construction Process Ramlink SECI model Johari Window Knowledge visualization IDEF0 Business vs. project processes Knowledge management Visio

The final output will be a master thesis, which will both give insight in existing processes in CFM and Whitespace, and give a suggestion of how to improve internal processes, based on a knowledge-sharing foundation in a groupware environment.

The Author of the thesis would like to thank the Architectural company C.F. Møller for invaluable context for the thesis, this would not have been possible without the commitment from the employees participating in the internet survey, the interviewees and especially Quality-manager Lars Christiansen for the help and day to day sparring, but also for allowing the author be to be located at their office in Aalborg. The author would also like to thank Whitespace Architects in Bangkok for taking their time to be interviewed and observed, and supplying the thesis with context and ideas. The author would also like to thank the consular from Aalborg University Kjeld Svidt for providing valuable feedback and knowledge to the thesis, and the interviewees from the other companies conducted. Thank you all.

C.F. Møller

Lars Christiansen
Helle Lehmann Staun
Klaus Algreen
Thomas Busk Bech
Niels Fuglsang Christensen
Christian M. Johansen
Geir Armann
Annie Winther

Whitespace

David J. Meyer
Ton Kmutt
Phil Almmanoj
Sutut Sakkhamjdhn

RAMBØLL

Tim Fynbo Johansen

AP

Jørgen Korsgaard
Jette Pardi
Thomas Herskind

nn5

Lars E. W. Jespersen

A. Enggaard A/S

Nils Frandsen

RESUME (DANISH)

Dette er et kandidat speciale, som er et produkt af det sidste semester på uddannelsen Cand. Scient. Techn. i Bygningsinformatik fra Aalborg Universitet. Den er lavet for at skabe et fundament for virksomheder til at forbedre deres praksis, med procesbaseret vidensdeling. Hovedmålet med specialet hvordan man gør interne processer hos rådgivningsvirksomheder forståelige for de ansatte, og hvordan det gør det muligt at bruge processer som basis for vidensdeling, analyse og forbedring. Specialet fokuserer på at analyserer virksomhedens og dets ansattes behov for et nyt IT system, der understøtter nuværende praksis. Det nye system vil blive udtrykt som en funktionel model, hvor en liste af mulige eksisterende løsninger bliver præsenteret til at forbedre virksomhedens totale kvalitet.

Konteksten er hovedsaligt baseret på samarbejdet med arkitekt virksomheden C.F. Møller (CFM). En aftale er lavet imellem CFM og forfatteren, som har skabt et fundament for gensidig gevinst af viden inden for specialets område. Kandidatspecialet står for interne undersøgelser, som er en del af chefen for kvalitet Lars Christiansens arbejde. Grundet hans ny udnævnelsen som chef for kvalitet for CFM, vil undersøgelserne skabe indsigt i hvordan niveauet af kvalitet bliver udført inden for virksomheden, og hvordan det er relateret til nuværende arbejdspraksis. På grund af dette, vil undersøgelsen blive brugt i fremtidigt arbejde med at forbedre kvaliteten hos CFM. Udover den danske case, vil specialet også sammenligne data fra den Thailand baseret arkitektvirksomhed, Whitespace. Dataene vil bidrage som en international kontekst af problemstillinger og måder på at gøre kandidat specialets udfald internationalt bæredygtigt.

Resultatet af dette bliver et kandidat speciale, der både vil give indsigt i eksisterende processer hos CFM og Whitespace, og give et forslag til hvordan man kan forbedre interne processer, baseret på vidensdelings fundament i et Groupware baseret miljø.

DEMARCATION

The thesis will focus on analyzing, developing and incorporating the process based knowledgebase in the co-operating company C.F. Møller, together with an ESN (Enterprise Social Network) to facilitate the process map.

The thesis target audiences are individuals from the construction industry in general, with interest of improving internal total quality. Though focusing on construction advisory businesses and their context, theories and where solutions would be applicable to other areas of the construction industry.

The final produce is not meant as company specific solution, but a general solution to consultant companies with similar traits in the construction business as the companies credited. With C.F. Møller and the Bangkok based architectural company Whitespace, both will form a context for developing an IT-solution, which can be applied not only to a Danish company, but an international.

The work will focus on internal processes in companies of two reasons. The main reason is that much work has been done addressing external process relations in the construction industry like BuildingSMARTs Information Delivery Manual (IDM) or American Institute of Architect's (AIA) Model Progression Specification (MPS) e.g. Their focus relies on the exchange of information between companies, rather than internal processes, which has been an area that has been a very little specific literature about.
The other reason is that much focus during the "new age of digitalization" has been put on the ideal futuristic solutions. Many solutions that are on the drawing board and currently being developed, and are only in the early stages and are not ready for fully implementation as of now, but will be a powerful tool and a future that could be 5-10 years from now. This thesis will strive for presenting solutions which is not a futuristic proposal, but operationally applicable within a much shorter timeframe.

The end product, is a process based knowledgebase and the ESN system, demarcate the general functionalities, due to the MUST method, the process will not strive to develop a completely new system, rather focusing on implementing existing systems, that contains the functionalities required. Development of a complete product of this kind will take more than a semester to complete for a project at this size and is not a possibility. Because of this the thesis is limited to define requirements, possible IT-solutions and how they could fit in the C.F. Møllers existing context.

READING MANUAL

The thesis is built according to the MUST method, to map the needs and context of which functionalities is required to effectuate the current business processes. Because of this the thesis is separated into six main chapters. From Preparation to Renewing chapter phases is drawn mainly from the MUST method, with utilization of Contextual Design tools, which will be explained at the preparation chapter.

Introduction
Presenting the thesis and other relevant information for the reader.

Preparation
Creating the level of ambition, comparing it with available resources. It also narrows down the task that the preliminary report must solve, and what not to solve. It plans and organizes the course of the project, and creates the foundation for further analysis.

Focus
Creating coherency between the preliminary surveys goal and the companies business and IT-strategies. Identifies C.F. Møllers general strategy, situation, context and IT / business-plan.

Depth-analysis
Focusing on work-related practice in designated domains. Documenting the workflows and general practice, modeling the gathered information in to models for further analysis and defining the problem, based on the context provided from this phase.

Renewing
Generating visions on how the IT-systems could function and how they collaborates with the organization. Is a study of what functions are needed to counter the problem defined in the former phase. The functionalities needed, will be described with the according theory that will support the choice of function requirement.
The requirements will then be consolidated and compared through the existing solutions to help choose the best IT-solution based on the needs, hence theories. How the functionalities could work in the current work-practice will be described through a sketch storyboard.

Conclusion
In this chapter the thesis will be concluded how it is possible to counter the problematized issues presented in the Introduction chapter through the MUST method.

References
The references are made with brackets according to the Harvard Method. In the last part of the thesis, a bibliography will summarize the utilized references.

Thesis glossary
The thesis will contain a dictionary, that will explain most of the used technical terms and abbreviations used.

Citations / Quotations
Through the thesis citations have been used from other works and collected empirical material like interviews and observation. The indication of used citation is shown through italic text marked with quotation marks

CONTENTS

Chapter 2 INTRODUCTION

This thesis is built on the argument that the global recession has increased the importance of competitiveness in the construction business. Not because that competition not has been tough before the crisis, but because the crisis has made the amounts of contracts in the AEC industry smaller, hence the importance to be a lean and fit company with a high degree of competitiveness, in order to survive and to keep a healthy profit margin. This section will document and argue that the crisis is especially affecting the construction business consultants industry like architects and engineers. This will be part of the basis for the initiating problem definition.
An article at Building Design and Construction Network deemed the trends after the financial crisis as the following (http://www.bdcnetwork.com/zweigwhites-2009-aec-industry-outlook-strategy-and-insight-design-construction-firms):

- **Recession**
  Project-owners plan for growth has in many cases been put to a hold, or postponed, and it is increasingly difficult to borrow money for new projects. Buildings are left unoccupied due to many companies' bankruptcy or layoffs which reduce the need for new construction.

- **Residential real estate downturn**
  In the years before 2008 the real-estate marked in the USA has boomed, but the economical crash and mortgage credit crisis reduced the demand for housing projects. This results in less need for infrastructure projects and commercial constructions to support the housing market. Another factor is the reduction of tax revenue on houses shrinks the governmental budget for new construction.

- **Stalled merger and acquisition activity**
  Pre 2008 a strong stock marked provided many companies with capital to invest in construction projects, but post 2008 the stock markets crashed and left them less money for investment. Companies still battles with slow inclining prognosis and belief in future marked makes them hesitant to invest.

- **A changing labor market and labor expenses**
  Laborer expenses are leveling of due to crisis and unemployment rates. But is still relatively high compared to the crisis. Because of that much work will go to countries with lower wages and competent employees, regardless the location.

In Europe the construction business was also affected by the prime mortgage sub-crisis in United States in 2008, which started the global economic and financial crisis. In 2008 the economic growth dropped into recession with minus 1 % (Percentage point) in the Euro zone, from a growth of approx. 3 % (PP) growth in 2007. The construction business experienced a slowdown in growth of 0,2 % in 2008. This was a result of several factors including credit conditions, financing difficulties, fewer contracts due to lack of confidence in future market e.g. The crisis influence on the construction business was delayed by overlap of cold weather in the winter of 2008 – 2009 and the first effects was felt in early 2009.

A general trend in the European Union (EU) is the number of construction permits. In Denmark construction permits decreased from 24.000 in 2007 to 14.000 in 2009 paints a similar picture throughout the EU. Both the government and private clients do not have financial capacity and vision to initiate new construction. The main area work in the construction business conducted today, is focused on refurbishment of old buildings, energy-renovating and civil-engineering. (Nyt fra danmarks statestik, Nr. 402, 9. august 2012, Nistirescu, Ploscaru, 2010)

BANKRUPTCY

In a time where the financial crisis has brought several companies in the construction business to bankruptcy, it is now a big part of many companies strategy, to stay trimmed and efficient in order to compete in an increasingly competitive business, in order to survive.
Sadly the construction business around the world is still struggling, and figures show that the numbers of bankruptcy in the Danish sector is still very high (Figure 1), compared to the previous years. The figure shows a tendency that is supported by the falling number of "begun construction of square meterage". To ensure that the company is safe from the treat of bankruptcy it is important to ensure a high level of productivity internally in the company, to stay competitive (Nistirescu, Ploscaru, 2010)

Figure 1: http://www.danskbyggeri.dk/presse+-c12-+politik/presse+-c12-+politik/nyheder/nyheder?docID=25893

PRODUCTIVITY

Figure 2 shows the labor productivity from the mid-sixties to after the millennium. The figure measures the contract dollar work per hourly work hour.

It is clearly seen that construction productivity is falling compared to the non-farm branch. In average the construction business has declined by 0,59 % in productivity each year, compared to the growth of the non-farms 1,77 % yearly. (http://www.aecbytes.com/viewpoint/2004/issue_4.html)

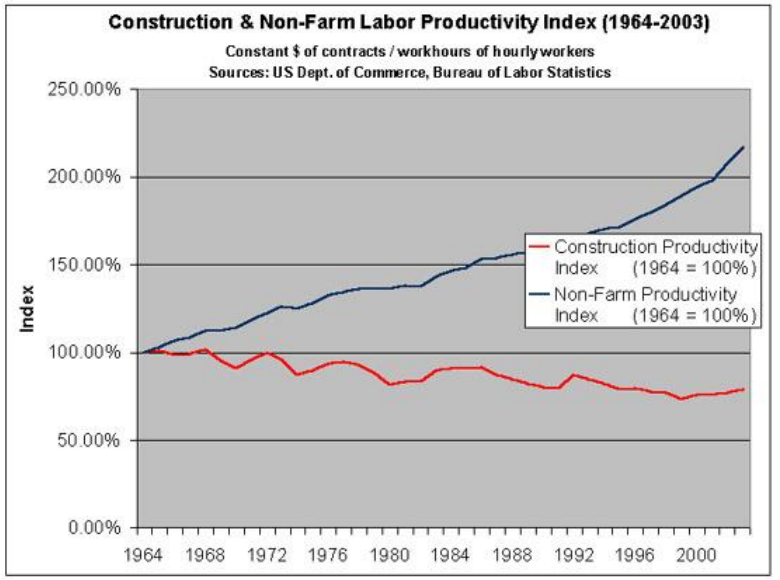


Figure 2: http://www.aecbytes.com/viewpoint/2004/issue4-images/fig1.jpg

Stay Competitive and trim business

With the US AEC (Architecture, Engineering and Construction) company leaders, rating the second most important issue "the need to stay competitive, to survive" after the performance of US economy. The most popular way to stay competitive was to trim down the companies. This was by reducing bonus payments, freezing salaries, laying staff off, cutting back IT expenditures e.g. (Howley, 2010)

Productivity for consultant firms in the construction industry

Comparing Denmark with other European countries, general productivity is among the highest, but when adjusted to the prices on materials the productivity is ranked in the middle. (Produktivitetsniveauet i dansk og europæisk byggeri, Erhvervs- og Byggestyrelsen 2009)

The consultants (Engineers and architects), profits are low compared to other businesses in the industry. Measured profits pr. year-work, only painting, glazing and electrical business is less efficient of generating profits (Kan byggevirksomhederne tjenepenge? Erhvervs- og Byggestyrelsen 2010). The construction business has difficulties when it comes to gaining profits, while the general non-farm companies development have increased its productivity. In a Danish context the productivity in general is ranking average. The construction consultants in Denmark is struggling with decreasing productivity, and the consultants are ranking low in productivity compared to other businesses in the construction industry.

As a conclusion of this, the European market is immensely affected of the global economic and financial crisis. The industry is affected by a high rate of bankruptcies. The consultants also struggle with low productivity, where compared with the other branches in the AEC business, has better productivity. The construction consultant companies need to adapt for a reality where less work is tendered, and in order for the company to survive, the company needs to be in front when it comes to productivity.

INITIATING PROBLEM DEFINITION

TOTAL QUALITY- THE NOTION WHICH THE PROBLEM DEFINITION IS BASED ON.

With the need to increase competition for the construction consultants, described in the introduction, is it important to identity how it is possible to do so. As written in the introduction, the construction consultants have problems with productivity, lack of contracts and an uncertain future, dominated by a grim forecast. As a respond to this it is significant for the company to increase its ability to compete with others. One way of staying ahead in competition can be summed up by increasing the internal and external "efficiency" This notion is based on two conditions that has to be met to ensure highest total "efficiency". (Bejder 1989)

This figure shows that if your company execute their activities satisfactory, according to the specifications defined by the client they will acquire external "efficiency". This is also known as the quality of a product. The internal efficiency is based on the amount of internal resources utilized to create the specifications. The level of internal efficiency is defined in how much specification it is possible to acquire from the used resources. By increasing the total efficiency it is possible to reach higher productivity due to inner efficiency and win contracts due to outer efficacy, thus increasing business competition. This notion will be used in the thesis to define how to increase a company's ability to increase its competitiveness.

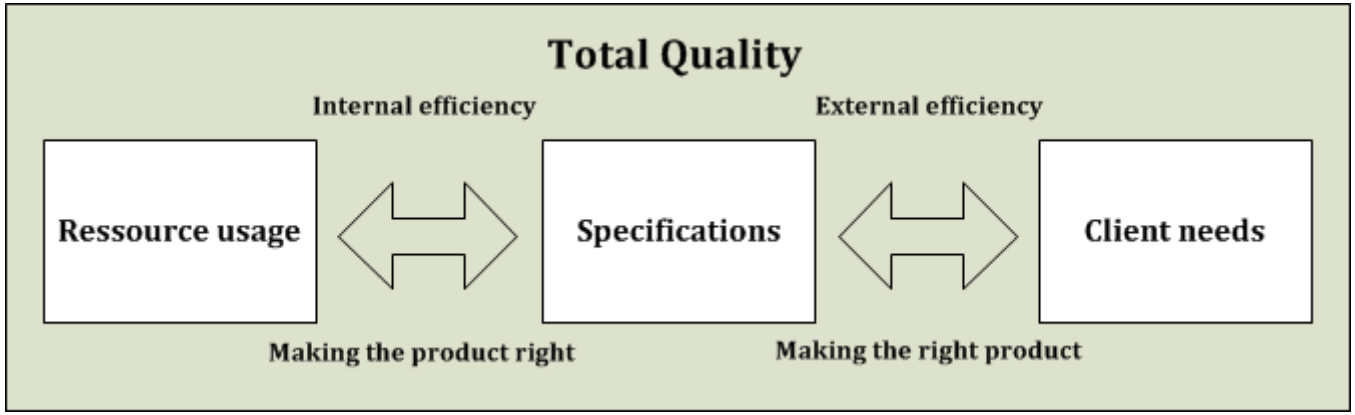


Figure 3: Total efficiency (Author, 2013)

INITIAL PROBLEM DEFINITION

The author finished his studies at University College Nordjylland with a Professional Bachelor Education in Architectural Technology and Construction Management, was working at a local architectural firm. During this work he realized how different people did their work, and how much quality and efficiency could fluctuate. Often people would invent their own solutions which resulted in large amounts of work that would be repeated without adding any value to actual work, this is a broadly accepted mistake in the construction business and it has been claimed that construction project processes usually present non-routine features that do not easily lend themselves to systematic repetition. (Gann and Salter, 2000) When it came to quality assurance, the same problem occurred. The company did not have any plan for this, resulting in different ways of assuring quality from employee to employee, and from case to case based on the individual notion of importance. With many factors like this to determine how quality was done, difference in methods and level of quality would be very different.

These conceptions were applicable to many other facets of the work done at the company. For a company to stay ahead of its competitors, the incentive to ensure the maximum level of total quality throughout the company is crucial. In order to counter this issue three notions of how to increase the inner and outer quality by how knowledge is flows and works in a company, and how to ensure that the knowledge which the company derives from, supports this. This was the base for witch the author did three notions and hypothesis on internal work processes.

1. **Knowledge structure - Lack of general process standard**
   For employees it is often awe-inspiring to begin working at a new company. Rarely employees are presented to a manual in how work is done internally, and if anything were written down, it would either be very comprehensive or very scarce. Due to the new work culture and processes, an employee in the construction consultant companies has a learning curve that is relatively steep. How would it be possible to contribute with a standard that is dynamic enough for the construction business, yet precise enough to give the employee a standard to work form, and contribute to the project with his or her area of unique knowledge?

2. **Acquiring knowledge - Time consuming process to get knowledge**
   Every building is unique. Different materials, context and design are often the traits of modern buildings. Combined with legislative requirements, change in clients e.g. the amount of knowledge concerning a construction process vast. Not a single person is capable of containing such knowledge, and due to the lack of a knowledge base that could help finding this information, it is a time consuming process to find and select the right knowledge at the right time. How would it possible to make it efficient to gain knowledge on a minimal use of time?

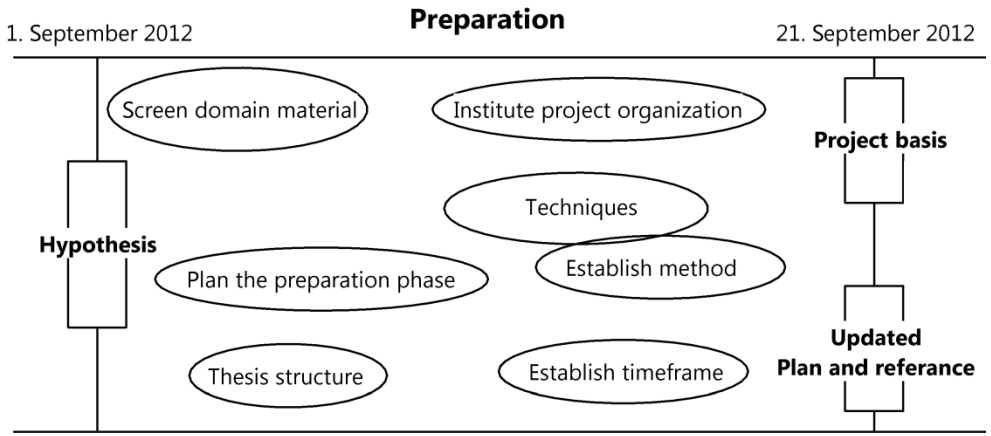
3. **Representation of knowledge - Available knowledge is intangible**
   It is possible to find knowledge about company processes. Sometimes company processes are described in ISO (International Organization for Standardization) standards, or a company's own homemade handbook. Reading through long manuals of process to find information or knowledge about a small sub-process in a comprehensive manual is a time consuming action, without gaining much value in profit-wise activities. Another factor is that acquiring knowledge can be time consuming and non-value added, reading about processes are very ineffective method of gaining knowledge. You only remember 10 percent of what you read, 20 percent of what you hear, 30 percent of what you see, 50 percent of what you see and hear, 70 percent of what you say, and 90 percent of what you do and say (Metcalf, T. (1997).

These three notions are interrelated in several ways, and are all based on how difficult it is to gain an overview in the construction process. It is now necessary comprehend a wide range of sub-domains in the industry. Ever-changing building-codes, technologies, materials e.g. It is from this that the beginning of the thesis will be built upon. And these three hypotheses will be verified in cooperation with the companies to gain further insight in the problem domains, to either confirm or invalidate the three notions. The result of this will be summed up at the end of the depth analysis, in the section called problem definition.

Chapter 3 PREPARATION

The setting for this thesis, as described in the reading manual it is built on the MUST methodology. What is included in preparation will be described in detail, in further down in the section.

This chapter focuses on defining the framework and motivation for the preliminary survey. This will define the level of ambition and how the organization will be structured. A method will be defined and the techniques that will suit the thesis, and clarify what activities will be utilized. It will give a foundation on the companies that will participate in the thesis, and what tools and methods are deemed right for the further analysis of the company. In a real world scenario, where economy, resources would be a critical factor, it would be decided in what would be invested in this survey. But since that this is a thesis, and has other characteristics, work is done in relation to two limitations. The first limitation is the resources. The thesis is created by the author, which do not have any budget, or similar to utilize. The other limitation is the timeframe, which has been defined by Aalborg University. In a "real life" MUST process, other factors like economy e.g. would be crucial for the thesis, but as explained is not in the particular case. The figure below, called Planning and reference-line planner present the themes conducted in the chapter according to the must method. This will explain the themes at the beginning of each MUST phase. MUST will be explained further, down in the preparation chapter.



ORGANIZATION

According to MUST, a project organization must be established. But because this is a thesis rather than paid preliminary report, done with the sole purpose creating such a report, the organization is founded upon the thesis project context. Because it has the characteristics of a thesis, the project organization does not act with the responsibilities of normal organization. This means that the participating companies and individuals will supply the thesis with context for analysis to create a possible IT-solution, but does not have any causal obligations for each other.

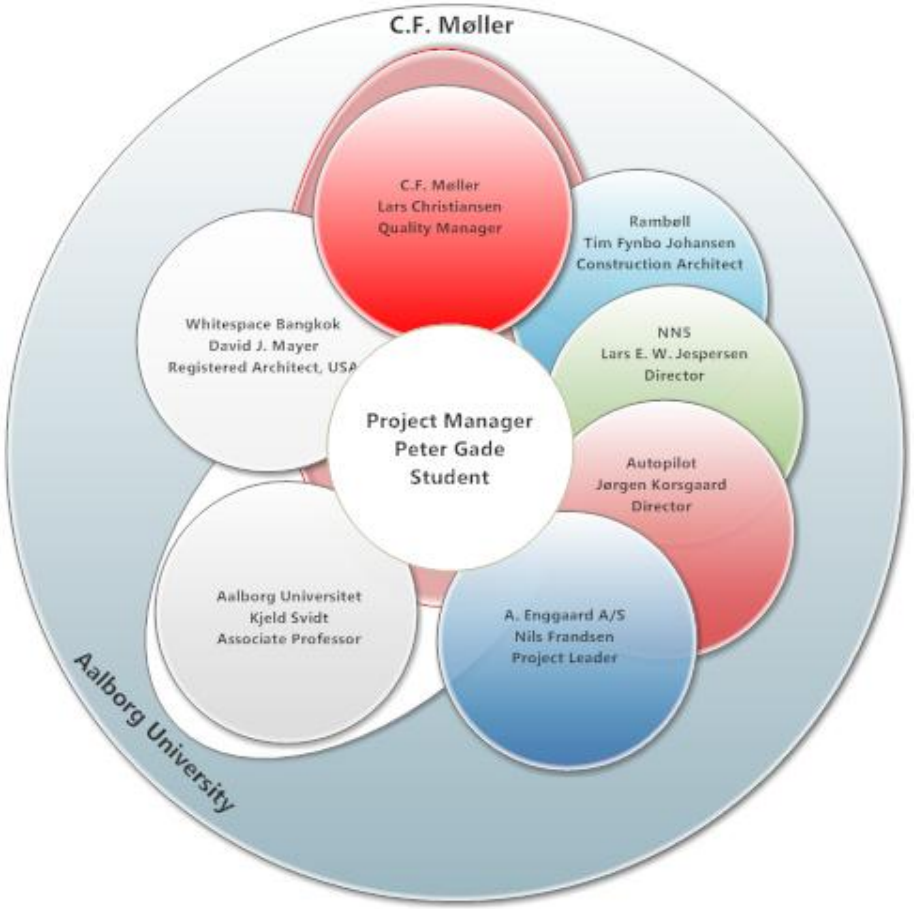


Figure 4: The thesis organization (Author, 2013)

The main relation is between Aalborg University and the Project Manager, known as the author of this thesis. The reason for this is that the Project Manager is a student at Aalborg University, under the curriculum, academic and general organization of AAU. This assembly will be referred to as the thesis group.

The primary thesis case is C.F. Møller Architects (CFM), and the foremost project context will originate from this company. Quality Manager Lars Christiansen is the main contact from CFM and is involved in the work to improve general quality at CFM.

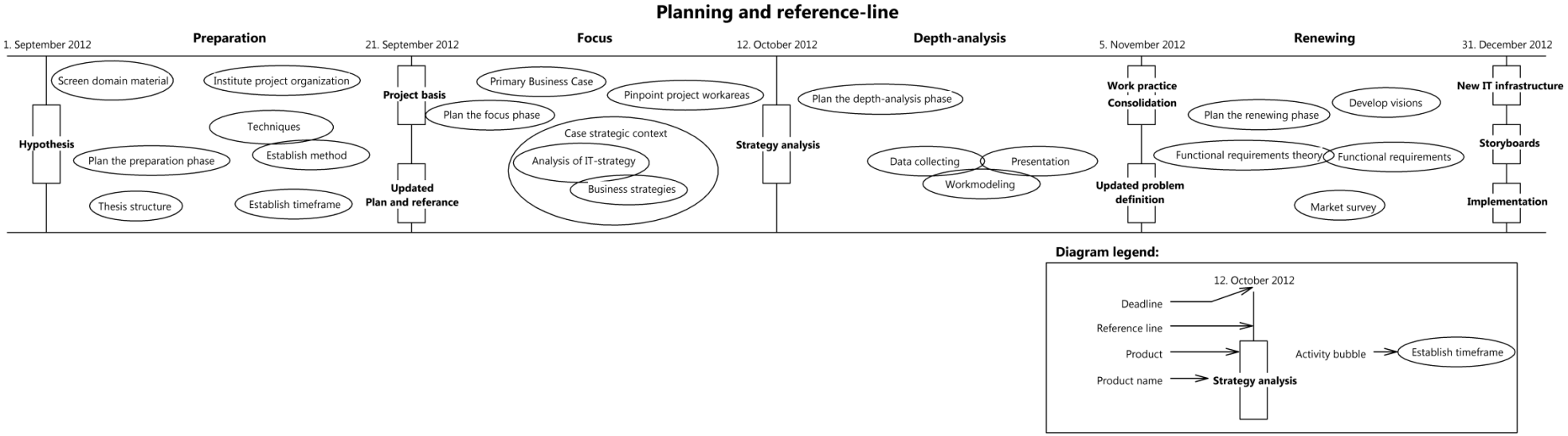
In order to make the thesis applicable to companies beyond Denmark, the Thailand-based architectural company; Whitespace is included into the thesis context. This idea of including a different company is to demonstrate the possibility to apply the same results from this thesis to similar cases as both the primary and secondary company. The secondary case company will supply with experiences, and context that will help shed light on how the issues in the Danish industry are struggling against.

The other companies listed Rambøll, NN5, Autopilot, A. Enggaard A/S will help support the thesis in the manners of the current processes and IT, and experiences.

PLANNING AND REFERENCE-LINE PLANNER

As a sequential organizer, named “Planning and reference-line” technique, it schedules the project workflow. It gives the opportunity to rate progress, and keep track on internal tasks. The technique maps products, activities, criteria’s and rating of products together with procedures for rating. This will give the project group an overview of the activities needed to create the sub-products. These activities and products are paired with dates which give the project group deadlines at the reference lines. The activities are meant as themes rather than headlines or similar. It can also help the reader to gain an overview on the general process.

This complete workflow is the process for the thesis from the beginning to the finished report.



METHOD

This is a thesis, and the structure referred to as the hourglass structure will be the main component. The thesis focuses on analyzing company and employee needs for a new IT system that supports current activities, and eventually defines functions needed to support current processes to make them more effective. This is the why this method will be user driven. Many theories has been created to support such a process, and the main method for user-driven design in this thesis, is the MUST Method. MUST (Da.:Metode til forUndersøgelse I Systemudvikling og Teori herom En.: Method for preliminary survey in system development and theory) –method. It is a method of preliminary investigation that maps context in strategy, needs e.g. throughout the company, resulting in a foundation for decisions for acquiring existing IT products, or development of new.

Another method called Contextual Design (CD) is employed, to supply the MUST method with tools to map company context. The reason for using CD with MUST, lies in the differences of the two methods. In some areas related to the theme of the thesis, tools and approaches from CD can be employed. These concrete tools will be described in the chapter of usage.

CD and MUST both is based on user-driven design, but differs in the approach, concerning detailing levels during the phases e.g.

One particular point where the method works different is the view on procurement. CD focuses on a IT-project designed from scratch, where MUSTs idea is that after the preliminary survey, work will be outsourced to a supplier if any solutions can be created on the open markets and fits the requirements e.g. Because of this it is not as necessary to describe the system in too much detail, as in Contextual Design. (Bødtker, Kensing, Simonsen 2008)

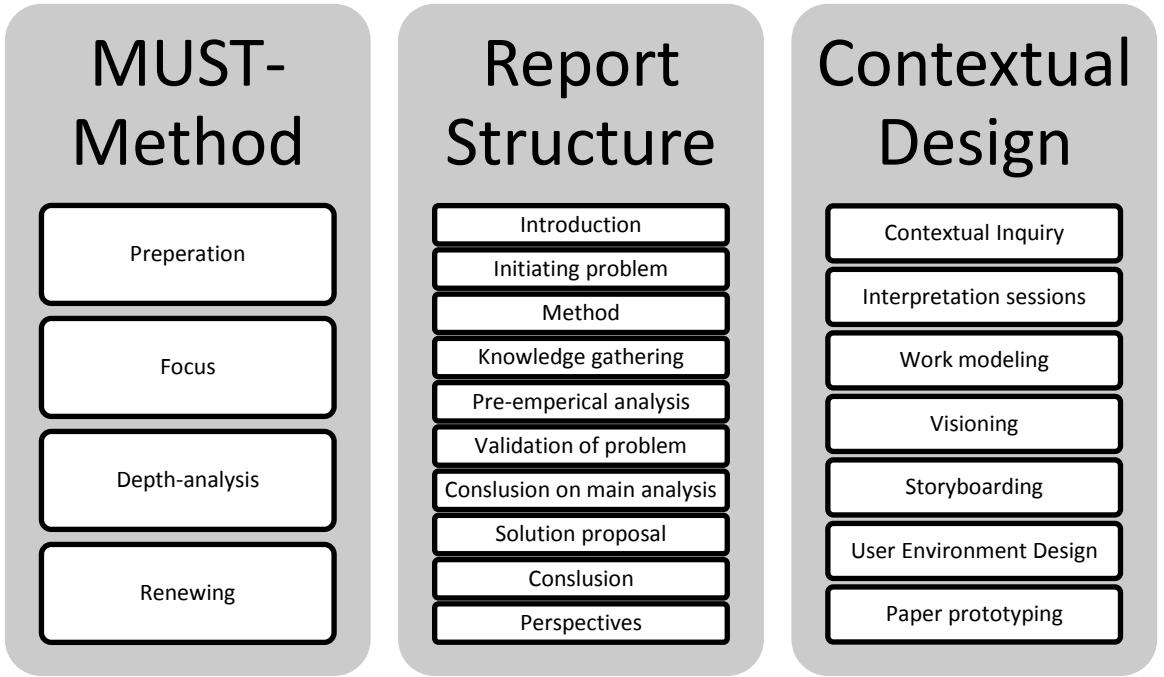


Figure 5: Showing the methods separated steps (Author, 2013)

Still the CD method has elements that can contribute to the MUST method, like diagrams and work-methods, not found in MUST. These two user-driven methods form the general method and are combined into the report structure. This will form the basis of the methodology for the thesis.

MUST METHOD

The MUST method was developed as a result of failed and delayed IT-projects in Denmark, and is based on research cooperation between the writers and Danish / USA-based companies. MUST is built on a Scandinavian approach to usability design, and the main principle of MUST is to form a basis for decision-making, when to either choose to develop or buy a new IT-system. It is meant as a resource that can support the design and execution of a preliminary survey. The method is a general approach rather than a specific step-by-step guide. The method is based on conceptual frames and techniques that clarify conditions that must be met to design IT-systems.

The method is split into four phases:

- **Preparation**
  Creating the level of ambition comparing it with available resources. It also narrows down the task that the preliminary report must solve, and what not to solve. It plans and organizes the course of the project, and creates the foundation for further analysis.

- **Focus**
  Creating coherency between the preliminary surveys goal and the companies business and it-strategies.
  Identifies the company's general strategy, situation, context and IT / business-plan.

- **Depth-analysis**
  Focusing on work-related practice in designated domains. Documenting the workflows and general practice.

- **Renewing**
  Generating visions on how the IT-systems could function and how it collaborates with the organization.

More details about MUST Methods, will be presented at point of usage, throughout the thesis report.

CONTEXTUAL DESIGN (CD)

This thesis has employed the concepts of contextual design, based on the work of Karen Holtzblatt and Hugh R. Beyer. CD focuses on a user-centered design process, that help the designer to collect, interpret and consolidate data in a structured way, and then use the collected data to make a prototype and testing the prototype with users. The method has primarily been used for designing IT systems, but has widely been used as a method for usability designing in general. CDs main objective is to make system design support and extend users practice. The methodology is based on science from anthropology, psychology and design. The design process is parted into two major phases:

Requirements & Solutions

- Contextual Inquiry: Gains contextual understanding of the customers in the field
- Interpretation Session: Interpretation of the data collected, to capture key issues.
- Work Models and Affinity Diagramming: Consolidate the data gathered from the costumers for a broad marked view.
- Visioning: Redesign how people work with the new technological ideas.

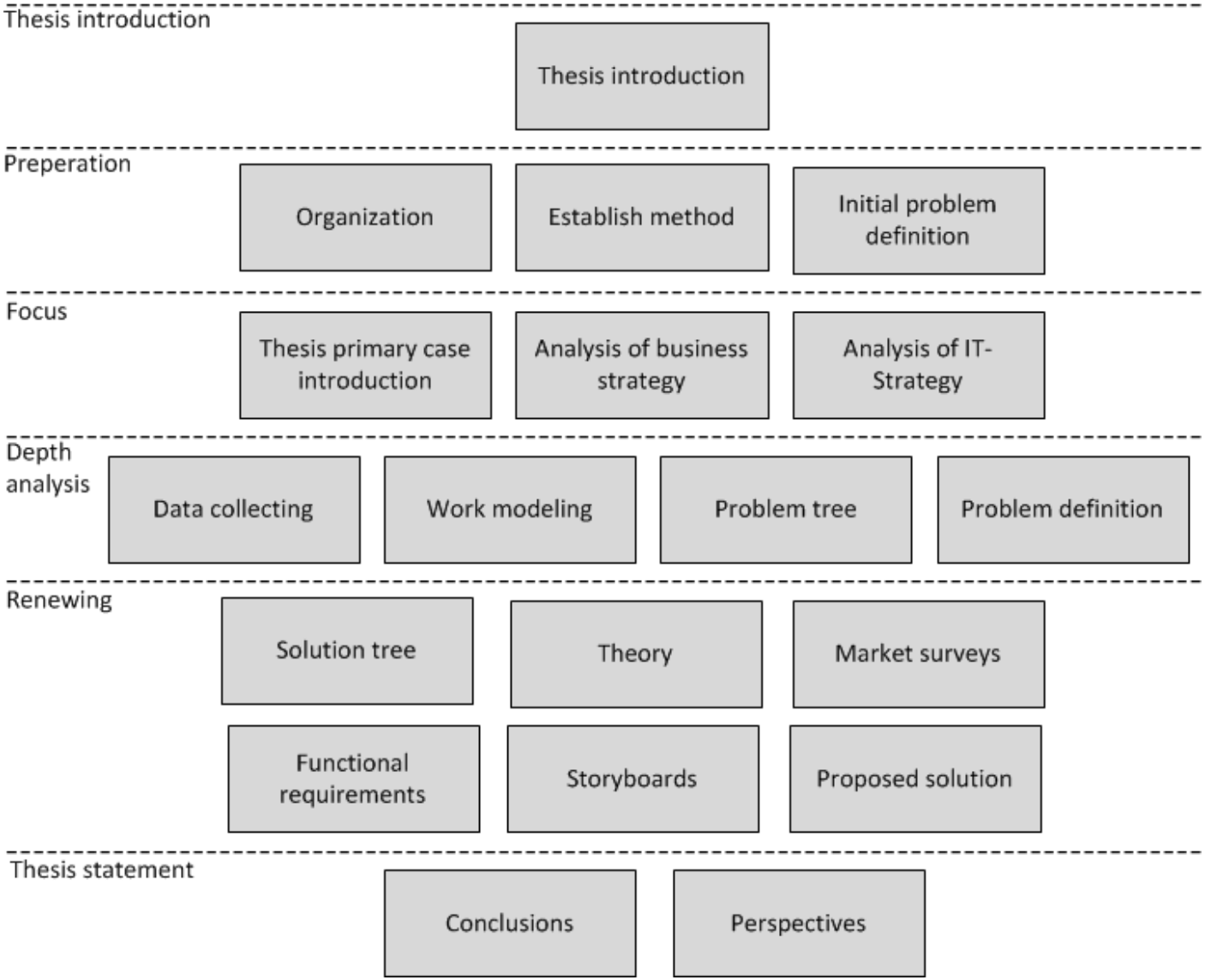
Highlights: What matters to the user, characterizing what they do.

Define & Validate Concepts

- Storyboarding: Works out detail about the new tasks and roles
- User Environment Design: Designs the system to support the new work-practice
- Paper Mock-Up Interviews: Mocks up the interface using interaction patterns for testing
- Interaction & Visual Design: Designing and testing the final look and user experience

Highlights: Redesign activities and technology to provide value and iterating the system with the users. (Beyer Holtzblatt, 1998)

THESIS STRUCTURE



TECHNIQUES

This section describes the techniques utilized on how to collect data about the users existing work-practices, new it-usage and technological possibilities. This is based on two kinds of knowledge, the abstract and the concrete. Figure 6: Shows the six areas of knowledge in the report. (MUST Method) and displays the different domains of knowledge needed to get the context of the case. Each area will get a method(s), to collect and describe the knowledge using techniques from either the MUST method or Contextual Design. The thesis look to achieve all six areas of knowledge about the context.

	Users existing work-practice	New it-usage	Technological possibilities
Abstract knowledge	A. Relevant description of users existing work practice.	B. Visions and design proposals	C. Overview of technological possibilities
Concrete knowledge	D. Concrete experiences with the users existing work-practices	E. Concrete experiences with new usage of IT.	F. Concrete experiences with technological possibilities

Figure 6: Shows the six areas of knowledge in the report. (MUST Method)

With the focus on gaining the necessary knowledge to design a system, which facilitates user needs and demands all of these variations of knowledge is needed. Because of this, each technique utilized in this thesis report, will be described. The headline tells the name of the technique, what theory it is from and in what knowledge domain it is relevant to utilize it.

SURVEYS (MUST) A

This survey type is based on a representative sampling among people of interest to the subject. The survey is a method for a company to get an instant picture of a general situation about a certain topic. (Hansen, Andersen 2009) Data collection will use two methods for analysis.

Self-Enumeration

This method will enable the respondent to answer the questionnaire without assistance and influence of an interviewer. This method requires a well-structured "easy-to-follow" questionnaire with easy instructions for the respondent, but has the advantage of being easy to administer. Response rate averages 70 % or less.

Computer-Assisted Data Collection

The survey that is required in this thesis is going to be surveying respondents across offices in Denmark. Because of this the most effective approach for data collection to map general trends in the company is the computer-assisted data collection. The advantage of this method is the flexibility and convenience of the functionality to both collection and capturing data is combined, with result in a faster and more efficient process. This method has few disadvantages, which includes that the respondent must be comfortable which the internet, and the percentage

of active participating in the computer-assisted data collection survey's respondents are generally lower than personal interviews. (Fellegi 2003)

PERSONAL INTERVIEWS / CONTEXTUAL INQUIRY INTERVIEWS (MUST / CD) A / B / C / D / E / F

With this method the normal procedure is to conduct it face-to-face. As described in MUST-methodology it is an in-site qualitative interview which means that the interview will be conducted at the interviewed respondent's workplace. (Bødtker, Kensing, Simonsen 2008) This will enable the interviewee to show work related tools like papers, systems, computers e.g.
The form of interviews has the highest rate of response 80-95 % but is more time-consuming due to the face to face session, transport e.g. (Fellegi 2003)

The personal interview is intended to get an increased understanding of how the informant executes his work. What is it about, why is it executed e.g. to understand the respondent work practice, goal and function. How the respondent executes his work gives an understanding of what is working the existing work-processes and what problems occur. It can also be used to separate tasks in groups and groups of tasks into work functions. It also a tool for a gaining an understanding of what work functions is done and what future functions could be executed and be supported by an IT-system. The interview will be held 1-on-1 in the field (Holtzblatt, Wendell, Wood, 2005)

The interview will be described as a summary and added to affinity diagramming. The interview can be applied to assess all knowledge domains according to Figure 6.

Table 1: Interviewer-Assisted versus Self-Enumeration Data Collection Methods

	Self-Enumeration	Interviewer-Assisted	
		Personal	Telephone
Cost	Low	High	Medium
Time	Longer	Average	Shorter
Response Rate	Low	High	Medium-high

Figure 1: (Fellegi 2003): compares personal interviews, telephone interviews and self-enumeration data collection methods with respect to cost, time to complete data collection and response rates.

VIDEOCONFERENCING (MUST / CD) A / B / C / D / E / F

This technology allows an interview to be conducted semi in-situ due to the dimensions of both sound and picture. It is about communication between two or more locations where simultaneous or synchronous two way video and audio is transmitted. It reduces the need for people to be located the same place, and can be a time effective technique to collaborate. (Mulbach, 1995)

DOCUMENT ANALYSIS (MUST) A / C

This is an analysis of reading through relevant documents and make notes about relevant information. With the document analysis, during the differing phases according to MUST Method, documents of interest in the preparation phase could be descriptions of the company, or at the focus phase it could be strategies that can support further surveys. In the depth analysis phase it would be descriptions of work practices, handbooks, e.g. This part of the MUST methodology, is not a written part section, but has been utilized throughout the thesis.

FUNCTION ANALYSIS (MUST) A / C

During the focus phase or the visioning phase it can be relevant to explore what work-related functions the employees execute. It has no direct relation with the IT-system, but is a way to clarify what potential an investment can have, and define goals, needs, demands and conditions herby. This analysis can support the other activities in the focus phase like the analysis of documents, strategies e.g.

This system will be related to the outside world. The technique is useful in situations where it is necessary to work out correlations between environment, business strategy, business processes, areas of work and it systems. The analysis is characterized as:

- **Adaptive**
  The analysis assumes that the environment is stable, and the company tries to adapt to new and changed demands from the environment.

- **Rational**
  Assumes that the company can be views as a goal-oriented work-system that has a function in relation to the environment.

- **Expert-oriented**
  The analysis will be based on the IT-designer to fulfill the analysis on the basis of interviews, document analysis, and describes the results in the same terminologies as the surveyed environment (Bødtker, Kensing, Simonsen 2008)

OBSERVATION (MUST) D / E / F

Is a central technique to gain an insight into the current work-practice, technological possibilities and proposals for a new system. Through observation it is possible to study how concrete work-practice is executed or how work is coordinated between employees, and how patterns of cooperation are playing out in the company.. After interviewing the employees, it is possible to confirm, or disconfirm how they actual execute processes.

Regarding many other techniques, but especially observation, the case of say/do is an important notion. When using different methods to get knowledge about work processes, the thesis report will counter the say/do syndrome. In some cases employees will say how they preform processes, but under observation do something else. The counter this, the thesis will utilize a combination of techniques of both do and say character. Often employees will tell you what is expected of them rather than what actually is done. This is important to notice that why it maybe can be a bad idea to follow company expectations on work-practice, and why employees are doing it differently. In other cases why employees do differently than they explained, can be because of they are not able to explain their work processes. Sometimes work is incorporated into people, that they do not notice what they are doing, or do not put any emphasize on a certain task, even if it is a critical one. It is important not to interfere in the observation process, and stay neutral and observant.

COMPANY VISIT (MUST) C / F

In the renewing phase, visiting a company to gain insight in new technological possibilities, and gain a opportunity to get experience in the new work-practices. The technique makes it possible to experience a technological system in complete realistic environment, how it is used and even try out the system. It gives an idea of what qualifications and organizational needs that would be required to implement such a system.

Because of this, the contextual inquiry will often be based on observation, where the interviewer will subtly observe the slightest actions of the user. The interviewer inquiries into the world of the user, hence the name contextual inquiry. This phase will be incorporated into the focus section, utilizing tools from CD.

INTERPRETATION SESSIONS (CD) A / D

In the interpretation sessions a team of mixed specialists start interpretation the data from the contextual inquiry, then learning the relevant problems countered by the user. Each specialist from the team, will contribute with his knowledge and sight on each issue, making the interpretation nuanced and highlights the possible implications business, design, marketing-wise. This is forming the base for the shared understanding of the users world.

WORK MODELING (CD) A / D

Because of the complex nature on how users work, it is very essential, how you measure and map the processes. There are many ways of modeling the work, and there are no definitive ways of doing so. Some methods are more suitable for a specific kind of work, than others.

Often the design team do not have the skill or insight required to the work-structure done by the users, by looking past the apparent processes. It is important to look past the obvious actions, and into the underlying intents and workflows. CD has five ways of portrayal the work, in this thesis, will be utilized.

- **The sequence model**
  Models each detailed step that is required to accomplish a task. It shows the strategy, intent, goals and most important the breakdown that happens to the user during the sequence. The model is designed to visualize problems that the user experience during a work-practice.

- **Flow model**
  Shows the communication between users, on how they do work activities. This shows how both formal and informal groups interact, and how work is divided into formal and informal roles and responsibilities.

This will enable the user to interact with the design, and make it possible for the designer to get valuable feedback. The tests and observations will happen at their workplace, making the scenario as realistic as possible, with realistic events. In the way, the testing will ensure that the design will iterate around the vision of user-centered design, ensuring that the needs and problems will be taken care of, by designing the User Environment for the user, and creating a stabile platform for future workflows and further designing, and concludes the contextual design.

Problem & Solution Tree (Logical Framework Approach, LFA) D

As a base tool for analyzing the problem according to LFA, this can help identifying the "root cause", and not only the symptoms. The problems get arranged into a "problem tree" which sorts the problems in three categories. Cause, Focal Problem and Effects. The problem then gets sorted out in a hierarchical order, from the bottom up, first connecting the causes for the focal problem, which leads to the effects of the focal problem Figure 8: Concept of problem tree (Delevic, 2011 p. 18). The context for the content is based on the data collection that is conducted according to MUST.

To analyze the objectives that are needed to solve the problem, the objective or solution tree can help this process. It helps formulate what objectives needed to counter the problems defined in the problem tree, and connects means-end relationship in the diagram, and hierarchy of objectives. The negative situations are converted to solutions and are transformed into positive achievements, these achievements are the objectives, and are visualized in the objective tree as a means to an end. This helps strengthen the project objectives in accordance by addressing the clearly identified problems in the problem tree. (Delevic, 2011)

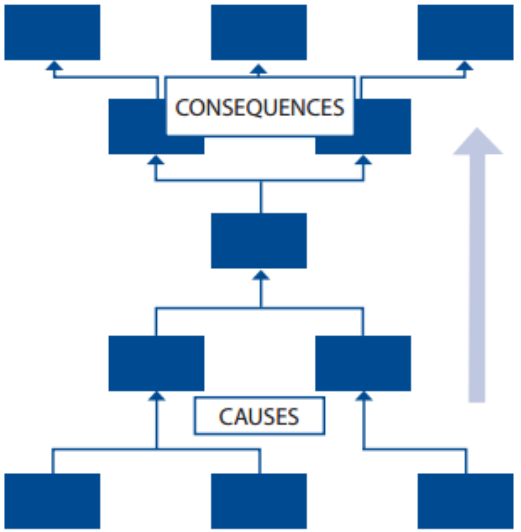


Figure 8: Concept of problem tree (Delevic, 2011 p. 18)

Storyboarding (CD) F

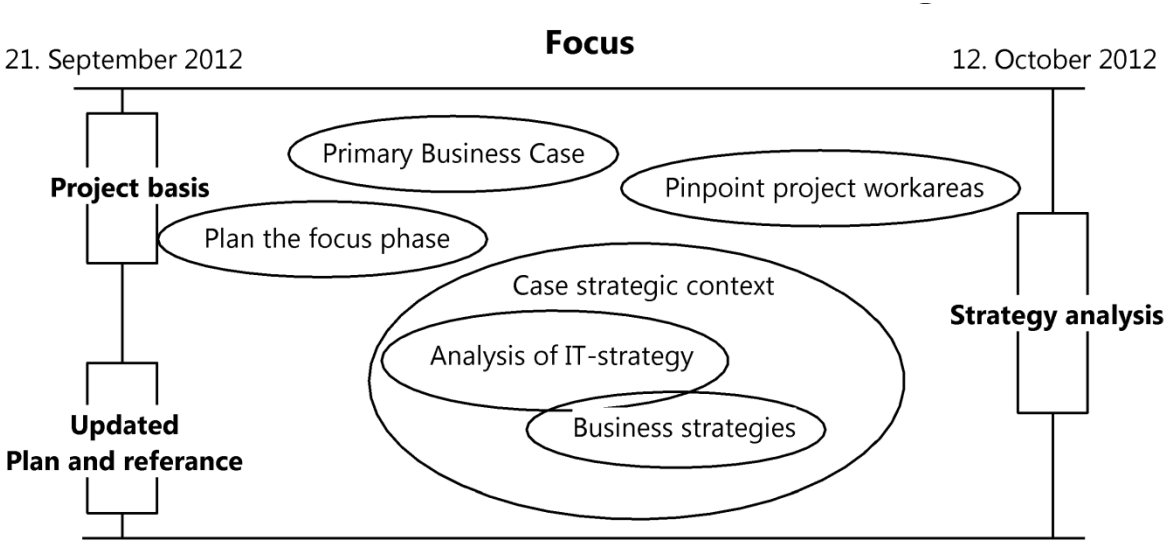
After defining the general direction from visioning, it is necessary to add more details to the function, behavior and structure of the system. This part will include the user's tasks to ensure that the system will take both the users interaction and the tasks into account. The storyboard describes how the user completes tasks in the new system, step by step. The storyboard makes sure that the given task will be coherent across interaction between users, and maybe supporting systems.

Chapter 4 FOCUS – THE STRATEGY ANALYSIS

In this phase the thesis will clarify and match the preliminary assessments goal with the company's goal for business and it-strategy. By doing this, identify and demarcating the areas of work. As a result of the focus phase, the work areas with relevance of the IT-systems will be chosen. The focus phase is because of that, bound closely to the company's general business plan, and makes it possible to be rated to overall goals defined in the strategy.
Due to an already defined business an IT – strategy from C.F. Møller according to the MUST approach, the focus will only document the strategy laid by the company.

The results from this section will be used in the depth analysis section as a demarcation of the already defined hypothesis defined earlier in the thesis. The results will be chosen from the criteria of business-relevance perspective and will be rated from direct usage in the aspect of business and work-practice. The means of this is to argument for the coherence of both hypothesis and strategy.
This will also be a key factor to ensure that the company's strategies will be met during further work of the thesis.

There will be no strategy analysis of Whitespace, due to the fact that the thesis is mainly addressed to C.F. Møller and their strategy.



PRIMARY BUSINESS CASE

C.F. Møller is one of Scandinavia's biggest and oldest architectural companies. They work with a wide spectrum of projects, everything from urban planning, architecture, landscaping, and development of components to general design. Their focus is to work with the simple, clear and unpretentious. This ideal has followed the company from its early days in 1924, and is an important part the design mindset even today, together with focus on placement and with international trends and local dialog. The company's main office is located in Århus, Denmark and has 5 departments located in Copenhagen, Aalborg, Stockholm, Oslo and London. It has approximately 325 employees. According to Byggeriet Evaluerings Center (Constructions Evaluation Center), who evaluate the performance of the construction consultant companies, in regards of costumer satisfaction the company scores above average, and in general performs well in the industry. (Grade book from Byggeriet Evaluerings Center, 2012)

C.F. Møller and other architectural companies are characterized as knowledge companies, because their output is based on knowledge transformed inside the company. Companies like this have the following traits that define them as a knowledge company. (Sveiby Lloyd, 1987)

- **Solves complex non-standard problems demanding creativity**
  Designing projects are unique and requires a high level of creativity.

- **Has a small flat organization**
  Is important for best possible knowledge creation, but is not always how architectural companies are organized. C.F. Møller is based on a flat organization.

- **Grows organically and through alliances rather than by acquisition**
  Many strategic alliances but also general acquisition jobs.

- **Develops the organization through developing the know-how of the employees**
  Employee knowhow is the base of C.F. Møller which is increasing its efforts to make the transition of old CAD system to new, through educating internally the employees.

- **Has managers who are formal as well as informal leaders**
  Informal leading is one of the most used in C.F. Møller

- **Treats its clients individually**
  In C.F. Møller their clients are treated individually.

- **Few are non-skilled employees**
  The output generating employees have long educations and are deliberately hired due to their high level of skills and talents.

- **Builds company strength through skilled individuals**
  "Our whole foundation is secured by professional
  employees, who are actively involved in and contribute
  to the ongoing development of the company." Strategy 2015 – ONECFM

STRATEGY ANALYSIS

C.F. Møller recently published a new strategy with goals aimed at 2015 called ONECFM. The strategy is based on the idea of making the company more homogenous by incite shared standards of practice. This makes for the basis of the strategy.

> *"By ONECFM we mean an understanding of C. F. Møller as being more than the sum of its offices, a common architectural standard, a common culture and value system, and an ability to mix local and global knowledge."*
> Strategy 2015 – ONECFM

BUSINESS-STRATEGY

As written earlier in the thesis, C.F. Møller is not the only company affected by the economy crisis, and recognizes the importance of increasing competition, which is based on new standards and processes. This will be essential in a new market where competition not only will come where competition will not only be Danish companies but also other companies from around the world with perhaps more money and/or capability.

> *"the world and our market is also developing and changing. A still uncertain building sector worldwide, fierce price competition, changing customer demands requiring new standards and processes, and an increasing competition from engineering companies*

> *and contractors, who , with more volume and funds, are developing their own architectural branches and taking on new services."*
> Strategy 2015 – ONECFM

One of the focalpoints in the business strategy was to differentiate through technology. Including applying the new technology and implementing new processes to support them.

> *"Differentiators: Technology – we are in the forefront of applying new technology in our products and processes"*
> Strategy 2015 – ONECFM

Quality is important in a business like C.F. Møller. Quality must be an integrated part of the organization, including the technology supporting the work, including processes.

> *"Quality must be embedded in all our services, in our products, processes, tools and methods."*
> Strategy 2015 – ONECFM

IT-STRATEGY

With the introduction of new technologies in the company, they strive to standardize the use of technology, culture and workflows, to be able towards sharing work through departments, and to support the ONECFM idea and to make benefit of company size.

> *"By creating one or more digital project models, we can support ONECFM, where employees across the group can work on the same projects, using the same tools and the same "language" as well as optimize our workflows and thus create a base for better project economy".*
> Strategy 2015 | ONECFM Group support strategies - HR - IT - Communication

The management acknowledges the importance of supporting knowledge sharing technologies, sharing platforms and processes and methods in a group environment, and the importance of usability, to improve production.

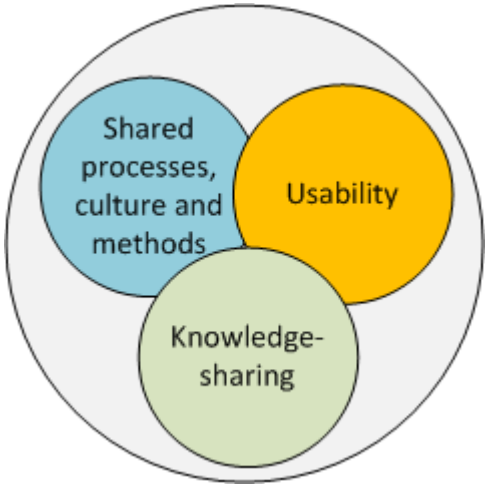
> *"Information technology is a critical part of achieving C. F. Møller Group's ONECFM objective, enabling and supporting knowledge sharing, shared platforms, processes and methods. We need to focus on technologies and tools serving as shared Group tools, like digital contract processes, room programming, project webs and calculation. C. F. Møller Group must continuously assess maturity and usability of digital tools, keeping an eye out for new trends and technologies to optimize our production. "*
> Strategy 2015 | ONECFM Group support strategies - HR - IT – Communication

The actual platform that supports the IT system is located on a private cloud, and backs groups combined of group-members located in different locations. The information must flow through project models, where roles determine what kind of information the receiver gets.

> *" The technical platform is designed to ensure independence of physical servers and locations by deploying a high degree of virtualization. The infrastructure is designed as a private cloud, independent of the Group's physical environment. Information architecture is closely linked to roles and processes and structuring data are well documented and incorporated into the project models."*
> Strategy 2015 | ONECFM Group support strategies - HR - IT - Communication

Summing C.F. Møllers strategy up, the main focus is to support a platform that gives the employees a base to act more homogenous from. This thought is made from the acknowledgement of increased competition in the business. Therefore C.F Møller seeks to increase internal efficiency by utilizing technology, and the quality output, which the technology must support. The technology must support a dynamic business where project-groups are not always located at the same location, hence the importance of sharing information through the technology set by the company. The technology must be characterized by usability, and knowledge sharing through processes, culture and methods, all of this created by a cloud-based frame that support the dynamic groups environment.

AREAS OF WORK:
This section will define the areas of work that is defined from the company strategy. The areas of work will be the focus in the thesis for the work in the depth analysis. The areas of work will is one of the first steps to define what criteria's the new technology must facilitate.

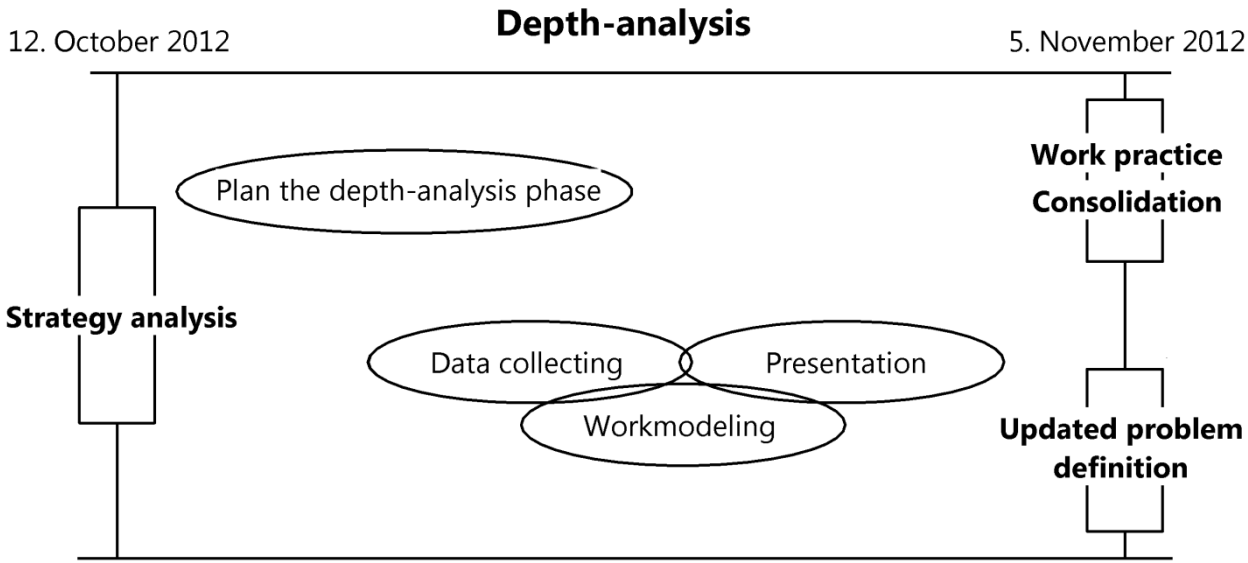


The new technology must be a platform that supports shared processes, culture and methods. This must include the other points of work. By integrating a high level of usability, it will gain incitement for employees to share their processes, culture and methods. This will also need to be a tool for spreading the knowledge throughout the company, which will support the other points of work. All three areas will affect and support each other.
These selected points in the company's strategy underpin the initiating problem description of importance. This will define the following areas of work in the next phase in the MUST chronology.

Chapter 5 DEPTH-ANALYSIS

The depth analysis phase strives to make an analysis of selected work areas, and consists of the main part of the MUST method. The objective in this phase is to establish a thorough context of the current workflows and what rationales that lies behind. By knowing the company's context, it is possible to define the conditions for change with new IT and processes. To achieve this context tools from the MUST and CD will be utilized, and will form the basis for the renewing phase.

In this section, the utilized tools will inquire and map the current workflows, and the reason to why the workflows are conducted as currently. The phase is built on the notion that workflows must be experienced in the employees' context, meaning that the produced descriptions will be using the same terminologies and categories as used in company's culture, and focuses on being anchored into the daily work practices. By doing this, a mutual accept and acknowledgment between the designers and the employees, is founded in the respect for the company and its culture. The result of the depth analysis will create context of the company issues and what is needed to reduce or remove the issues by acquiring or creating new software that facilitates this. This can result in a shift of focus due to increased knowledge about work-practice, which will be described later on in this section, as a new updated problem definition. The final product in the depth-analysis will be a context of the work-practice and a consolidation of problems and causes. This will mark the transition to the next phase.



DATA COLLECTING

To ensure a high level of usability of the IT-solution, it is crucial to understand the context and the users that will facilitate this. The user is everybody affected by the new system, from the end-user (The people that will us the solution directly) to the users that get affected indirectly like managers, IT-supporting staff e.g.. By ensuring that it is the users which are in focus, it is not the "buyer of the system" who the judge of what is needed and what is not. This will create a system which support user work-practice can be collected, and hopefully increase in total quality can be increased.

This data consists of work-practice and access to concrete experiences with selected employees and is about making the work-practice explicit. The data will be collected by utilizing the earlier described techniques in the method section. Techniques used in this section will consist of observation, interviews and surveys e.g. The work-processes will be based on the initiating hypothesis the questions were formed on the 3 notions defined in the beginning of the thesis and the results of the focus section.

The main participant of the thesis is C.F. Møller which is the main contributor of the data collected through internet surveys, interviews and observation e.g. To gain a more international and broad appeal, the architectural company Whitespace is also contributing with data. Both companies will draw a picture of a general trend. This is done to make the thesis be applicable to companies based on knowledge in the construction industry in different cultures and locations.

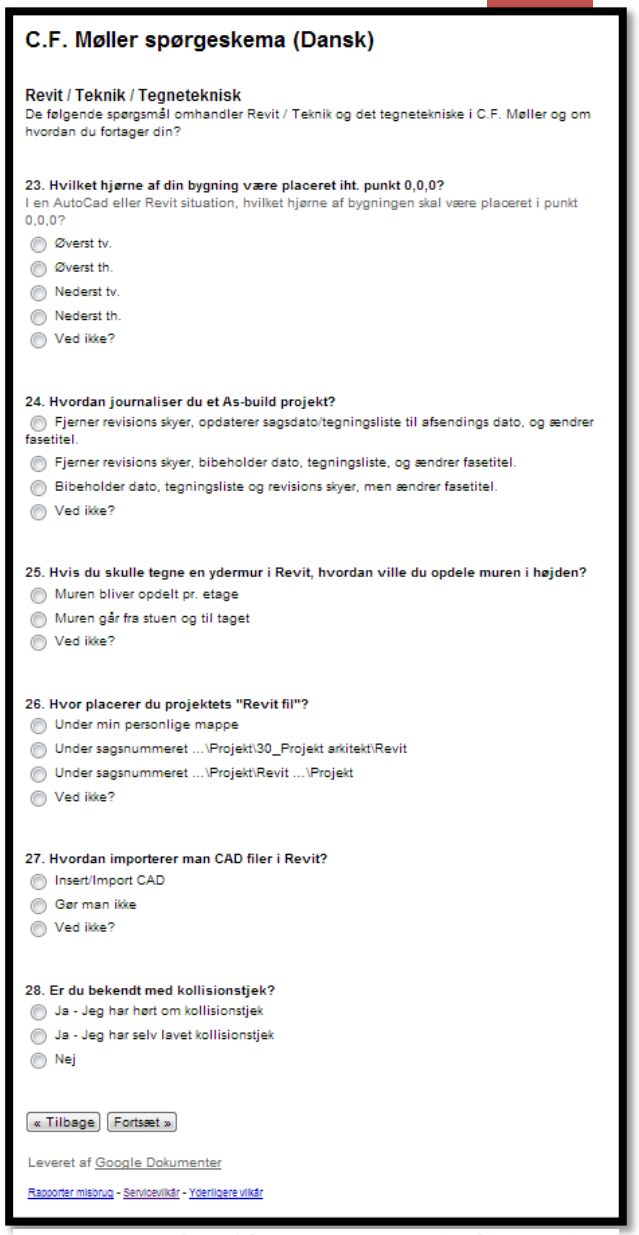
- **Internet Survey**
- **In-situ Interviews**
- **Telephone Interviews**
- **Video Conferencing**
- **In-situ Observation**
- **Company Visit**
- **Analysis of Existing IT**

INTRANET SURVEY

A intranet survey has been conducted at C.F. Møller to get a broad context about the employees work-practice. The survey contains questions about general work-practice, quality management, knowledge-sharing, IT-knowledge e.g. The results will be the base for further analysis for making the knowledge system more effective and useful in the company.

The survey is based on self-enumeration and is a computer-assisted data collection as described in the technique section. The software used is Google Docs survey form, which is a free online survey tool provided by Google. The survey will be anonymous, to obtain an incitement for the user to answer the questionnaire without any worries of persecution. Raw answers and the whole questionnaire can be found in the appendix.

The results will be analyzed for identifying problems with the current workflows, how effective the communication is, and what the level of training is required in relation to facilitate the current IT-portfolio that contains knowledge. The questionnaire contains 37 questions based on the previous mentioned themes. The employees participating are company designers, planners, leaders.


C.F. Møller spørgeskema (Dansk)

Revit / Teknik / Tegneteknisk
De følgende spørgsmål omhandler Revit / Teknik og det tegnetekniske i C.F. Møller og om hvordan du fortager din?

23. Hvilket hjørne af din bygning være placeret iht. punkt 0,0,0?
I en AutoCad eller Revit situation, hvilket hjørne af bygningen skal være placeret i punkt 0,0,0?
- Øverst tv.
- Øverst th.
- Nederst tv.
- Nederst th.
- Ved ikke?

24. Hvordan journaliser du et As-build projekt?
- Fjerner revisions skyer, opdaterer sagsdato/tegningsliste til afsendings dato, og ændrer fasetitel.
- Fjerner revisions skyer, bibeholder dato, tegningsliste, og ændrer fasetitel.
- Bibeholder dato, tegningsliste og revisions skyer, men ændrer fasetitel.
- Ved ikke?

25. Hvis du skulle tegne en ydermur i Revit, hvordan ville du opdele muren i højden?
- Muren bliver opdelt pr. etage
- Muren går fra stuen og til taget
- Ved ikke?

26. Hvor placerer du projektets "Revit fil"?
- Under min personlige mappe
- Under sagsnummeret ...\Projekt\30_Projekt arkitekt\Revit
- Under sagsnummeret ...\Projekt\Revit ...\Projekt
- Ved ikke?

27. Hvordan importerer man CAD filer i Revit?
- Insert/Import CAD
- Gør man ikke
- Ved ikke?

28. Er du bekendt med kollisionstjek?
- Ja - Jeg har hørt om kollisionstjek
- Ja - Jeg har selv lavet kollisionstjek
- Nej

« Tilbage | Fortsæt »

Leveret af Google Dokumenter

Rapporter misbrug - Servicevilkår - Yderligere vilkår

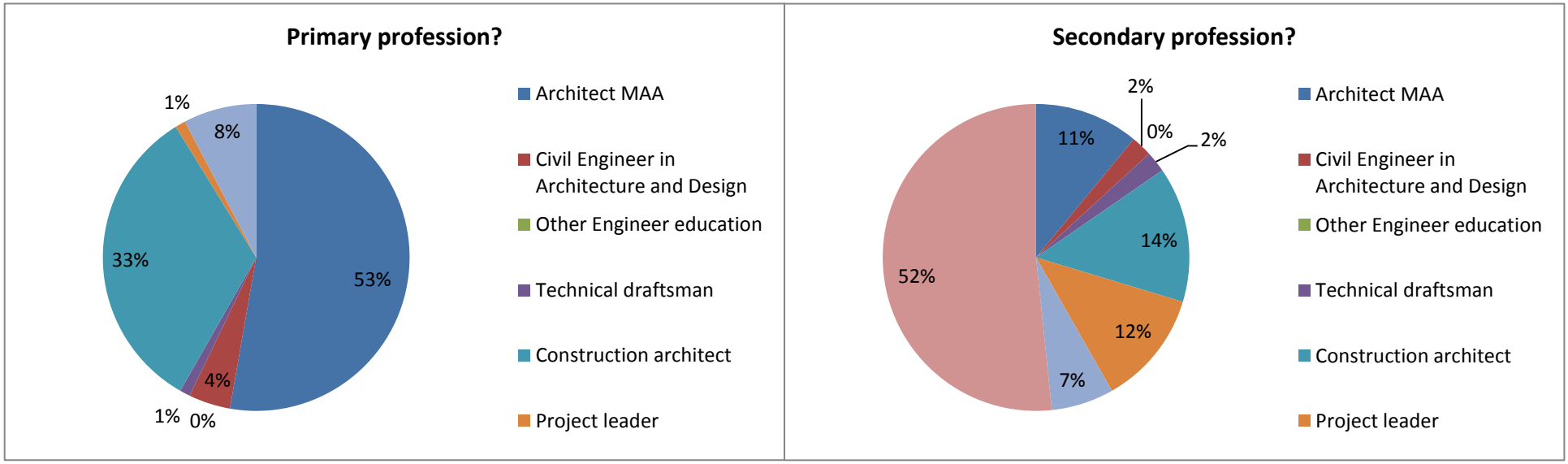
Figure 9: Screenshot of the internet survey (Author 2013)

Presentation of survey results

This section will focus on presentation of the results from the internal questionnaire at C.F. Møller. There were 37 questions, but only the relevant answers for the thesis will be presented in this section. The graph in the bottom shows the participants profession composition.
After a period of one month where the survey was open to attendance a total of 91 employees from C.F. Møller. That is 31 % of the 296 fulltime employees in the whole company across nations. In the Danish part of the company 227 people are employed, where 40 % participated. The participation pct. is higher due to the fact that the survey include all fulltime employees which also supporting staff (Kitchen, cleaning e.g). The participants were from:

Office	Participants	Employees at the office.	Pct. Participating in relation to native office.	Pct. Participating in relation to the Danish offices.
Århus	49	131	37,4 %	21,6 %
Copenhagen	27	77	35 %	11,9 %
Aalborg	15	19	79 %	6,6 %
Totals	**91**	**227**	**Average 50,5 %**	**40 %**

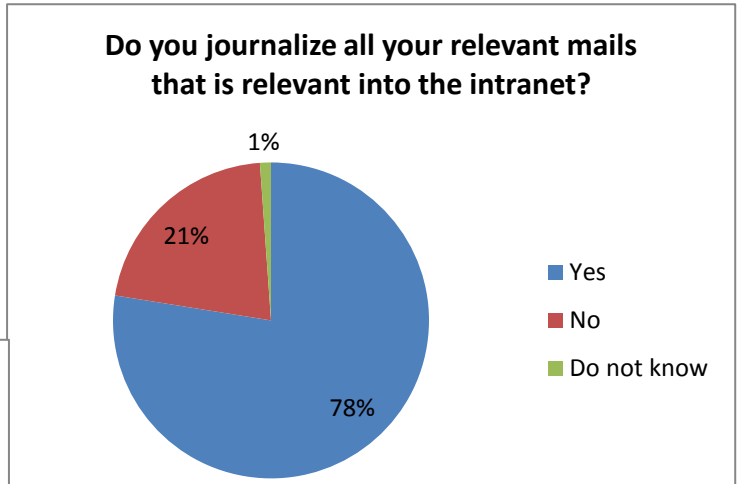
Figure 10: Participation of the internet survey across the Danish offices (Author 2013)

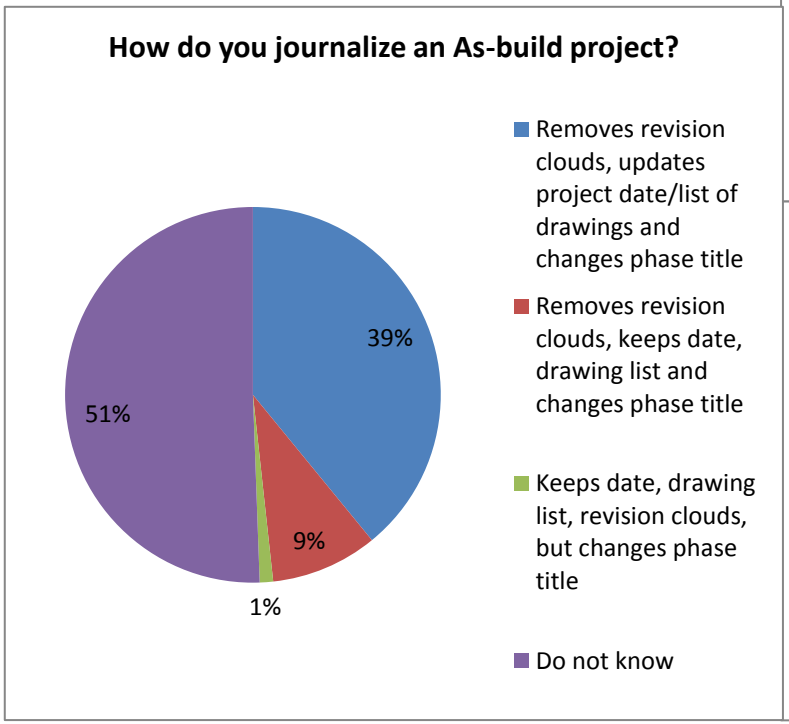


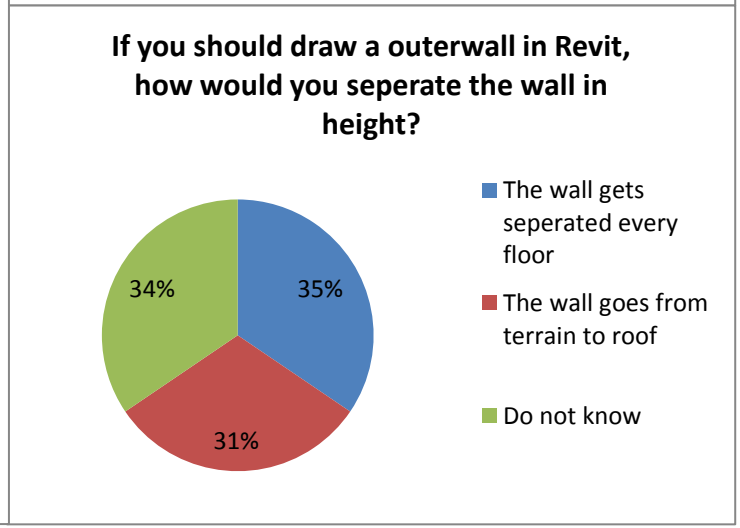
Difference in work-practice

The theme for the first question was based on the employees' perception of work-practice. The idea for these questions was to either confirm of disconfirm the hypothesis that work-practice is different within the office, and across the offices participating in the survey.
The results from the survey showed that in general, a difference in work-practice is present. Both how people answered to how the journalized As-build projects and how their technical approach to modeling walls in the design program Autodesk Revit had a big difference in what people answered.
The technical aspect of work-practice showed that a nearly perfect 1/3 difference in answers had different ways of modeling designs in Autodesk Revit. They were either separating the wall to each floor, or creating a wall from terrain to roof. The rest did now know.

This shows a tendency of work-practice difference across the offices, in the aspect of design work-practice. This could seem as an indifferent matter, but can affect overall quality of the model if not done alike, and can create inaccuracies when extracting data from the building model.



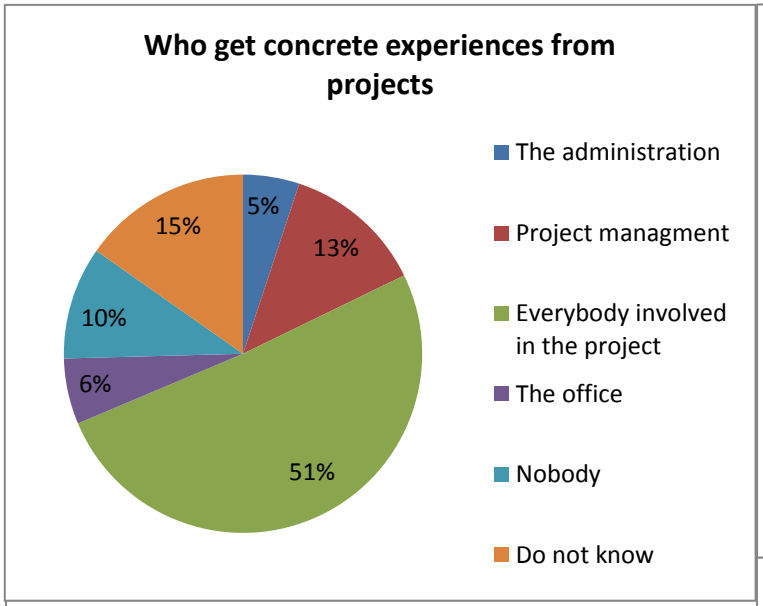


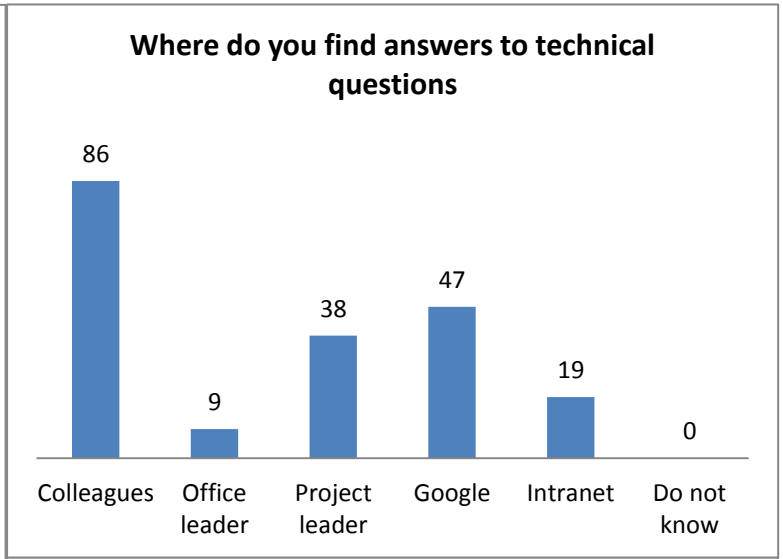


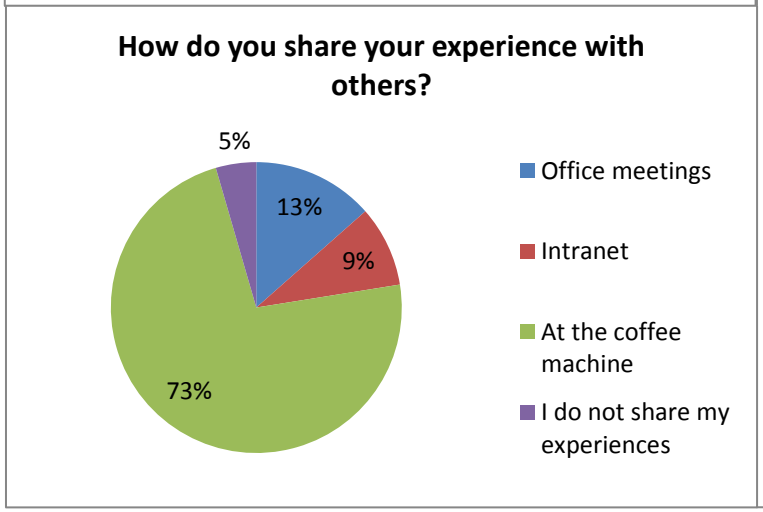
Knowledge sharing

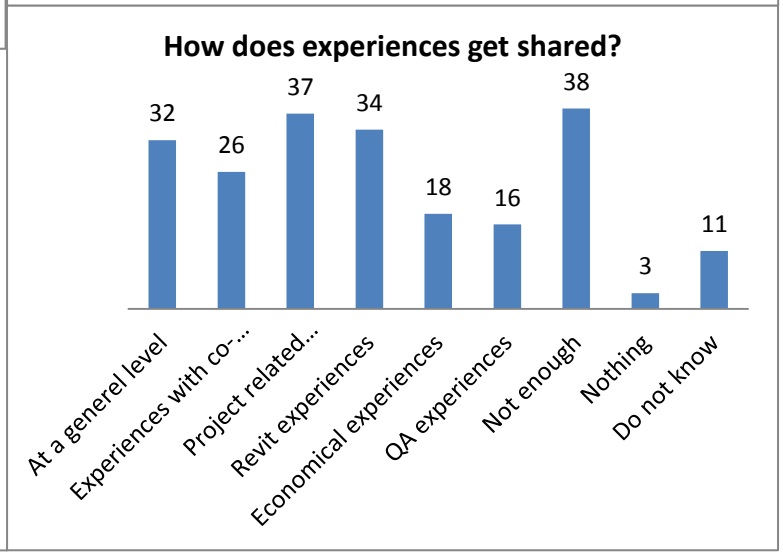
Another theme of the survey was how the employees perceived knowledge sharing in the company.

A general tendency shows that the employees get their technical knowledge mainly from colleagues, where the next sources used to acquire the knowledge were from Google, Project leader, and a lesser extend the intranet. 38 employees answered that experience is “Not enough” and shows that the employees are interested in sharing more experience, than the current situation. The experience is mainly shared among the participating employees during a project. The experience in general, gets shared informally “At the coffee machine”.









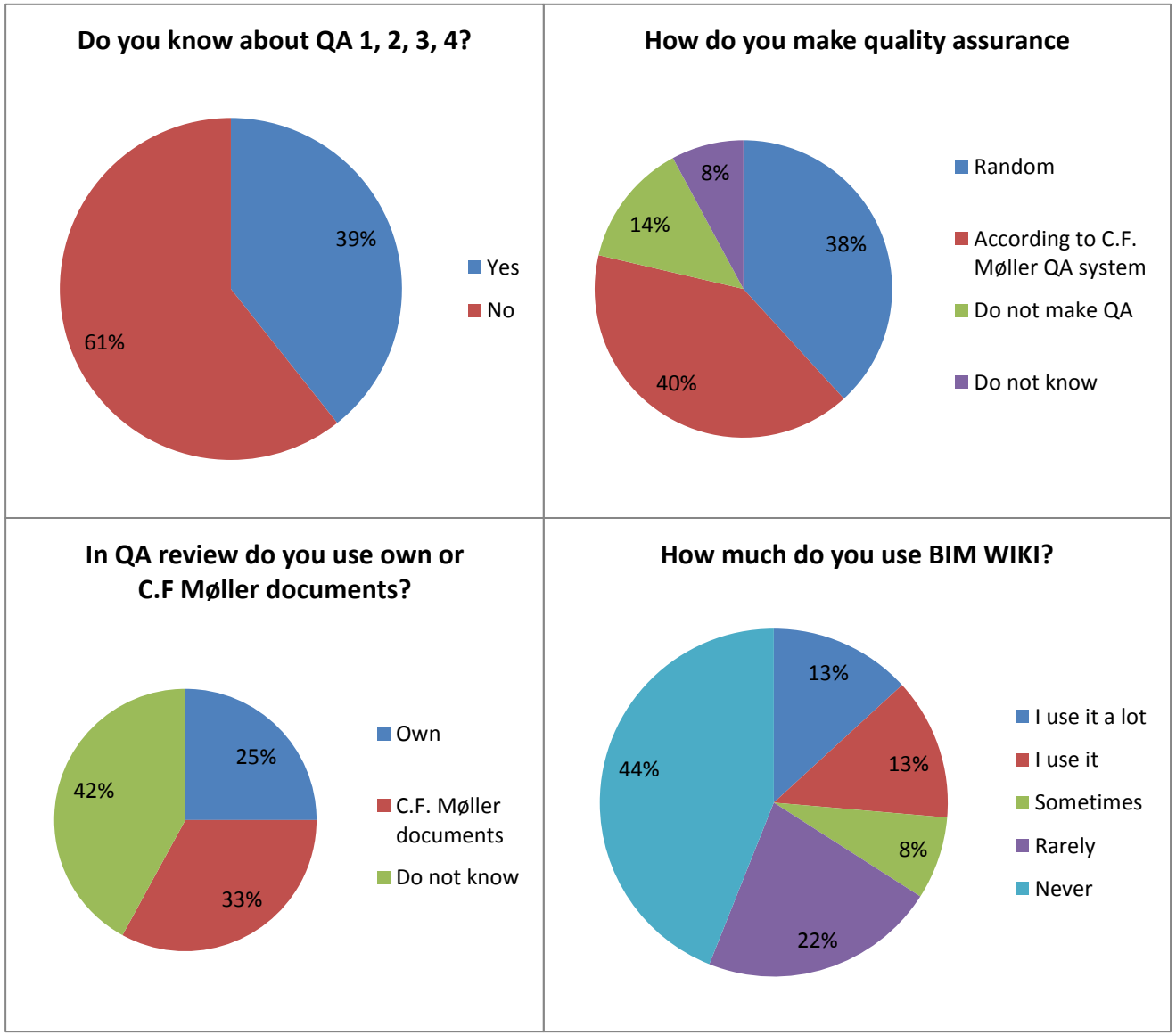
Use of company IT and standards

C.F. Møller has a company manual for Quality Assurance called QA 1,2,3,4 because it is divided into four sections. 61 % do not know about the QA manual, and 40 % perceive that they do QA according the company QA system, but only 33 % say that they use the company standard documents. 14 % says that they do not preform QA and 38 % preform random QA.

The BIM WIKI, a BIM (Building Information Modeling) knowledge domain is never used by 44 % and rarely used by 22 %.
34 % use the BIM WIKI sometimes to a lot.

In general the participants of the survey paint a picture of not utilizing company standards of performing QA and knowledge about utilizing the QA 1,2,3,4.

The newly formed BIM WIKI is never or rarely being used by 66 % of the participants, which can be because that the system is relatively new. But even though that BIM in generally is a newly introduced method in the company, one should think that required a lot of new knowledge needed about this area for the individual employee.



IN-SITU INTERVIEWS

The conducted interviews have been documented by notes, sound recording or video filming. The recordings are found on the attached DVD, and the notes from the interview in the appendix. The techniques utilized can be read about in the according section earlier in the report.

The interviews have been split up between the two participating companies.

Participants C. F. Møller - Aalborg

Christian Mosegaard Johansen, - Construction Architect – Context about general work-practice.
Geir Ármann Gíslason – Construction Architect – Context about general work-practice.
Niels Fuglsang Christensen – Construction Architect – Context about general work-practice.
Lars Christiansen – Project Leader and Quality-manager – Context about general work-practice and visions.
Thomas Busk Bech - Senior Project Leader – Context about general work-practice.

Participants Whitespace - Bangkok

David J. Mayer - Owner – Context about general work-practice, and visions.
Phil Almmanoj – Architect – Context about general work-practice.
Sutut Sakkhamjdhn - Architect – Context about general work-practice.
Ton Kmutt - Project leader – Context about general work-practice.

TELEPHONE INTERVIEWS

In some cases it has been necessary to conduct a telephone interview due to distance, time and convenience. The summary of the interview can be found in the appendix, and the technique is based on the same methods as the other forms of interview.

Participants A.Enggaard - Aalborg

Nils Frandsen – Project Leader – Context about co-operation with CFM.

Participants C.F. Møller - Århus

Helle Lehmann Staun – Head of Human Resources – Context about Intranet CV and competencies functions.

Participants NN5 – web, intranet, advisor, design, development - Århus

Lars E. W. Jespersen – Director – Context about the CFM Intranet system.

VIDEO CONFERENCING

Due to location and time, video conferencing can be utilized as a tool for communicating more effectively due to having a video camera that can show drawings, sketches e.g.

Participants C.F. Møller - Århus

Klaus Algreen – IT Manager – Context about CFM IT.

IN-SITU OBSERVATION SESSIONS

To gain insight to the companies work practice, the author the best way to document ones observations was the observation technique. The observation session was conducted with a video recording device, where it was possible to monitor the slightest process in completing a work related task. It showed the different patterns from employee to employee, and between differences between the cultures of C.F. Møller and Whitespace. The data from the sessions was compared to the interview conducted to minimize the say/do syndrome, which is described in the technique section. The recorded footage can be found on the attached DVD.

Participants C. F. Møller – Aalborg, Denmark.

Christian Mosegaard Johansen, - Construction Architect – Context about general work-practice.
Annie Winther – Secretary and Bookkeeper – Context about use of Autopilot system.

Participants WhiteSpace – Bangkok, Thailand.
Phil Almmanoj – Project leader – Context about general work-practice

COMPANY VISIT
In the renewing phase, visiting a company to gain insight in new technological possibilities, and to gain an understanding of other and newer work-practices. The technique makes it possible to experience a technological system in a realistic environment, how it is used and even try out the systems. It gives an idea of which qualifications and organizational needs that would be required to implement such a system. Because of this, the contextual inquiry will often be based on observation, where the interviewer will subtly observe the slightest actions of the user. The interviewer inquiries into the world of the user, hence the name contextual inquiry.

Participants Rambøll – Aalborg, Denmark.
- Tim Fynbo Johansen – Construction Architect – Context about Ramlink experiences.

Participants Whitespace – Bangkok, Thailand.
- David J. Mayer - Owner – Context about general work-practice
- Phil Almmanoj – Architect – Context about general work-practice
- Sutut Sakkhamjdhn - Architect – Context about general work-practice
- Ton Kmutt - Project leader – Context about general work-practice

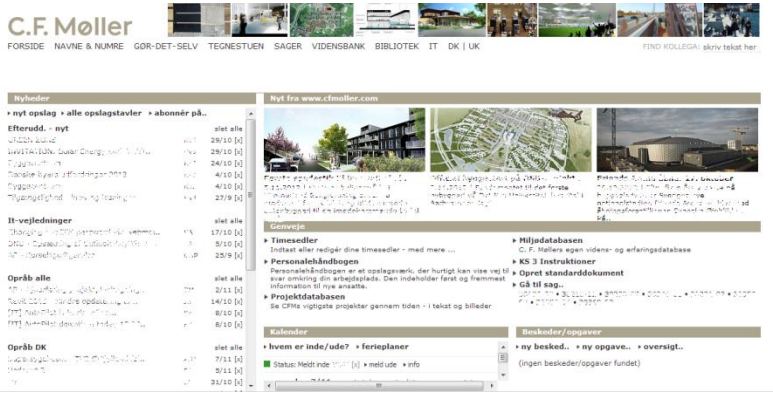
Participants Korsgaard EDB ApS – Århus, Denmark.
- Jørgen Korsgaard - Director, Development and Sales – Context about Autopilot and visions.
- Jette Pardi - General Manager – Context about Autopilot and visions.
- Thomas Herskind - Sales and Marketing – Context about Autopilot and visions.

ANALYSIS OF EXISTING IT-INFRASTRUCTURE

The existing IT-Infrastructure at C.F Møller is based on a portfolio of tools that specializes in different aspects. There is an ongoing development of striving to combine the functionalities into a shared structure, but is not done yet. This section is about current IT-infrastructure of how and where the knowledge is located and how it is connected to the employee. The IT-portfolio for C.F Møller contains the following:

Intranet

The intranet is a custom made solution by IT-developer NN5, Lars E. W. Jespersen, which functions as a base for company news and information throughout the concern. Most of the company based information is localized in the top bar, while news is placed as a column in the left side. The news is separated from different parts of the company. From the bottom up it shows news from the local branch that the employee is primary attached to, then the country, the company. Two new sections has appeared recently in the top of the interface, and is the IT-guidance's, and education news boxes.



Picture 1: Picture of Intranet – (Author, 2013)

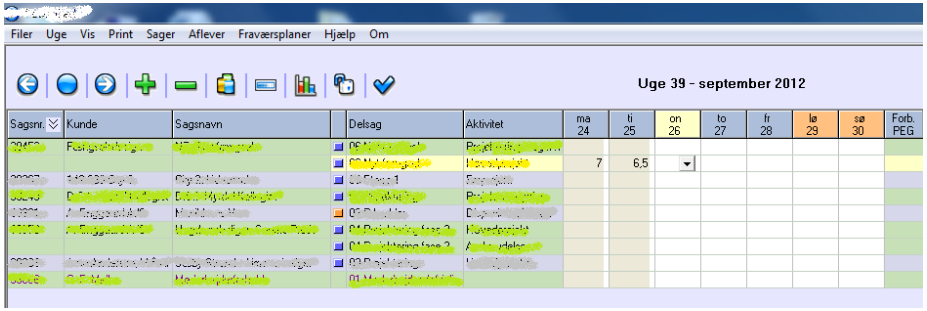
It also facilitates a calendar for allocating vacations e.g., but is separated from the outlook calendar that is used for general appointments. Below the calendar it is possible to check in at the office, letting colleagues know that you are present.

The profiles located on the intranet got an new additional function at the last update, that labels curriculum, skills and capabilities to the profiles. This functionality makes it more easy for locating the right employee for the right job in projects. This is especially useful when it is necessary to show company competencies in order to gaining access, to bid for specialized design jobs.

The system does also house a noticing system. You can send messages, and notices that connect to a project to project-members. Due to the arrival of Microsoft Lync, this functionality is not utilized anymore, but at still present, and functional. The Intranet also got a journalizing function. This enables people attached to a project to see relevant mails concerning the project. In situations where it is necessary to find and old mail concerning a project, it has becomes easier due to the fact that all the mails relevant to the project are centralized in the project journal. The connection between the mail service Microsoft Outlook, and the intranet is done manually through a series of steps. These functions are not connected to any other IT-solution. The only link with the intranet to the rest of the IT-portfolio is a link from the SQL server that creates employees profiles and projects that syncs between the intranet and AutoPilot.

AutoPilot

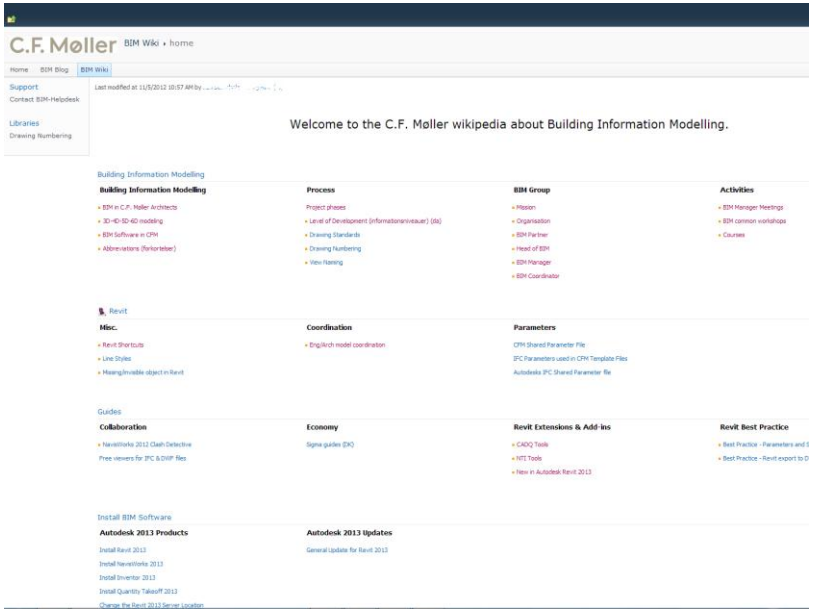
Is a tool for organizing projects resources. It gives the project leader an overview on how many hours spend, versus how many hours left to ensure project profit. The project leader can get an overview of project profitability by the end-factor. The end-factor is an economical value, which is based on the invoiced amount divided by the amount spend. The company then has a target of this value to be at a certain level for each project, to be acceptable. The program is only connected through the creation of a new employee profile, which it can communicate to the intranet system as written earlier. (http://autopilot.dk/), (Interview Annie Winther, C.F. Møller)



Picture 2: Picture of AutoPilot – (Author, 2013)

BIM Wiki

Is a knowledgebase designed in-house for anything related to BIM (Building Information Modeling) The BIM responsible employees update the site with guides, BIM standards for the company and meeting summaries from BIM Manager meetings. The knowledgebase is located on a separate SharePoint server. There is no linking between the BIM wiki site and other IT-systems than an address link. BIM Wiki is a new tool that was launched early 2012, because of the need increase the knowledge about utilizing newly arrived designing software like Autodesk Revit, and hence creating manuals that could be stored and shared from the BIM wiki site.



Picture 3: Picture of BIM Wiki – (Author, 2013)

Fileserver / Network drive

The network drive contains all the project related material, as drawings, word-documents e.g. The structure of the maps is custom made standard made by C.F. Møller. The drive houses general company knowledge based on documents on materials, architectural inspiration, project files, pictures e.g. There is no direct link between the fileserver and the other knowledge bases, besides the designing programs.

Microsoft Lync

The old Microsoft Office Communicator has changed its name to Lync, and is an instant messaging client that is used to communicate within corporate environments. It features instant messaging, voice over IP and video conferencing, where the contacts available are synchronized with the Microsoft Outlook contacts that are stored at the Microsoft Exchange Server. The communication between individuals is flowing through a dedicated and secure Microsoft Lync Server protecting the data.

In general Lync is a collaboration tool, where collaboration happens mainly through the Microsoft Office package where whiteboard, documents, desktop sharing, polling lists and the possibility of collaborate and share a specific application. It is possible to invite individuals and appoint them as presenters or demote them as attendees. Only a few employees utilize Lync at CFM according to Lars Christiansen (Interview Lars Christiansen) (http://blog.insidelync.com/)

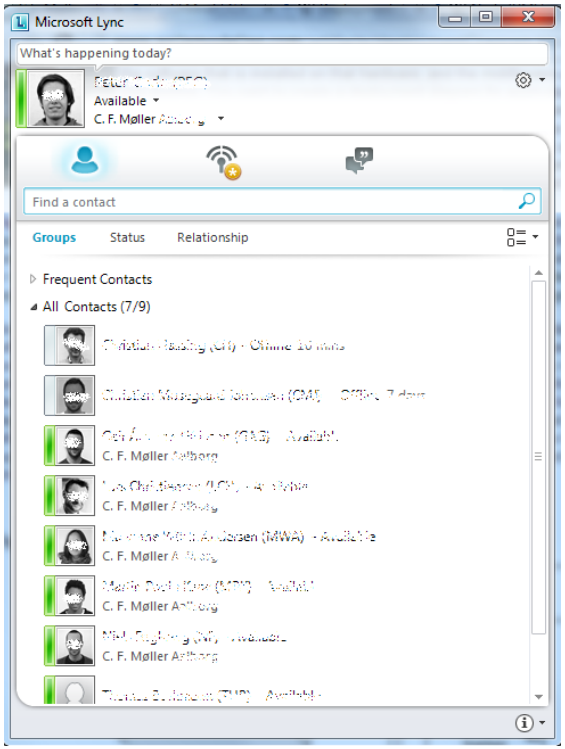


Figure 11: Microsoft Lync (Author, 2013)

The rest

Besides the four main knowledge domains, knowledge is lodged into some of the software utilized. Typically the knowledge is in the form of pre-modeled structures and components, or documents e.g. that can be reused. The company has a template containing the most used pre-defined objects. The templates are located on the network drive. (Interview with Klaus Algreen)

- AutoDesk AutoCad
- AutoDesk Revit
- Microsoft Office
- Microsoft Project
- Google SketchUp
- Adobe CS

Summarized

The IT-portfolio of C.F. Møller is a mix of specialized tools which meet the functionalities required by the current work processes. The intranet was designed in 1998 and included many of the functionalities that has been outsources to Microsoft products like Outlook that contains the e-mail and calendar feature. For resource management, AutoPilot was introduced in the 1. of April 2012, to increase the insight in project economics and resources for the project leader, and the BIMwiki was launched about the same time. The sources for collecting information and knowledge has grown, and undermines the functionalities that was already included in the intranet solution, but due to expanded functionalities and collaboration between the new Microsoft programs the intranet notification system and calendar is currently more or less unused.

The current numbers of specialized tools that are required by the user to have knowledge about utilizing is six, which for some of the employees is a lot. According to both the survey and interviews, only a few of these tools are actually utilized. During the interviews, a story about people using personal Gmail accounts instead of company mails through outlook has been told. It is a clear fact that only a few utilizes company standard documents, which shows on a statistics of how many times a standard document has been downloaded. To sum up, the employees do either not see the company provided IT-tools as a benefit to their current work-practice, or either do they not know that it exists. Other issues concerning internal politics can motivate the employees not to utilize the system. The question is “why do they not utilize the IT-portfolio to the full extent?” In the next section, Work modeling, tools are used to gain a better understanding of this behavior.

WORK MODELING

As described in the brief introduction to techniques, work-modeling is a tool to explain the complex nature of how users work. This section will try to comprehend the patterns of work at the company. The information is based on interviews and observations done at the company.

According to the case specific problems, the thesis focuses on how the company is trying to share processes, culture and methods, the level of usability and how they do knowledge-sharing. By mapping the information into models and maps, coherence and problems can emerge.

The way that people work is often complex and full of details. During work, the employee process huge amount of information, knowledge that enables a task to be completed. The process of doing so can be difficult to obtain, because even the employee is not always aware of the process details he or she is conducting. The section called Data Collection utilized techniques to clasp both the implicit and explicit activities. But the information captured during that phase needs to be structured so the data gets tangible.

- **Knowledge map**
- **Sequence models**
- **Flow model**
- **User-centered IT-Infrastructure**
- **Diagnostic cards**
- **Problem tree**

GENERAL KNOWLEDGE-MAP

In companies where the knowledge is a form of economy, the creation and exploitation of all kinds of knowledge is a key factor in generating wealth. In companies like the one referred to in the case, knowledge can be present, but even if it is present, there often is a gap between what is known and how to apply the knowledge in practice. Knowledge mapping helps to understand how knowledge is used and how it flows and where the assets and gaps are located. Knowledge mapping is a tool for understanding complex processes, resources and people involved in the system.

The knowledge map is an association of items of information listed visually. It can contain processes, networks e.g. The mapping contains where the knowledge resources are located and how these elements are moved around, where they are created and where they need to be utilized.

Now the knowledge domains internal in the company are listed in the figure to the right and defined the correlation between the domains and the user. The knowledge map is created from a perspective of the user in how sources is located, where flows, what constraints the knowledge within the organization. This knowledge map will be a general representation of how the user can obtain knowledge in the current company setting.

The rationale of mapping is to work out how the knowledge acts in the company and if it is acting according to the company strategy. This can reveal how the IT-system could facilitate the user to better assess the knowledge domains and highlight the "islands of expertise" and encourage re-use. The map is based on interviews, and observations.

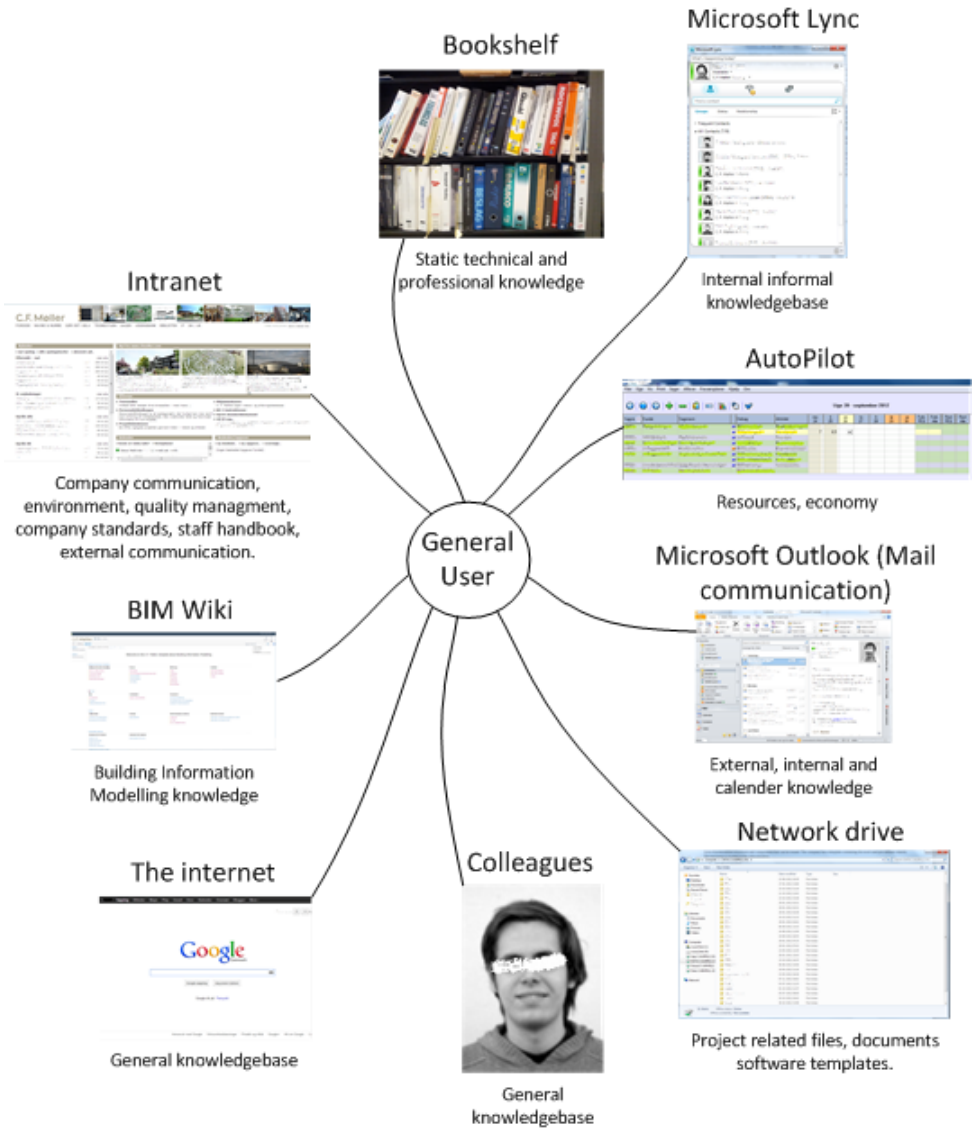


Figure 12: General User Knowledge-map of C.F. Møller (Author, 2013)

PRESENTATION OF THE IT-CONFIGURATION

To portrait the IT-configuration used at C.F Møller a customized diagramming method is utilized. The reason why visualizing the IT-architecture at C.F. Møller is to locate if the IT-system oppose the employees work-practice. A part of the IT-solution will be altering the current setup, connect the separate portfolio, to create a better work-practice support to the employee.

The User-centered IT-configuration

All servers shown are run as virtual servers, expect the Citrix server. This means that servers represented at the diagram, is run collectively on a few static servers, setup as clusters. Each office besides Århus has 2 virtual servers, Århus has 3. This means that if one server shuts down to power failure or similar, the other server can continue to process the virtual servers. This allows for an easy setup of the servers, and great supplies the system with great backup. The intranet is shown as HTML, but the data is located on the SQL server and the Internet Information Server (IIS). This allows for authentication and control of the server e.g.

The diagram shows that the current user focused system is run on eight different servers, which each has its pros and cons according to connected system. The Microsoft Exchange Server (MES) must be paired with Outlook and Lync to ensure profile and calendar functionality, where the MES Gateway enables Microsoft profile functionalities across co-operation companies. The Lync server is s specialized server for running Microsoft Lync, which also is connected to MES, which connects profile history and functionalities between Lync and Outlook. With outlook a web login is provided for access through the internet, and with Lync it is possible to

Autopilot is mainly run on each individual employees PC but can be run on a Citrix server. The data from Autopilot is stored at the SQL server and views make it possible to manually sync profile and project data when they are created in Autopilot. This can then be synced into the Intranet system, and reduces redundant work, and mistakes. The data flow is mainly connected through the Intranet, which works as a hub for information throughout the company, but calendar and messaging functionalities are not utilized nor synced due to the employee mainly use Outlook or Lync. There is no link between the file storage, where all the project related documents and files are located.

Data from the BIM Wiki is mainly stored at the Microsoft Sharepoint server. But data is also stored at the SQL server, but is not utilized in coherence with other parts of the IT-portfolio, the same is applicable for the Windows fileserver, which is not connected by any means, and are a sole function. Plans are to implement project data from the SQL server, to be synced into the fileserver map system. This can allow for an automation of the creation of project map structure.
It is possible to connect to the system from the internet, mainly through the company homepage www.cfmoller.com, where both Outlook, Intranet and the Citrix server running Autopilot e.g. is accessible. To protect the data, a firewall has been setup to secure company data. The setup is visualized at Figure 7: A user-centered view on the IT-Infrastructure (Author 2013) / (Video conference with Klaus Algreen)

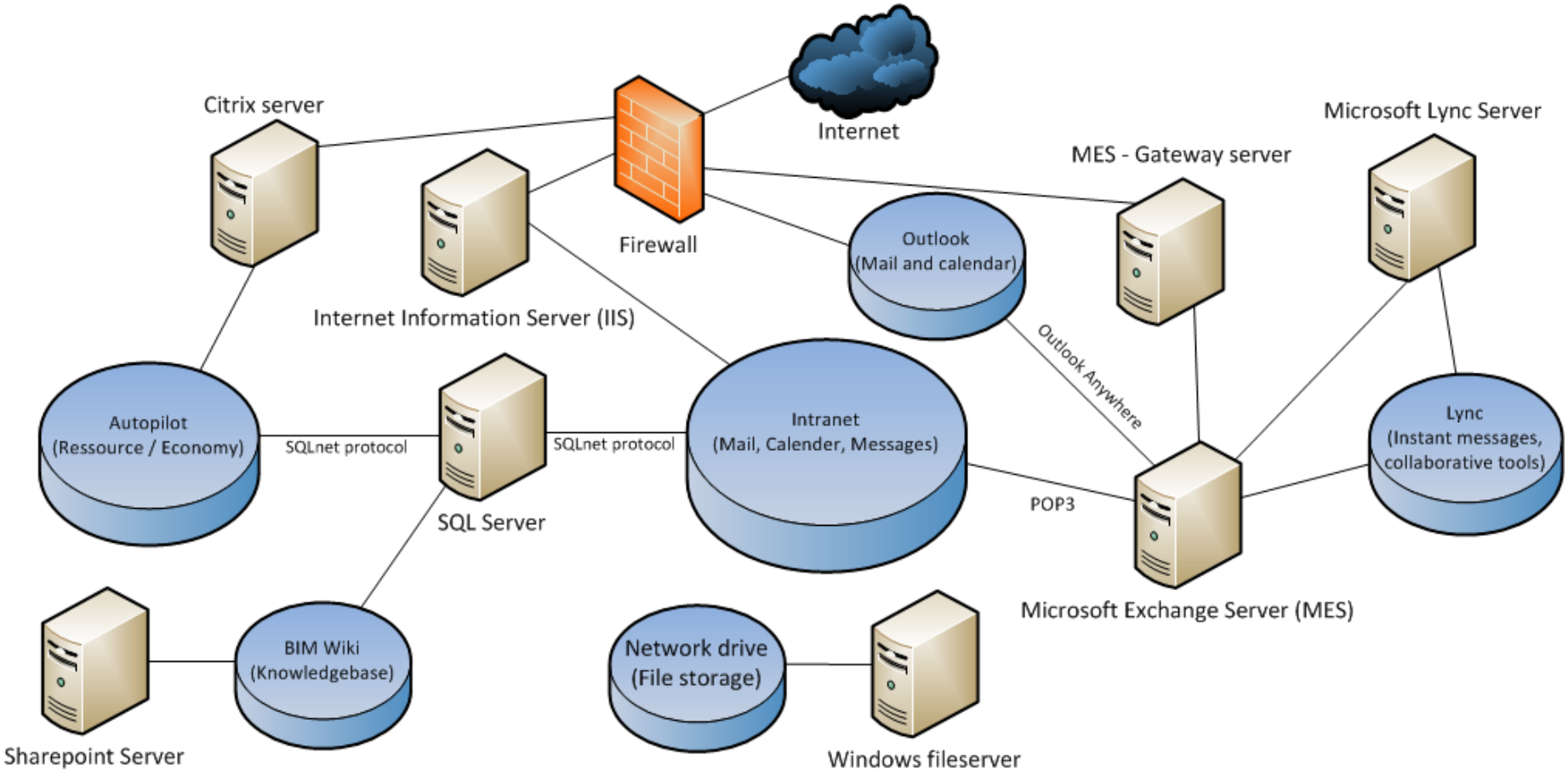


Figure 7: A user-centered view on the IT-Infrastructure (Author 2013)

SEQUENCE MODELING

These models represent sequential steps on how a user preforms a certain task. The sequence is a result of interviews, observation and interpretation sessions. The goal with sequence modeling is to work out what the user is doing to complete a task, consolidating both the information captured during the interviews and the information captured during observation of the user. This will ensure that all important details of the process will be noted, and the possible breakdowns will be better supported. In short the sequence modeling documents the real concrete and real steps the user takes to complete his/hers work. The sequence model consists of three elements:

The step:
The activity that the user did at the appropriate level of detail.

The trigger:
A situation that prompts the user to start at new task, or it can be a new particular step. The trigger always starts the sequence model.

The intent:
The reason why the user did the activity. It can be known or unconscious.

The breakdown:
A "breakdown" is when activities experience trouble during the work-practice, where the practice is not conducted accorded to the intent. An example could be when a learner has to prepare a deliverable and cannot find the original assignment, to work out the deliverable requirement. This is a breakdown, and indicates a possibility of improvement.

The data collected to create the sequence diagrams is based on the data collecting section and can be found in the DVD attached to the thesis, in both sound and video format.

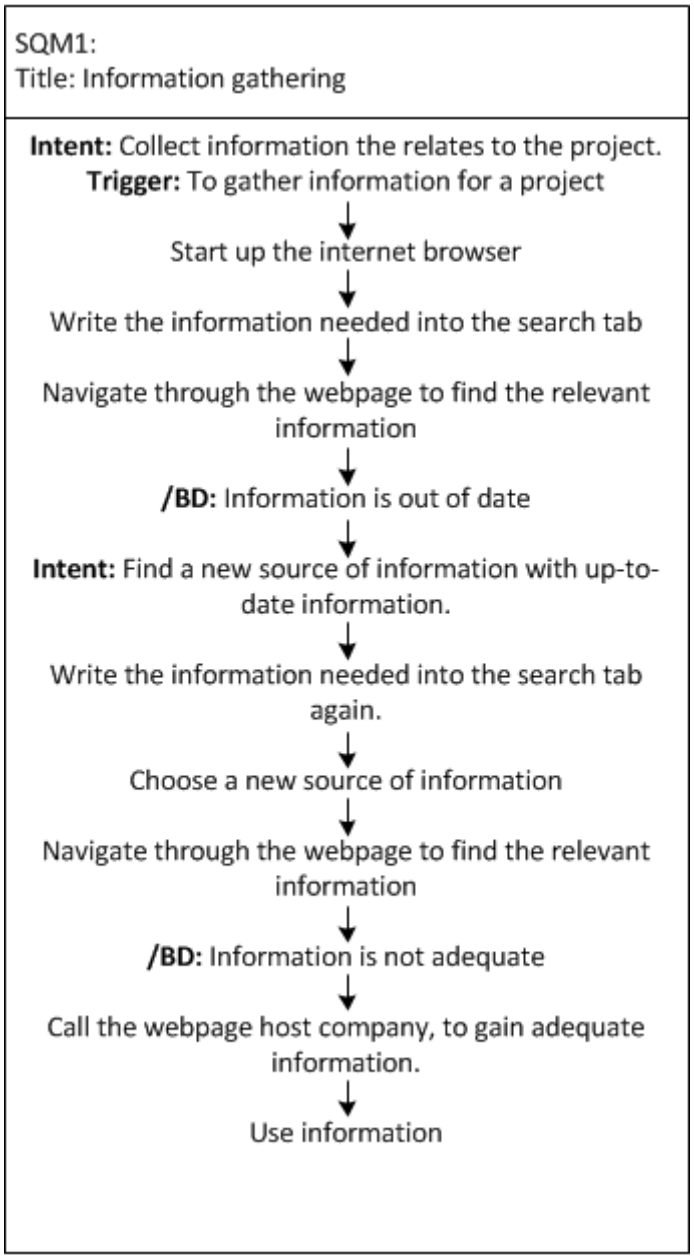


Figure 8: Sequence model 1 (Author 2013)

Analysis of Sequence model 1 (SQM1):

This shows the steps of knowledge gathering. The intent of the sequence model is to collect knowledge for the project, and the trigger is to gather the knowledge. This information can either be found on the internet as shown in this model, or by other means supplied by the knowledge domains supporting the company. The biggest threat is the risk of getting un-valid knowledge, either because it is false, outdated or inadequate.

As shown in the results of the intranet survey, less than half of the employees did know about the minimum free space from the walking line to the ceiling height at stairs according to the Danish building code (Bygningsreglementet 2010). 8 % answered 2,0 meters and 20 % answered 2,2 meter while the rest answered that they did not know.

Most likely this is because the Danish building code defining this, has changed fourteen times since 1995, thirteen of the changes happened after 2001. Because designing buildings is a complex matter, with many aspects it is very difficult and some would say impossible to know everything about every facet of this work-practice, and keep the information ready in the memory. People who answered that the height requirement is 2,0 maybe used their memory from the Danish building code from 1995 to 2008 e.g.

Because it is often a tiresome process of acquiring knowledge about a given area, people tend to use their memory. This is also a factor that people which is under the pressure of time, where they do not find it necessary to acquire knowledge besides what they remember and do make sure that the knowledge utilized is up-to date. Due to the fact that controlling every piece of knowledge that needs to be applied to create an output would generate a huge amount of non-value added time to the project.

As a relation of the information not being adequate, more time is needed to collect and combine the data found on the knowledge environment.

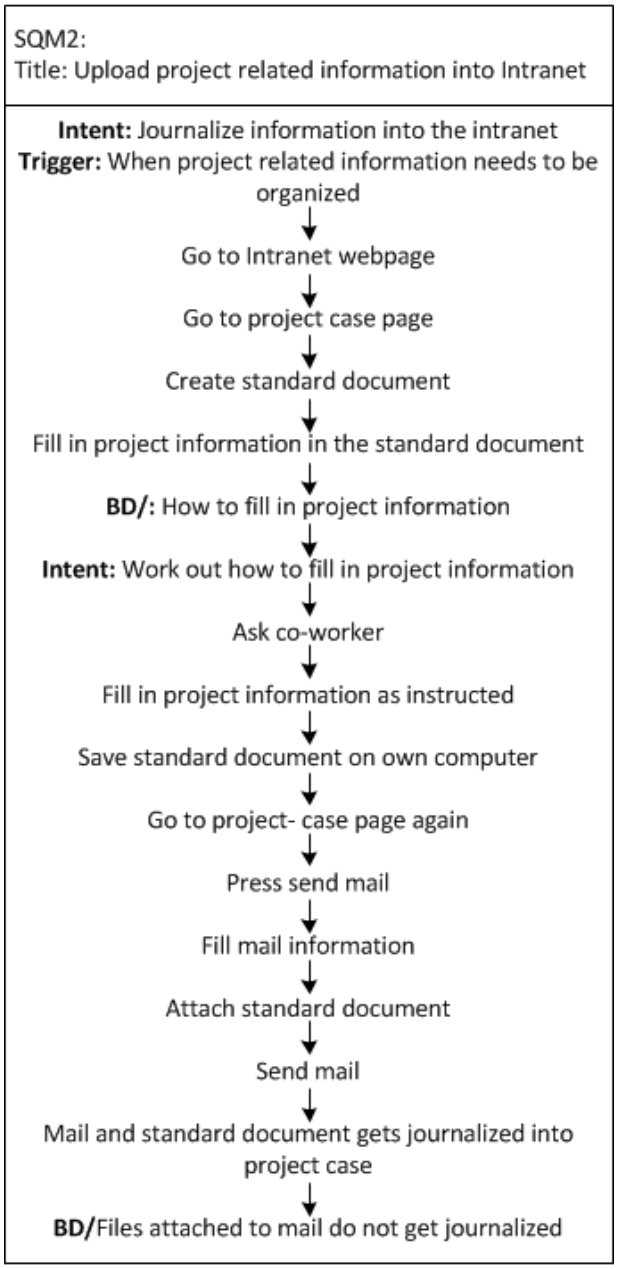


Figure 9: Sequence model 2 (Author 2013)

Analysis of Sequence model 2 (SQM2):

This sequence model shows the steps to journalize external project related information or knowledge to the internal journalizing function, at the intranet. This is done in order to either share it with project group members, or as a safeguard to possible legislative issues that could occur in the future. By not journalizing external to internal project information or knowledge, and if any misunderstandings between the company and the client/ co-operating partner occurs, finding the root to the misunderstanding can be difficult to obtain if not journalized. This is due to the high turn-over of employees. The survey showed that employees only are at the company for a short period of time, before moving to another company. One of the main reasons is also easily affected by fluctuations on the economical markets. And by not journalizing, it could result in crucial information that gets lost in a former employees mail account, which gets shut down when he leaves the company and disappears. A result of this can have huge economical effects on the company.

Tests shown from two employees, one with organized mails and one with unorganized mails took a speed test of how long time it took to journalize a mail could do so between 20-30 seconds. It is important to mention that the journalized mail did not receive any extra information during this process like project information or mail information, which in a normal process would take at least 60 seconds.

"By filling out information during journalizing mails, it can easily take a minute to do, and it is not unusual to journalize 60 mails a day" Interview Lars Christiansen – Project Leader and Quality-manager

This will results in one hour of non-value time added every day. Which basically is 252 hours spend pr. person. This number must be viewed as a general indicator and not a complete truth. Not every fulltime employee in C.F. Møller journalizes 60 mails every day. But still demonstrates how important it is to minimize such activities.

Figure 10: Sequence model 3 (Author 2013)

"The Copenhagen office does seldom utilize the intranet and the functions" Interview Lars Christiansen – Project Leader and Quality-manager

This could be because it can be a process that is time consuming and require knowledge about each step, making it less usable. If nobody forces them to utilize, they might do not see the direct advantage of journalizing at the intranet, and instead keeps the information to themselves.

Analysis of Sequence model 3 (SQM3):

This sequence model shows the steps that need to be taken to contribute to the CAD knowledgebase like BIM Wiki. It is not possible to contribute directly, but has to happen through a group of specialists located at the Århus office.

To contribute you have to communicate to the CAD specialists and explain the experiences learnt, for them to articulate it on the knowledgebase. Due to the tools available like phone, mail, instant messenger it can be difficult explaining the experience, and requires that the employee want to contribute his/her experience to the company.

"It is difficult to get hold of the CAD specialists in Århus, when located in another office" Niels Fuglsang Christensen – Construction Architect

Employees experience that it is difficult get in contact with other specialists in the company, either to contribute or to gain knowledge. It works dis-encouraging for both sharing knowledge to the specialist, and increases the time required to achieve the knowledge needed.

There is no system that facilitates contribution of the CAD knowledgebase directly. To do so it has to go through a CAD specialist. This makes it difficult to contribute, and because of the "bottleneck" situation can demotivate the employee to make any contributions.

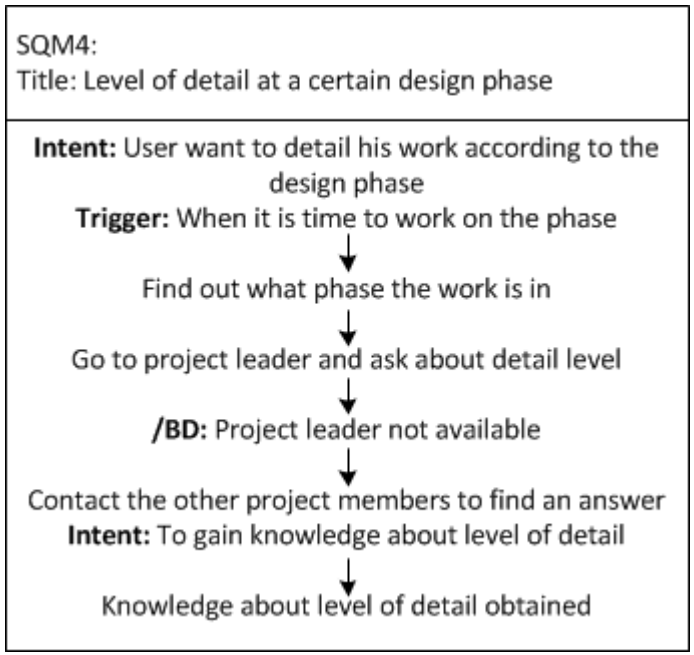


Figure 11: Sequence model 4 (Author 2013)

Analysis of Sequence model 4 (SQM4):

This sequence model shows that the user needs to interrupt and contact group members or project leader to obtain general process knowledge. The reason why the term "general" is included is that it can be comprehensive to explain all the steps and information needed to perform the task needed according to the scope of work. If the asked individual is short on time e.g he/her will be more likely to dump information on the scope of work rather to be engaged and explain the employee the greater perspectives of the project, which is needed to define the scope.

Even though the scope of work is defined it can be difficult to articulate due to the many details included in that, meaning that it is explained on a general level, which often results in detailing the project too much. (Interview Phil Almmanoj – Architect)

FLOW MODEL

This flow model shows the communication between the different internal, external actors and the knowledge domains consulted. The flow model is made to give an overview on how the usage of the knowledge domains is utilized and affected by the company, and external actors. Actors are defined by circles, large squares define IT-systems, that contain the knowledge bases, and the smaller squares are the knowledge-bases.

A flow model of how knowledge is moved around in the company is created to give an overview on the present situation. Shows the communication between users, on how they do work activities. This shows how both formal and informal groups interact, and how work is divided into formal and informal roles and responsibilities. Arrows on the strings symbolize in what direction knowledge flows.

The flow model will consist of "red Z's" to describe when there is a "breakdown" during the flow of knowledge. A "breakdown" is when activities experience trouble during the work-practice, where the practice is not conducted accorded to the intent. It has the same functionality as described in the sequence model explanation.

Shown on Figure 12: Flowmodel of knowledge flows from knowledge-bases to cultures at C.F. Møller (Author 2013), the breakdown icons are marked with a number. Due to the size of the flow model, the breakdowns affecting the flow of knowledge is described in this section. It includes the title of the breakdown, the trigger event that started the need for knowledge, and what the intent for knowledge was. This model is a product of information gathered in the data collection section.

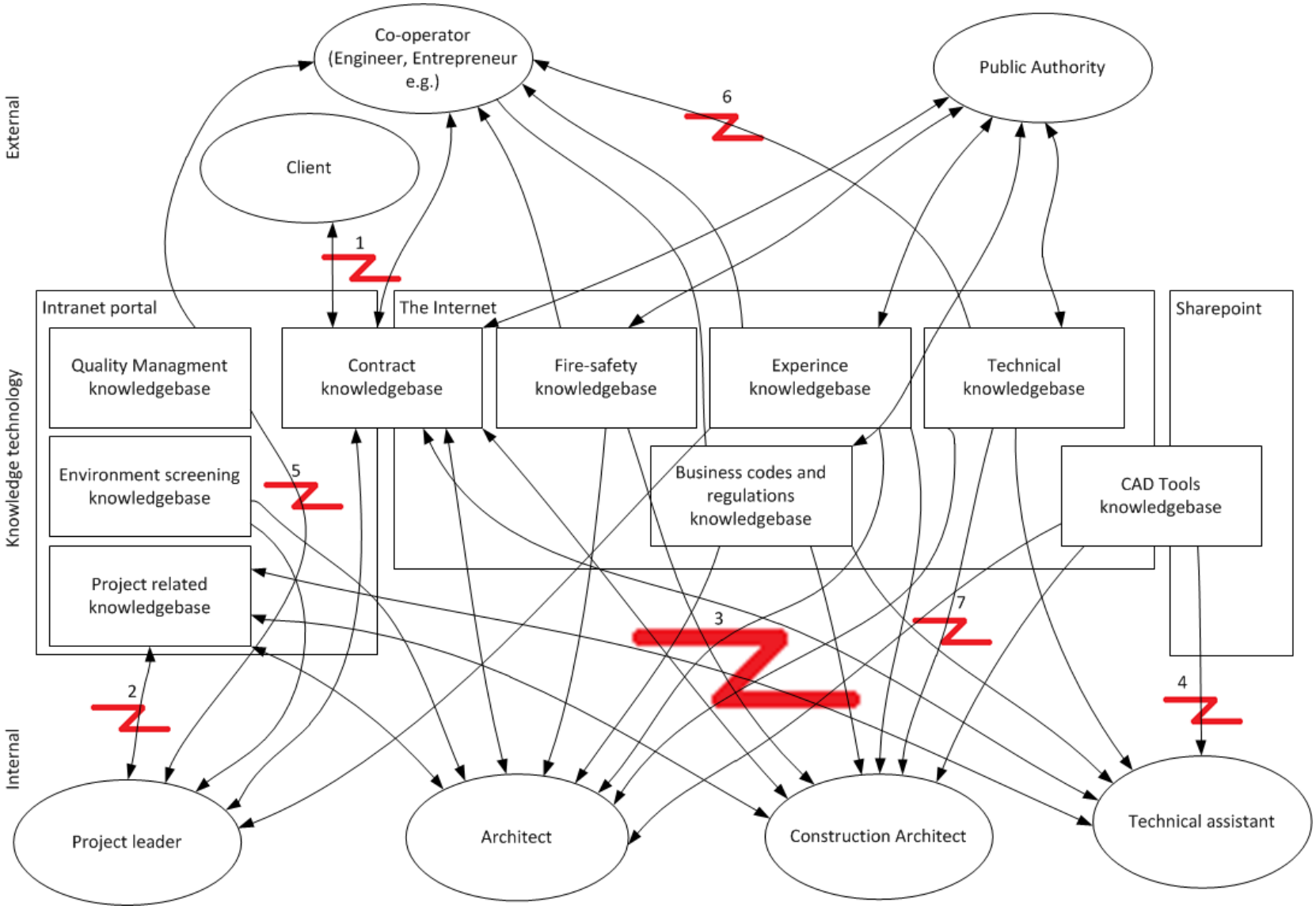


Figure 12: Flowmodel of knowledge flows from knowledge-bases to cultures at C.F. Møller (Author 2013)

FLOW MODEL DESCRIPTION WITH BREAKDOWNS:

1: Client contracts are not specific enough

Trigger:

When distributing material to the client or co-operators.

Intent:

Communicating the design to the client and co-operators.

Breakdown:

The current Danish de-facto scope of work standard description is open to interpretation in many areas. When an agreement gets signed by client and designer e.g. it is possible to determine what is important to include, and what is less important due to project and client context. If there is no internal system of what the different phases must contain, the level of documentation differs, which can result in unhappy clients.

A company with a brand like C.F. Møller is located at many different locations and has different cultures, because they do not have any specific knowledge-base of what each phase contain. Because of this the client will get different levels of material from different offices, though it is the same company. This is basically a chance in the quality of output, which can reflect badly on the company. (Interview with Niels Fuglsang Christensen) Another issue is that the client/co-operator to internal project leader relations differs from project to project. And this relation is crucial in determine what material is needed. Sometimes the client or co-operator expects more drawing material, because he has a different context than the former, and scope changes, and it is subjectively determined besides the general scope of work agreement. (Interview with Nils Frandsen)

”Arkitekt:
• Arbejdsbeskrivelser og tilbudslister
• Tegninger omfattende hovedtegninger, oversigtstegninger, bygningsdelstegninger og detailtegninger
• Ajourføring af beregning af etageareal og bebyggelsesprocent.” (PAR og FRI’s ydelsesbeskrivelse – 2012)

The quote above is from the de-facto standard of scope of work in Denmark and describes the general scope of work for an architect during hovedprojekt (Main project). The scope can vary from a few drawing to thousands. The scope is often built of former experiences that can be difficult to determine, due to project complexity and context.

2: Some Project leaders are not motivated to upload project related material.

Trigger:
To solve dispute after/during a project with co-operating companies or working with a project.

Intent:
Journalizing project information, in order to keep the employees working on the project, up to date with the latest information. And to ensure documentation for eventually future legislative claims.

Breakdown:
In some cases misunderstandings, errors or other factors lead to incompliance between the company and other co-operating parties. Then it is necessary to go back in the information sent to take a second look at the information sent to one another, like mails, drawings and so forth. The company does already have an intranet portal to facilitate this, but the Project leaders do not always remember or feel motivated to upload mails or they do not feel it is giving more value to their project right away. The journal is only an efficient tool, if the necessary information from the client, entrepreneurs, engineers and other co-operating parties are present. Finding a mail in the inbox that can solve the dispute, can be like finding a needle in a haystack, being a time-consuming event. (Report of how much the intranet has been used C.F. Møller, located in the appendix), (Interview Lars Christiansen)

3: Complex web of information-gathering.

Trigger: To gather information for a project.

Intent: Collect up-to-date information that relates to the project.

Breakdown: As shown on the flow model, even with a cut down number of knowledge-bases there are many different places to find information about a certain subject. Not every company culture needs the same information, and the information needed differs from project to project. With high numbers of different places to look up information, at different technological frames, it can result in differences in the quality of the information sought.

Another issue could be that the information is incorrect, or not updated according to current regulations. This can happen if the user looks up fire-safety on an internet search machine. This triggers many results, some more valid than others. Often educated people will find the correct place for the exact information, but is not always the case.

If a specific question is formulated inconsistent at a given knowledge source, and it is necessary to look for additional information elsewhere. Employees end up finding information different places, and sometime the information is outright wrong, because the information is not correctly formulated. (Interview with Christian M. Johansen)

4: It is not possible to contribute to the CAD knowledgebase.

Trigger: Work cannot be completed, due to lack of knowledge about CAD.

Intent: To gain knowledge about a certain problem during CAD designing.
Reuse of CAD knowledge.

Breakdown: Sometimes it is important to have knowledge about a CAD issue to continue designing. When you have worked out the problem, either by contacting a colleague, finding the information in the company CAD knowledgebase, or by looking at different internet knowledge-bases explaining how to correct the problem. This can be a time-consuming action finding the right information, placing it in the right context. When you or other colleagues have to look up the same issue on the internet, a lot of time will be wasted. (Interview with Niels Fuglesang)
In a knowledge creating company like CFM, acquiring the right information at the right time is essential to ensure maximum efficiency. The current environment requires the employee to re-invent solutions to the problem again and again, even if the neighbour has the solution. But the system does not support an easy way for the employees to contribute to a CAD knowledgebase, besides contacting the CAD specialist at the Århus Office, which seldom have time to absorb the knowledge.

5: Project leaders do not use material about Quality Management in the intranet portal.

Trigger: When work is done, quality management is necessary to ensure quality of work output.

Intent: To secure quality of the output of the company.

Breakdown: According to the survey presented earlier, the interview (Interview Lars Christiansen) and numbers from C.F. Møller (Print of the downloaded numbers of the standard documents can be found in the appendix.) showed the number of times standard documents has been downloaded was very low. The standard documents for Quality Management seldom get used, and Quality Management is in general randomly conducted. When not utilizing company standard documents or when the employees do not know about company standards for quality management, the level of quality can fluctuate. Some people do not bother utilizing company standard quality management on their project, to assure a level acceptable by co-operating parties, resulting in disputes affecting the overall outcome of the project, a loss in external quality.

6: Difficult to preserve overview.

Trigger: Handling the many aspects of design, communication e.g. can make it difficult to preserve an overview.

Intent: The intent is to keep track of economy, time management and other critical aspects of the project, which is important to ensure project success.

Breakdown: Both C.F. Møller and WhiteSpace architect claimed a loss of overview of the project was a common issue. With high complexity, limited timeframe, change in client demands and needs, with many participants the loss of overview will often occur.

Due to the difference in size of the two companies there is a difference between which systems the different companies have available to create an overview of the project. C.F Møller has tools to support overview of project communication from the intranet function "project journal". This can give project members access to crucial mails that the project leader shares, or from other members. Where Whitespace relies on a close internal co-operation between the project members to ensure that information in continuously shared, and overview is maintained, hence this is not always the case. When employees are burdened with a short timeframe, and many issues to attend to, then the overview can fade away. (Interview Phil Almmanoj and Sutut Sakkhamjdhn – Junior Architects, Ton Kmutt - Project leader 2012) (Interview Lars Christiansen C.F. Møller 2012)

7: Level of knowledge detail and scope is too Low/high.

Trigger: When an activity needs to be finished.

Intent: Employees to finish an activity at the right scope.

Breakdown: Loss of productivity due to unnecessary detailing in projects. / Lack of project detail.

The interviewed employees at both companies (C.F. Møller and Whitespace) had similar problems of defining the scope of work at an activity. At a general level the scope is defined de-facto in Denmark PAR og FRI's ydelsesbeskrivelse 2009. But this scope is open to interpretation, and at a specific scale the interviewed experiences difference in scope throughout the company. The level detailing is based on former experiences from projects, and co-operators. But level of detailing is not always the same, in regards of both the need from the client, or the co-operator. Often the employees will increase the level of detail to a higher level, to be sure that the receiver will not be misunderstanding the information sent. (Interview Phil Almmanoj and Sutut Sakkhamjdhn – Junior Architects 2012), (Interview with Christian M. Johansen) (Interview with Nils Frandsen)

DIAGNOSTIC CARDS

This tool will list the issues and possible solutions concerning the primary and secondary business-case. Problem related to the hypothesis and will found the basis for mapping the issues. The tool is meant as a base for summing up the possible problems, causes, consequences and ideas for solutions for the project problems. The data in this will work as the foundation for the problem tree that will define what the new IT-system will counter, and hence that, create the new problem definition. Data for the cards in the category in problem, cause and consequence is summarized from the latter chapter. The ideas for solutions are both interviewee and author's ideas for solution, which is later utilized as a focal point to find relevant theory to counter the new problem definition.

The problems cause and consequence listed, is based on the material outlined in the previous chapters. Ideas for a solution are a result of brainstorming during the interview on how to counter the problems, which is utilized in the solution tree e.g. For more information and citations, look in the appendix.

Number	Problem	Cause	Consequence	Ideas for solutions
1.1	Difficult to prioritize communication like mails. What is the most important mail?	Non-prioritized communication. The mailbox is like huge basket where communication is flowing into. Level of importance is determined manually every time receiving a new mail. Project leaders get a lot of questions related to work-practice and processes during a project which can be difficult to control.	Increase in project-related stress, loss of total quality and lack of overview.	To reduce the need to communicate by mail to the project leader, the processes of activities could be standardized to gain knowledge of company work-practice without having the need to ask to the project leader for work-practice. General communication could be limited due to this. And reducing the amount of internal mails e.g.
1.2	Experience gained from projects do not get shared in the company.	Lack of time and overview is the most common reason why the employees say that they do not share the project experience. The gains from the experiences cannot be measured easily and the improvements are often acquired in other domains than the employees own.	Misunderstandings, design errors e.g. are not corrected due to the lack of sharing the experience. The problems occur again at some point and will be a source of unnecessary project expenses.	A more effective IT platform that facilitates sharing of experiences throughout the company according to company strategy, work-practice and cultures.

Number	Problem	Cause	Consequence	Ideas for solutions
1.3	Little or no re-use of experience or material from former projects in new projects.	When there is no system for re-use of digital project material like project specific objects (Like custom made Revit families).	The information has to be created once again, which will result in redundant work. This is relevant for custom-made documents, Revit families or alike.	Make a platform that support and gives an incitement for sharing project experiences. This should be as visible as possible to ensure that the experience lodged, will get attention throughout the company.
1.4	Only sub-conscious re-use of experiences in projects.	Knowledge is implicit and difficult to express.	High level of re-invention and ineffectiveness. Will not be able to share experience throughout the company.	Make the tactic knowledge visible through visualization, and other means, and make the knowledge available throughout the company.
1.5	Lack of overview.	High complexity, limited timeframe, many project parameters to account for.	Increase the rate of redundant work, and errors. And will increase the internal risk of sub-optimizing.	Centralize project information within one platform if possible.
1.6	Lack of communication during the project.	High level of stress and lack of overview limits the communication between project members.	Increase the rate of redundant work, and errors.	Increase the informal incitements of communications by facilitating groupware functions in the solution.
1.7	Little of no training of new employees – learning by trial and error.	Lack of time to guide new employees due to stress and limited time for other activities caused by project.	Increase the rate of redundant work, and errors.	Make work-practice maps that can explain the company work-practice.
1.8	Difficult to grasp scope of work and detailing.	Time spend on defining scope of work is limited, and material supporting this is coarsely detailed.	Increase the rate of redundant work because of unnecessary detailing, or the product will suffer of an insufficient level of detailing that could increase the risk of construction errors on the construction site. And unwanted solutions, which could result in a lower level of external quality.	By mapping work-practice, the scope of work gets more tangible.

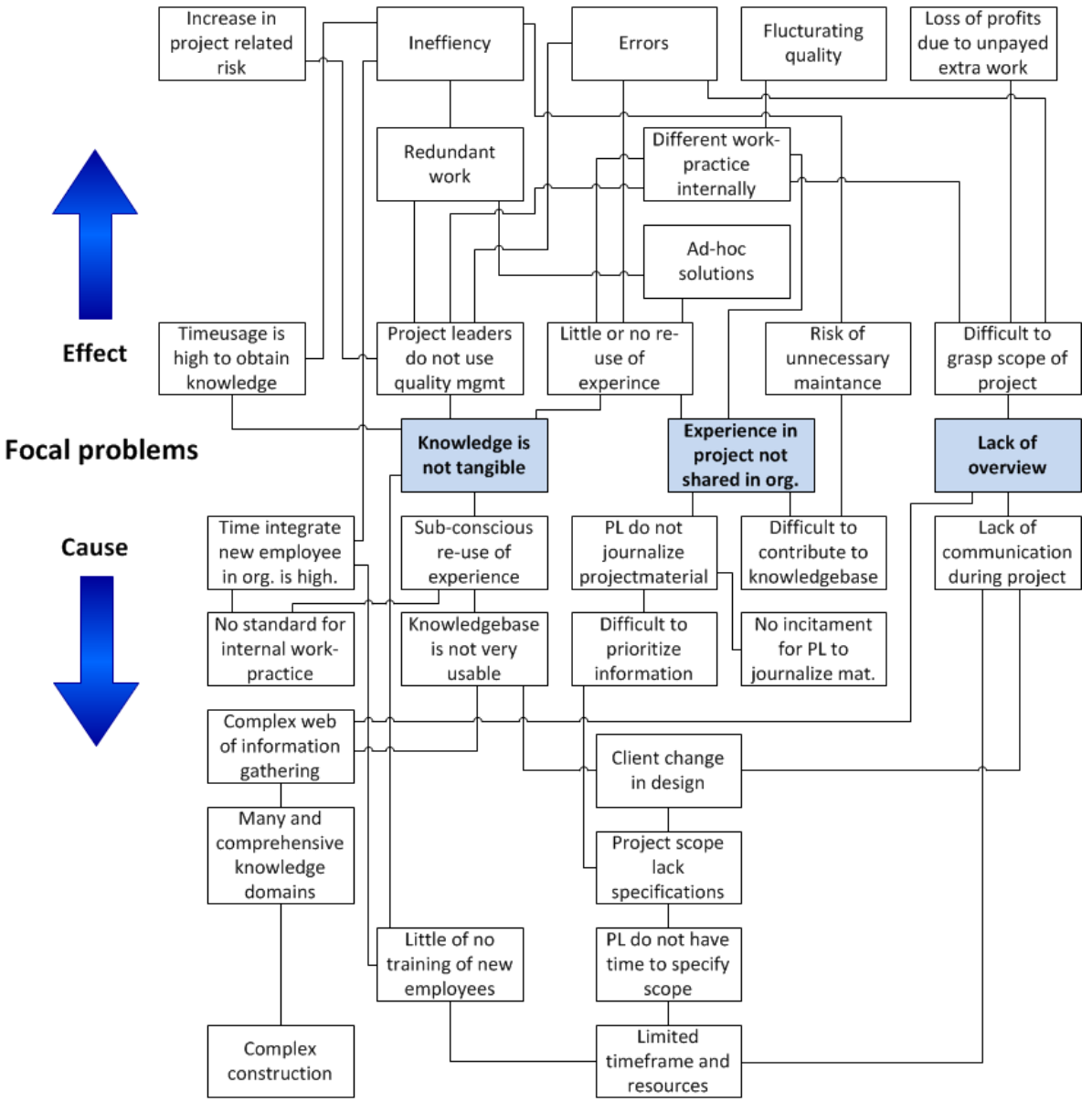
Number	Problem	Cause	Consequence	Ideas for solutions
1.9	Client changes in design.	The project scope is lacking detail in scope due to high number of activities and generalized de-facto standards supplied by PAR and FRI's ydelsesbeskrivelse (Scope of work description).	Lost profit on extra work done to the client due to unspecified scope of work. Increase of stress during the project.	If the work-practice is mapped, it can be easier to explain to the client what is included in the offer based on the work-practice map.
2.0	Complex web of information gathering.	Many knowledge domains to obtain information from.	The risk of obtaining the wrong information and usage of time to acquire is high.	Centralization of information.
2.1	Project leaders do use company material about quality management located at the intranet.	The material created by the company is not visible enough, and too comprehensive to grasp.	Employees create ad-hoc solutions for quality management that might not match company standards, which could result in construction errors and legal issues.	Design the quality management material with a high level of usability, and give the user an incitement for using the company quality management instead of creating ad-hoc solutions.
2.2	It is not possible or difficult to contribute to the knowledge-bases.	There is no system to facilitate contribution to the knowledge-bases. Contribution happens by direct communication with the employees responsible of capturing the knowledge.	The task of maintaining the knowledgebase gets too comprehensive and expensive for the company. The employees will not be keen enough to use the knowledgebase, due to lack to "ownership-feel".	Make a framework that supports user contribution for the knowledge-bases. This will insure lower maintenance fees for the knowledge system, and growth in employee happiness, by increasing "ownership feel" hence professional acknowledgement.

Number	Problem	Cause	Consequence	Ideas for solutions
2.3	Some Project leaders are not motivated to upload project related material.	There is not direct incitement for the project members to journalize the mails if the level of communication outside the intranet is functioning. The advantage is not visible before problems occur. The process of uploading project related material requires many steps, and is a time consuming process, and documents attached to the mail is not included in the journalizing.	During the project period information needs to be spread out to the project members, it is crucial that the right information gets to the right employee. If a project leader does not journalize the mail correctly to the centralized communication platform like the project journal e.g. errors will occur during the project. It can also increase the risk of legislative issues if claims should appear later in the process and finding the right e-mail from the co-operator is impetus.	Give the project leader incitement to upload project material, and make the process of doing so as easy as possible.
2.4	Different work-practice internally.	When no standard for work-practice internally is present, people develops their own work-practice based on former experiences and culture.	This will result in difference in external quality due to the difference of how the product is created.	Create a work-practice map that can help standardize it, throughout the company.

PROBLEM TREE

To define the causality of the problems and how they affect each other, a problem tree is created. It provides an overview of all the known causes, and how they affect the environment. This will form the problem context that will form the problem definition which the rest of the thesis is formed upon. The analysis of the problem helps break down the problem into more manageable pieces, which can help prioritize and understand how the problems interconnect.

This problem tree is showing that the focal problems is formed around three separate issues. Knowledge that is not tangible, experience that is not shared through organization and a general lack of overview. Even though the natures of the three issues are different, they have interconnected causes and effect. To improve the negative effects shown in the top, it is crucial to focus on the three focal problems, by eliminating or reducing the causes.



PROBLEM DEFINITION

As defined in the problem tree, it summarizes the focal problems, which will be the point of what the IT-solution must facilitate, in order to increase total quality. This is based on three notions that have been modified from the initiating problem definition according to the new gained knowledge. The tree focal problems are the basis for the definition of the general problem definition, and the three sub-problem definitions.

How can knowledge creation supported by IT in a construction advisory company achieve better internal process, in order to increase overall total quality?

With the definition of the main problem in the thesis it is necessary to find a solution to the 3 sub-problem definitions, defined in the problem tree.

1. **Creation of knowledge: How is it possible to increase the level of overview for everybody assigned to a project?**
   The current practice is not optimal for creating knowledge. The knowledge is not always tangible, available, or accessible, due to the listed other sub-problems. A system is needed to facilitate people to help them create the necessary knowledge according to scope of work.

2. **Representation of knowledge: How can knowledge be visualized to gain a better understanding for the employees?**
   Knowledge within in the company is often intangible because the knowledge used at the projects is based on sub-conscious tacit knowledge, which can be difficult to transfer with the current collaboration tools available.

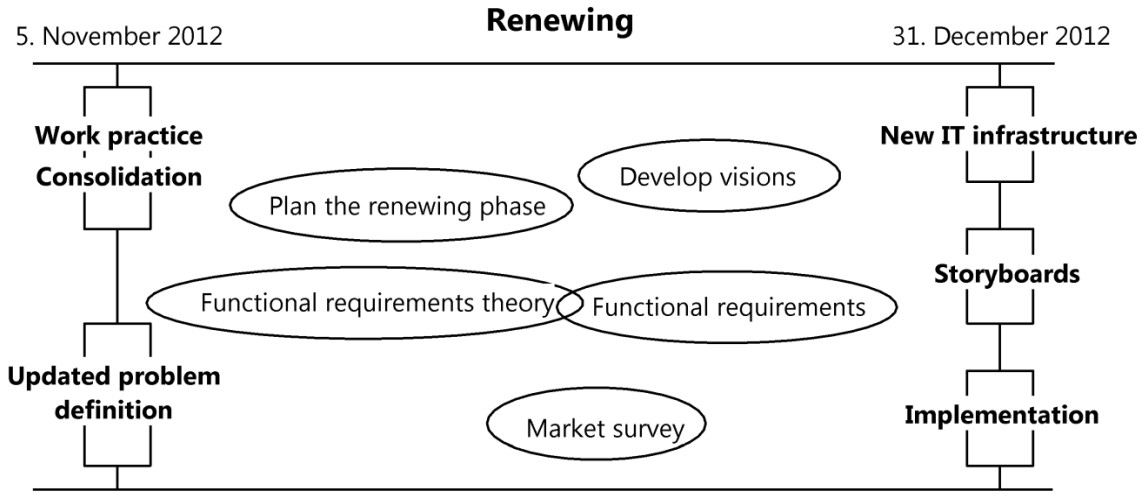
3. **Usable knowledge**: **How is it possible to make knowledge acquired by the company usable?**
   When the knowledge is not tangible, it is because the available knowledge is incoherent, and difficult to obtain. This has been identified because of the lack of overview, due to many separated knowledge elements and difficulty of communicating it. This is rooted in a general level of limited timeframe for the project. Besides that the current knowledgebase is deemed somewhat un-usable.

Chapter 6 RENEWING

This part is about the understanding of how the problems can be transformed into solutions by inventing new processes with the use of IT. IT is now possible to utilize the collected data to work out, how to improve existing processes and issues. This improvement will happen through facilitating new technology to streamline the old processes, or inventing new services to support the existing market.

This is done by presenting theory, which counters the issues presented in the problem tree. The renewing will include a vision, which will be a story, in how users will use the technology in the new context. This means that the vision will have a system, delivery and support structure that strives to make the new work processes successful. The visioning will happen on a rough level, which will not focus on small details, but the new "general" processes, and a plan on how to initiate the implementation.

The vision intension is to set a direction for the design team, without solving every detail and enable the design team to get an overview of the whole solution to secure the consistency.

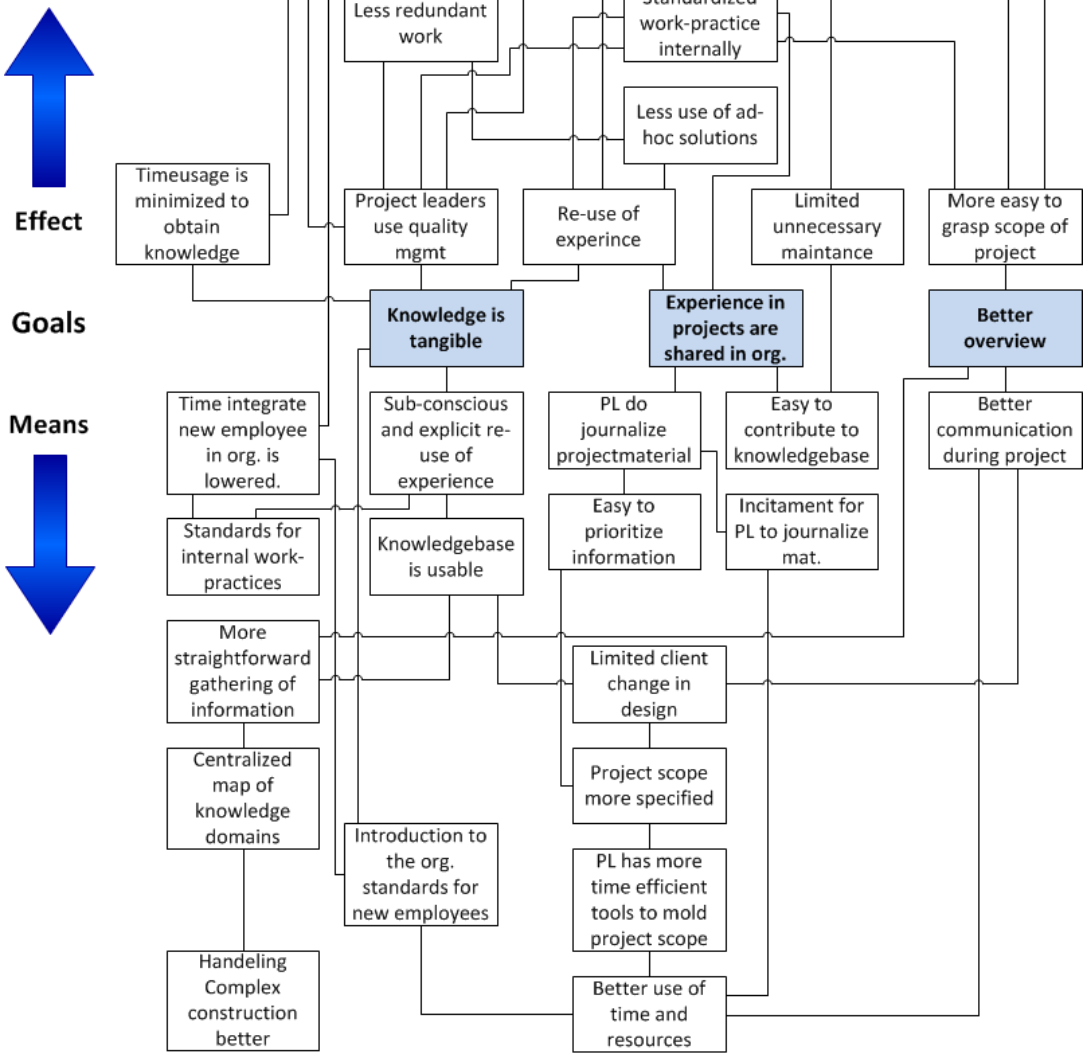


SOLUTION TREE

To counter the issues crystalized in the problem tree, a solution tree is created. The solution tree is developed with the idea of reversing the negative statements that is formed in the problem tree to try converting them into positive ones. The solution tree works by breaking the solution into the means of solution. (Delavic, 2011)

The objective with the thesis is to counter the global issues concerning increased competitiveness. To counter these issues it requires an increase in total quality. The goal tree shows what objectives need to be met, like reduction in project related risk, less inefficiency e.g. based on the goals that are needed to be met for this to be successful. For the goals to be fulfilled the depth analysis provided a context of what is needed to be resolved in the design of the IT-solution. The solution tree, gives an overview of the thesis objectives, goals and what means are necessary.

The following chapter will be based on how we can fulfil the goals defined in the solution tree to gain the aimed effect, the increase the total quality, hence general competitiveness.



THE BRIDGE – INTERDISCIPLINARY EXPLANATION

In order to successfully change the current practice, this contains the issues defined in the problem definition, and how to solve it, defined in the solution tree. As shown on the illustration three main solutions must be facilitated in the solution to close the gap. **Error! Reference source not found.** is a metaphoric figure that tries to explain how the solution is thought to be solved.

The current practice, foundations that supports the pillars, possible IT-solution and how the increased total quality, is all built on the notion that construction is a complex matter, in both physical and psychological form. In order to bridge the gap between how current practices are conducted as described in the Depth-analysis chapter the possible IT-solution that must be supported by the three foundations and pillars displayed. Both the pillars and foundations show the interplay of interdisciplinary subjects that affects the IT-solution. This theory on this interplay from the different subjects will support the Possible IT-solution and create a bridging solution that can facilitate a transition of the problem load to the other side of the river, and result in increased total quality.

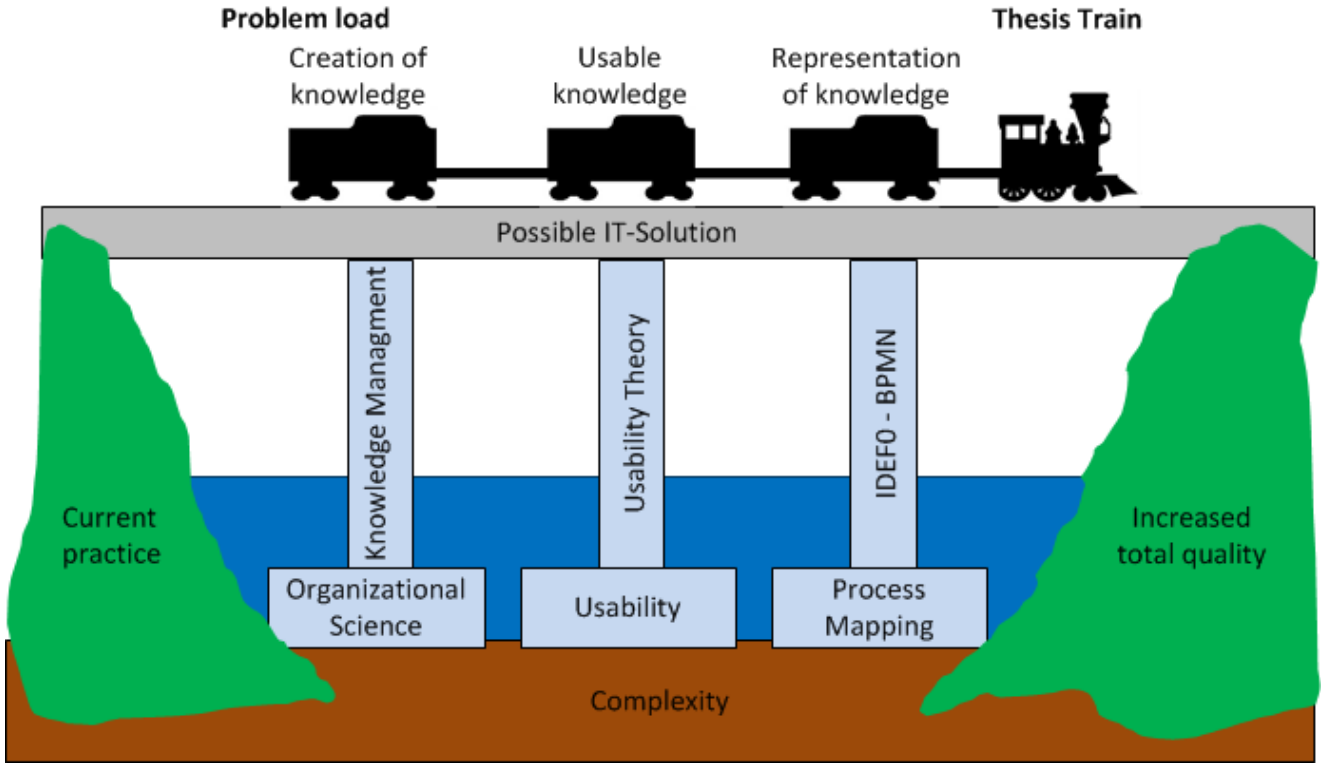


Figure 13: The bridge that must bring the company from current practice to increased total quality. (Author 2013)

COMPLEXITY

This section will try to explain how complexity in general and split as psychological and physical complexity has a huge influence on how the current work-practice is conducted, and how it is possible to change it to increase total quality. Everything is affected by the complexity, how people perceive construction, communication and knowledge. How the physical aspect of constructing a building is a great deal more complicated than producing a car in a factory, hence the difficulty to apply organizational science.

As seen in the depth-analysis section, one of the main factors to why employees had a difficult time to keep an overview of the project, was due to the complexity of it. This is the reason why that the thesis looks at what complexity is in relation to the physical construction complexity and the psychical complexity, both having an impact on how processes are done, and affects everything related to this thesis. If construction was not complex, or as complex as it is at the present, it would be easy to apply Lean construction and other theories to the creation, and the AEC industry could achieve the same increase in productivity as the other and less complex industries as shown in the introduction.
The goal for this section is to comprehend how complexity is related to the whole construction industry's practice, and what theory concerning how to better understand it. This can help explain what it is how it can be reduced or controlled and how to make the IT-solution facilitate work-practice that can counter the vast complexity.

Merriam Webster on Complexity:

"A whole made up of complicated or interrelated parts".

Why this subject is so difficult to handle, is shown in lack of productivity has many researchers named the issue to the complex nature of construction. (Dubois Gadde, 2001 et al.) The same issue applies to the nature of human behavior. Our mind is a very complex matter, which play a big part in how we act in a working environment. In this section I will try to describe some notations on how to understand what and why both areas affect the overall complexity of the construction process, and how to improve it, through the IT-solution proposal.

CONSTRUCTION COMPLEXITY

Some might argue that comparing the complexity in the construction industry with Nano technology and other life sciences industries, construction of buildings is somewhat simple. Anyone is capable of creating a building, but only a few people have been able to crack the DNA code. But construction is not what it used to be, and complexity of it, has increased immensely the last decades. An example could be that in resent time, design and construction of buildings has been increasingly more difficult to comprehend and a complex matter. In Denmark the legislation for heat loss e.g. in buildings has been changed and raised two times in the last few years. (http://www.bygningsreglementet.dk/br10_02_id104/0/42) and by adding up the rest of the changes in legislation, new technology, different co-operators, changing designing tools, unique client demands, change in construction localities e.g. it is not as simple as maybe first perceived.

The construction business has been characterized by the complexity of modern buildings; we see is getting created today. Increasing demands of performance and design cause more comprehensive building codes, advanced components, procurement methods and increasing client demands. In general every building is characterized by the one-of-a kind type product, with many different consultants, companies and contractors with different cultures. (Teicholz, 1997) If you combine the number of possible permutations with the combination of location and entities the variations are almost intangible. This has led to reinventions of more or less standard solutions again and again as the construction business continues to build new houses and buildings. (Gidado, 1996) With the complexity of buildings, the different ways to solve issues concerning the production of the building from the earliest phase to the demolition is nearly infinite. And there is not one single solution to each issue. With the complexity of the building, the risks of making mistakes during the different phases through a buildings life, increases proportionally to the level of complexity.

As written in the beginning of the thesis, the productivity in the construction industry is not performing as well as other industries, and is in general blamed the industry is blamed for inefficiency in operations which focuses in short term perspectives and which drives sub-optimization. This is hampering development in the innovation and technical aspect. (Dubois Gadde, 2001 et al.)

This complexity is often based on the means to strive for the perfect human environment. The complexity rose gradually from the beginning of the later centuries where we had the introduction of electricity, running water, gas e.g. with these amenities there followed several possible hazards. (Mahadev Rahman, Complexity in building design)

When you have running water, you need to protect the structure from leaks, to prevent fungus. When you have electricity and gas you need safety installations/materials/planning to prevent fire, and so forth. Because of these hazards many countries strive to reduce the hazards with the building codes, creating a web of complex directions and procedures that need attention of specialists handling each topic with upmost attention.

This thesis builds on the following definition on complexity (Homer Dixon 2000) (Interview Thomas Busk Bech).

- **Multiplicity**
  Number of components. Building projects as described contains many components to facilitate the human needs.

- **Casual Connections**
  Buildings components has a high number of links between components, often the links between components are very comprehensive.

- **Independence**
  The larger the module that can be removed from the system without affecting the systems overall behavior, the more resilient and less complex the system. In construction projects in general it is rarely possible to change a module without it affects other modules. And sometimes errors occur because it is difficult to maintain an overview of what modules affects each other, due to the high number of components.

- **Openness**
  To outside environment, not self-contained, difficult to locate boundary.

- **Synergy**
  The degree to which the entire system is more than the sum of the parts.

- **Nonlinear behavior**
  The effect on the system is no proportional to the size of the change to the component.

Relation to the IT-solution

With the notion of high complexity of the projects due to client demands, co-operation partners, legislation and materials from a theoretical standpoint, matches the problems described in the Depth-analysis section. It is a clear conception that this level of complexity must be facilitated into the IT-solution to make it comprehensible and increase the overview of the many factors included. It will not be possible to reduce the numbers of entities e.g. that demands focus and are vital to maintain the overview, but try to collect as much vital information and knowledge as possible, and at some areas can automate the creation of knowledge. In the concrete aspect it will be linking the different knowledge-bases together and form a system that can collect the different information, data and knowledge to a center, to form a higher notion of knowledge, based on the perception of the user.

While not possible to reduce the complexity of construction, the IT-solution must facilitate a process built on this complexity. It has to be dynamic, due to the nonlinear behavior, and must be able to contain AEC based knowledge built on a high numbers of components and links, which is interrelated. The level of openness, has to be made more explicit, in both terms of scope of work.

PSYCHOLOGICAL COMPLEXITY

Back in 1797 the German philosopher Emmanuel Kant, formed the notion of the modernist mind of the human being. In his work, "The Categorical Imperative", he describes the human as an autonomous individual that act accordingly to own reason and objectives. (Immanuel Kant, Metaphysics of Morals 1797) Kant also suggested that each individual was a part of a system, which has been the base of nature and organizational science. Kant defined a system as a bounded set of self-organizing, interacting parts which produce both themselves and an emergent whole. This section will present theory that can help the IT-solution to counter the complexity of the human mind.

Human "as-if" part of a system of causality

The idea is that an individual interacts with its parts, to produce a bigger system, gradually. An example could be the leaf which act based on placement of the branch, and rotates accordingly through placement and location of the sun, the branch is interacting with the trunk and so forth, which created a tree leaning towards the sun. Every part of the tree act accordingly towards its egoistic gain, and that is how the it ends up forming the tree itself. This idea was formed by Kant, imposing that sub-parts, defines what the system is. (Immanuel Kant, 1797) This notion is applicable to understand the company in the same way. The organization is nothing without its employees, and without them the company is only empty chairs, computers, and machines. It is because when the employees are present they are the organization, and how they act affects how the company acts. This is the concept of causality which forms the base on how processes are conducted in the company. (Stacy 2007)

In order to make a company act coherently, the employee must be presented to an environment that supports how the employee do his/her work-practice. If it do not support the work-practice, he/she will be most likely not to act with the environment, but develop it in his own direction, to act in accordance of own egoistic needs (As shown in the depth-analysis that people invent their own solutions if they do not feel it supports them).

Human perception of knowledge

Kant also described the theory "transcendence philosophy", which describes that the human conscience has a natural tendency to organize events in systems of knowledge. This happens automatic, and states that we could not have perceptions without a naturally taxonomy. (Kant, 1787) It is based on this notion that we act based on the current level of knowledge accordingly to own reason. Hence the importance of having the newest and current information during an action is vital.

Everybody knows that it is impossible to know everything, but it is important to have updated critical knowledge about the employee area of work, which is it a big part of an employee's professional career. Today we have numerous tools to facilitate this transportation of knowledge, to make it easier to acquire knowledge, so we can spend more time on value increasing processes.

Magico-mythic thinking

Back in the pre-scientific days where people living in the west, experienced nature as a mysterious force that acted upon them with great violence, and put them in situations of great anxiousness filled them with emotions, which made the people less capable of reflecting about the context in a broader perspective. This anxiety was the product of what sociologist Elias called the Magico-mythic thinking. This magico-mythic thinking lead to understanding nature as an impersonation of good or evil in a shape of a personalized god e.g. which leads to explanations where people acted in acceptance, submission and conformity. It is here that Elias claims that the modern way of thinking organizations in the magico-mythic way, is similar to the way how people experienced the nature back in the pre-scientific days, because it is difficult for the individual to think in a detached sense, and look at things in the bigger perspective.

"People come to talk about social forces acting on them and organizations as "thing" that exists outside their interaction." Elias (1998)

"Social scientists talk about societies, institutions and organizations as "wholes" or "systems" which is the creation of a mystery in order to solve a mystery. What he calls for to generate an alternative, more detached mode of thought, is a focus on the actual processes of our interdependence." Elias (1998)

He notes this because the mainstream organizational and management literature has a tendency to promote this Magico-Mythic thinking. The literatures cover the Magico-mythic explanations with rational sounding language, and thereby convey an illusion of control, but in reality do not change what is going on in the organization. In the end the employees are settled with a sense or illusion of someone in control.
As Elias points out, it is important to operationalize the strategies employed to achieve an actual change in strategy. New management strategies must be operationalized through changed processes. For this to happen, the IT-solution must ensure that management strategies are made operational through changed processes. If Management "declares" a new strategy, the change is not likely to be transferred into the business processes, and the strategy will be rendered useless, besides creating an illusion of management in control.

Psychological complexity and the IT-solution

With these 3 notions on psychological complexity explained, the notions must be incorporated into the IT-solution. The solution must facilitate an environment that benefits the employee and his/hers processes. They must gain an experience of improveing their work, which makes them better employees. If the solution succeed it must happen through incorporating the primary case strategy into the system, so the strategy gets facilitated through the new processes deemed by the arrival of the IT-solution. It not, the strategy will only be words, and not change company efficiency.

KNOWLEDGE MANAGEMENT

Companies like C.F. Møller, Whitespace and companies alike are built on the same principle of production. Instead of machines to make the produce, it is the knowledge worker. It has been said that besides the traditional resources for any kind of production, labour, capital, land e.g. knowledge is THE resource, and being the essences of money and muscle power. Because of this, the hunt for knowledge and the means of communication is the ultimate replacement of all other resources.(Toffler 1990) Knowledge is power (Newsweek, June 14, 1993)

Regarding the thesis the main problem defined is how knowledge is managed in the cases. Both companies had problems of capturing knowledge from previous projects and containing it, into the organization. This resulted in errors, redundant work and in general a decrease in company productivity and competiveness. The IT-portfolio used by C.F. Møller has a frame for lodging knowledge, but was not used as much as specified. Without being able to share and size the knowledge, it is difficult to create knowledge, which is a crucial part of being a knowledge-based company like C.F Møller or Whitespace. An empirical example of the importance of applying knowledge to the company can be seen in an observation from the author Drucker that begin to apply knowledge to work-practice, which resulted in productivity rise of 3,4 to 4 percent compound a year. (Nonaka, 1995)

This this chapter will try to get an understanding of what knowledge is, how it is created and how in controlling it better creates higher efficiency within a company according to the problems defined in the former section.

The following chapter will mainly be based on the work of Ikujiro Nonaka, a professor emeritus and writer at Hitotsubashi University, and who is one of the most renowned and influential people on business thinking (White, 2008) and creator of one of the most cited theories in Knowledge Management. (Gourlay, 2003).

WHAT IS KNOWLEDGE?

Merriam Webster on Knowledge:

"The fact or condition of knowing something with familiarity gained through experience or association"

Knowledge can be found in formalized shape and in person-based experiences as tangible associations.
Generally knowledge is a concept of multifaceted meaning, but to describe knowledge in detail, it is appropriate to differentiate what information is versus knowledge.
Often information and knowledge is used as it is the same, is a common misconception. There is a clear distinct between those two.

"Information is a flow of messages or meaning that can change or be added to knowledge."
Machlup (1983),

"Information is that commodity capable of yielding knowledge, and what information a signal carries is what we can learn from it"
Dretske (1981)

This defines information as a flow of messages where knowledge is a product of a flow of information, that is possessed by carriers commitment and beliefs.

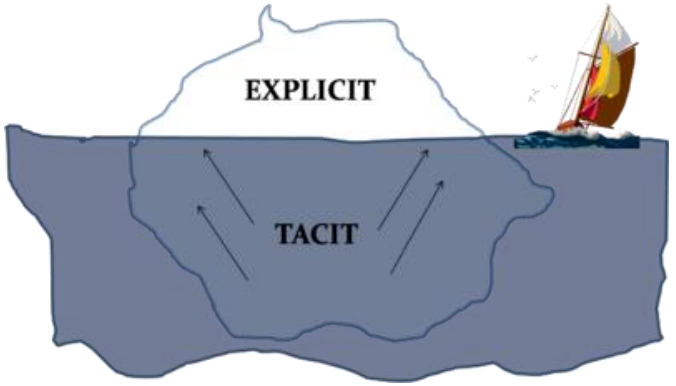


Figure 20: Knowledge according to Nonaka: (http://upload.wikimedia.org/wikipedia/commons/thumb/9/92/KM_iceberg.png/400px-KM_iceberg.png)

Knowledge differs in to shapes. The first is called tacit, the second explicit. It is a continual interchange between the tacit and explicit knowledge and that drives the creation of new ideas and concepts. For many years the western companies viewed knowledge as being merely of explicit form, based on viewable numbers and letters e.g. The Japanese had a different view of looking at knowledge. They saw it as an iceberg floating where only the tip of the iceberg was visible and consisted of explicit knowledge, where the tacit knowledge that was beneath the water surface supported the visible tip (**Error! Reference source not found.**) The theory was first described and brought up by Michael Polanyi in 1966. He defined it as "We can know more than we can tell". He meant that knowledge can be expressed in more ways than words, numbers, and it only was a small part of the knowledge that actually is possible to express.

He divided it up in to categories, the tacit and the explicit knowledge. This is called the epistemological dimension of knowledge creation.

- **The tacit knowledge**
  Is often learnt during apprenticeship, and is communicated through action, commitment and involvement. It is based on a person's cognitive skills like beliefs, intuition, mental models and technical skills like knowhow. The knowledge is in its nature subjective and is not exact enough to express in words, sentences, numbers or formulas.

- **Explicit knowledge**
  Is the formal knowledge that is formal and systematic, like books, databases, context free formulas, manuals e.g. In general it can be expressed in all the ways that tacit knowledge do not. (Nonaka 1994)

KNOWLEDGE CREATION

As defined in the presentation of the case, C.F. Møller and companies alike, knowledge is their economy, and it is the output of knowledge that is transformed into profits. Hence the important of creating an environment for the employees where knowledge creation is supported and where the employees can contribute to the total quality of the company.

When a company needs to create new ideas, or knowledge it happens in the interaction between the explicit and tactic knowledge inside the human mind. This continuous transfer, combination and conversion of the types of knowledge creates knowledge, an example of this could be knowledge created by conversation between two employees, interacting by drawing a section in a software program e.g. In general the knowledge is formed through practice, collaboration, interaction and education.

According to Nonaka, to create knowledge three characteristics must be present, and be based on the conversion of tacit to explicit knowledge is expressing the inexpressible. (Nonaka 1994)

1. **Figurative language and symbolism**
   The figurative languages do not have the purpose to be taken literally, but is meant to meet the characteristics of the "figure" both explicit and tacit. An example of this could be when you refer to a football player as a "tiger", on the football pitch you imagine that the player has the same characteristics like a tiger, where it represent speed, agility and strength, maybe also relating to the tacit relationships e.g. This is built on the notion that individuals has a distinctive experience and context to understand the figurative language and symbolism intuitively. When employees have obtained knowledge that they know but can not explain they often use this kind of expressions.

2. **Shared personal knowledge**
   To distribute knowledge, the knowledge of the individual employee must be shared with others. Organizational knowledge is built on the interaction of the individual employee in the group. The knowledge can be amplified through dialogue, discussion, experience sharing and observation in the group. The group members can create new point of views through dialogue, hence the possibility of creating conflict and disagreement, which is giving the group member incitement to question existing premises, and gain a new sense of experience through this.

3. **Ambiguity and redundancy**
   New knowledge can be created through ambiguity and redundancy. The ambiguity can be utilized from the management to empower the groups to gain a new ways of thinking about things, and alternate meanings. Said to be the creation of knowledge through chaos. Redundancy is normally seen as a negative factor in the organization, but in the sense of knowledge creation is can be an important influence to encourage frequent communication, and a common cognitive ground. This enables the employees to transfer tacit knowledge. This happens through the notions that the employees have overlapping common information that can give the employee a sense of what other employees are having difficulties to explaining, and gain insight on issues from new perspectives. An example of this could be two groups battling the same task, and finishing the task with two different solutions. This enables the groups to argue what process is the best approach.

An IT-solution can support the figurative language and its symbolism as Nonaka explains. It requires that the company management has the ability to announce or define project characteristics by words in metaphors of illustrations that can be shared throughout the company. The shared personal knowledge can be facilitated through employing the SECI model, which the next section will explain.
It is impossible to remove redundancy, but to increase the total quality it must be limited. It is important to utilize redundant work, when it is inevitable, and utilize it to create new knowledge.

THE SECI MODEL:

According to Nonakas theory of knowledge creation, it is the interplay of the explicit and tactic knowledge that creates knowledge. The SECI model, as shown below, visualizes how the matrix symbolizes the conversion of knowledge. It happens through four processes called Socialization, Externalization, Combination and Internalization. These processes happen through social actions between individuals where the quality of the tacit and explicit knowledge increases for every time knowledge moves round the matrix (Nonaka, 1995). The theory of how knowledge is created according to Nonaka can provide insight as to how the IT -solution support knowledge creation.

Socialization:

Means the transfer of tacit to tacit knowledge. This happens when people interact through meetings, brainstorms, apprenticeship. Because the tacit knowledge is difficult to formalize because it is dependent on the time and space factors, it can only be acquired through social interaction like shared experiences, like spending time together in the same environment.

Externalization:

As the name expresses, it is the transition of knowledge from a tacit to explicit form. This usually happens through publishing or articulating knowledge, which enables the tacit knowledge to be communicated. By writing about a concept developed in a brainstorming session, it crystallizes the meaning and allowing it to be shared with others.

Combination:

This knowledge conversion is formed through combining explicit knowledge with other explicit knowledge. In other words it means combining design prototypes or other forms of articulated knowledge. This can happen internally in a company, or by combining knowledge found outside the company combining it with the articulated knowledge from inside the company. The result of this transition is new explicit knowledge that is spread amongst the employees of the organization. This aspect is very suitable for IT-autonomy. Which will be a focal point in helping the knowledge creating process to be facilitated by the IT-solution.

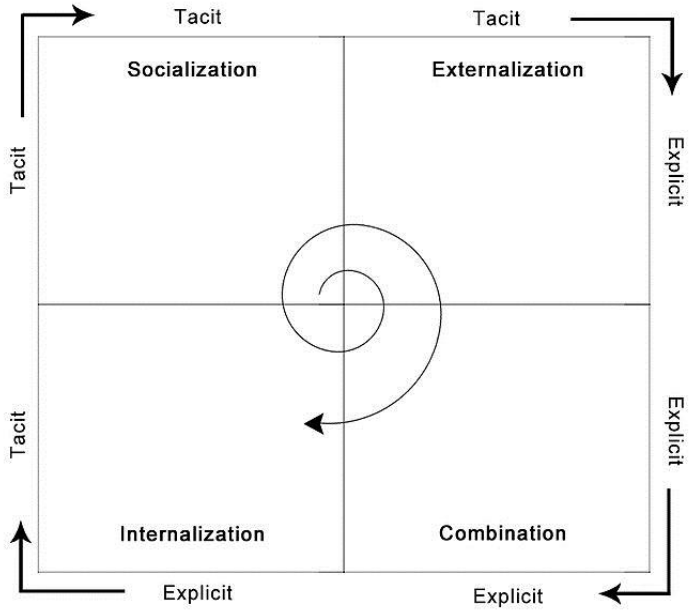


Figure 14: Nonakas SECI Model (http://reganmian.net/wiki/_media/pages:seci_model01.png)

Internalization:
When internalizing the knowledge the transition goes from the explicit to tacit knowledge, this is the absorption of knowledge of the individual. This happens because the individual is picking up the combined knowledge, created in groups e.g. This makes the base for further and better reflection of knowledge, which enables individuals to spot patterns in the knowledge and make increased sense. An example of this could be knowledge created by the organization, like a process map. By utilizing the map, again and again it get converted into tactic knowledge once again. Now the employee have knowledge about company defined work-practice, but might not yet be able to express it, then the knowledge have been transformed into the socialization phase again, and beings all over.

This model is a continuing process of the transitions of the knowledge between the two different kinds of knowledge.
In the theory Nonaka emphasizes that the reason for the success of Japanese companies is how they create new knowledge through the transition of tacit to explicit knowledge. Knowledge always starts with the individual employee, but if the employee of a company has special insight, it is of little value to the company in general, but if the employee can convert his tacit knowledge to explicit knowledge it can be shared throughout the company.

LEVELS OF KNOWLEDGE CREATION

There are different levels of knowledge creation, ranging from the individual, group, organizational and inter-organizational aspects to the knowledge creation processes. These different levels of knowledge have an influence on each other, and have different ways of functioning. This chapter tries to determine the different approaches to achieve the best possible frames for knowledge creation at the different levels. By knowing how knowledge creation works between the abstractions of an organization, the IT-solution can create a better interplay of those by supporting the different levels best as possible.

Individual knowledge creation process

The individual knowledge is created through personal experiences that is caused by interaction with other individuals or the environment that is processed by the individuals mind. The individual interprets the experiences in a rational and objective way, under the influence of causal relationships or formal structures. This becomes explicit knowledge by the transition of tacit based knowledge like emotions, personal and subjective meanings that is founded in the context. In this way individual knowledge creation is an ongoing cycle, based on the SECI models four processes, which is stimulated by moment, place and environment.

Group knowledge creation process

A group in this regard can be viewed as an open system which contain different individuals that creates knowledge via the SECI processes, very similar to the individual process. The group gets knowledge from higher levels of knowledge creation that defines the rule-set of institutional and general environment. In this aspect it is the organizational level that defines the institutional rule-set and the intra-organizational level that defines the general rule-set. The members of the group function as individual knowledge creation processes and that sums it up at the group level. Group members are hugely affected by interacting with each other by observation, imitation and practice e.g. that is shared between members in their context by the means of socialization as a body of shared tacit knowledge, which is group specific. In the next process externalization the group strives to express its tacit knowledge by means of metaphors, analogies or models. The Combination of the explicit knowledge happens through formal reasoning, logic and dialogue between the group members. The last process the Internalization is present when the knowledge is closely bound to the practice and experience. The knowledge then gets rooted into the subconscious minds of the group members, where this part equally relates to all of the group members.

The Organizational Knowledge Creation Process

At this level, the SECI process is very similar to the levels described earlier. The organization is supposed to be viewed as a company or similar. This organization consists of a numbers of subsystems, groups, teams. These elements contains individuals or/and elements. The organizational knowledge creation happens from the individual to the group level, and contributes to the collective body of knowledge of the organization. The organization is acting according to the environment hence the highest level of knowledge creation the inter-organizational.

The Inter-Organizational Knowledge Creation Process

The highest level of SECI processes is a body that consists of agents representing customers, suppliers, government, allied and the media e.g. This can be viewed as the environment outside the organization and it is the interaction between the organization and this that triggers the SECI processes at this level. This is everything outside the company, there is no higher level of knowledge creation, but is a sum of the affecting environment. The environment creates its own knowledge based on the accumulated components like the organizations sub-systems.

In general the individuals create their knowledge based on their context by interacting with external, internal entities, environment. The groups and organizations create knowledge by its own components and with the relationship with higher level entities.

The figure to the right shows how the different levels of knowledge creation increases the dimension of tacit and explicit knowledge hence the higher level of knowledge creation. Each spiral contains the process steps of SECI. (Muina, de Castro, Saez)

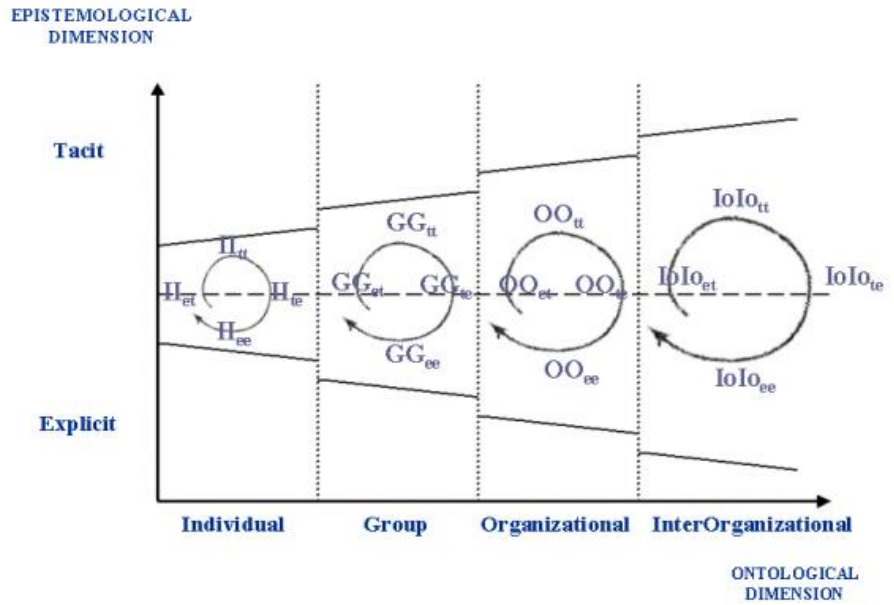


Figure 22: Epistemological SECI: (Muina, de Castro, Saez)

How this relates to the IT-solution.
This theory reveals how knowledge is created through the different levels in the organization and how the environment affects and contributes to knowledge creation. The theory indicates important notions affecting the structure and functions of the IT-solution. This section will sum up, what functions and structure the IT-solution will have to focus on, to ensure the best possible IT-environment for the employees.

- **Group-based interaction tools**
  The group-based interaction must support interaction based on the SECI model and process. If the solution is not sufficient to support Externalization as best as possible, other solutions might be utilized, hence de-centralizing the knowledge, which is against the goals.

- **Give the best conditions for the SECI process**
  The solution must contain tools that can help each transition, like the Externalization, to make it more easy for employees to express their tacit knowledge through visualization tools e.g.

- **Creating company hangouts (Socialization)**
  An important aspect of the Socialization process in the SECI model is transferring tacit knowledge. As the title of the process shows it is about socializing between individuals. Practice, guidance, imitation and observation which are a part of the socialization can be difficult to work into an IT-system, hence normal happens face-to-face. But events like meetings and brainstorms can be useful for exchanging experiences and are possible to incorporate into IT-systems. The system must facilitate digital whiteboard meetings, and videoconferencing.

- **Facilitate an IT-structure that can store knowledge and share it throughout the company.**
  When groups create knowledge, it must be possible for the group to store the knowledge created into the company. By creating a system that can give the group an incitement to contribute with the newly gained knowledge, and make it possible for other employees to absorb.

INCREASED SEMANTICS IN KNOWLEDGE

In Nonakas theory, Semantic is the meaning of information that is important to make information more potent. Generally information is important to formalize knowledge, and can be seen from "syntactic" and "semantic" perspectives. The syntactic perspective is when information is looked at without regard for meaning or value. An example of this could be when you look at your phone-bill. It is not important to understand the meaning of the registered conversations, but only the sheer volume of the phone-calls in duration and number.

Nonaka means that the genuine theory of information is a theory of the contents in our messages, not about its form. In the sense of the semantic aspect, it focuses on meaning. This means that the syntactic aspect does not give the receiver the meaning of information, hence not the importance of information in the knowledge creation process. This definition can lead to disproportionate weight on how information is processed. This aspect is not taking to account how un-useful information is, when the organization creates knowledge out of information in a chaotic and unclear state. By giving information "new" meaning, from the semantic point of view, it gives a new approach of interpreting events or information that before the increased semantics would have been impossible comprehend, new ideas, unexpected connections and so forth. When an organization want to produce knowledge creation the semantic aspect, is of highest importance (Nonaka 1994)

In relation to the defined problems, it is up to the interaction of the employee and his / her group members to create the knowledge based on the available information. This could create issues in the project process because there is no standardized work-practice, and the work-practice is based on previous experiences and context. To give the individual, group and organization a possibility to express the tactic work-processes to discuss and create new and enhanced knowledge a system of translating the tacit knowledge to explicit can help to create a better semantic aspect of the organizational knowledge. This functionality will help in every aspect of the SECI model to enrich the knowledge according to company work-practice.

- **Through socialization:**
  With the possibility to brainstorm work-practice through a sketch process map can help employees to interact and transfer the tactic knowledge while brainstorming the processes.

- **Through externalization:**
  By allowing the employee to express his/hers tacit knowledge of work-processes by the activities that relates to other activities it can create an increased semantic knowledge. This can help articulate the knowledge as a flow of activates that gets crystallized through the process map.

- **Through combination:**
  With the creation of work-practice maps it allows the maps to be compared with other maps either done internally in the company at other offices, or from other companies externally. This can help form new and improved knowledge, which can be shared through the company.

- **Through internalization:**
  To internalize the knowledge the map must be used by the employees, and with the employees using the maps, the knowledge gets internalized throughout the company, which gives base for further reflection to enhance the organizational knowledge.

VISUALIZATION OF INFORMATION AND KNOWLEDGE

As a Chinese proverb once said "A picture is worth one thousand words". It is by this notion that defines the importance of displaying information visually. In many businesses visualizing information is a very critical aspect of documentation and communication. Like the case that has been described the AEC businesses are founded upon information visualized in the form of plan, sections and facades e.g. For other businesses like doctors using diagrams, or the economists showing share quotes on charts. It is the external process that alters the cognitive conditions, and enhances the memory and the problem solving capabilities.

This enhancement build on to perceptions, the first is the possibility of communicating an idea or process e.g. and it can be created visually, or even discovered while creating the idea visually. During the creation of the visualization new knowledge is created.

With the term cognition meaning the acquisition or the use of knowledge, which is what, defines the purpose and means of visualization, and the notion that visualization is not the means of a pictures but the means of insight. This insight aspect of the visualization is based on discovery, decision making and explanation, and by utilizing information visualizing it is possible to increase the ability to perform the cognitive activities better. A small experiment has been conducted to show the difference between solving a piece of math without being able to use pen and paper to visualize the information, and with. The result showed that the piece of math was solved five times faster with pen and paper, than without. This experiment shows that taking your thoughts outside the mind, amplifies the cognitive performance.

The increase in performance is built on the notion that an individual is not capable, or has difficulties to comprehending the data required inside the mind, due to limitations of the memory. By taking the piece of math "outside" the mind, by visualizing it as numbers and symbols on

a piece of paper gets our memory extended by this. By doing this it is possible to make the paper remember the partial results instead of withholding the information in your own memory.

With the possibilities of having the visual information manipulated it can contribute to the individual with the possibility to view the "what if" situations by manipulating the data, to quickly comprehend the results and manipulate it. (Card, 1999)

How visual representation of information amplifies cognitive functions:

- **Reduced time searching for information**
  Another study conducted of how the use of diagrams showed that by grouping information, it was less necessary to waste time for searching for information. It was easier to comprehend the information due to the gathering of information in a small space at the visualization.

- **Enhanced recognition of patterns**
  With visualizing information it was very easy for the individuals using the diagram to see patterns in the information shown, that otherwise would be intangible if not shown as a visualization. It also serves at a simplification and organization of information, which can be abstracted to the position where it fits in the organization.

- **A manipulative medium**
  The possibility if manipulating the visual data, due the system being placed in a manipulate media like an IT-system.

- **Perceptual monitoring**
  By monitoring visualizations allows for keeping track on a large number of events that can show if anything acts out of accordance.

- **Perceptual Inference**
  By visualizing information, problems can be made more obvious than before, and enable other computable graphics processes to occur.

- **Increased resources**
  It is possible to store huge amounts of information that is easily accessible due to the visualization, which can also work as an external memory that can offload work for once cognitive system. The information derived from the visualization can also be parallel processed with text and other media to convey new meaning. (Card, 1999)

VISUALIZING WORK PRACTICE THROUGH PROCESS MAPPING

As described in the visualization section, is important to facilitate visualization for the employees to make their work-practice as efficient as possible to muster their cognitive abilities. This could happen through aiding the employees to know company work-practice and to empower them to contribute to make the processes fit their context and needs, by that it is necessity to map processes internally in the company.
The reason for creating a process map is to express the common need for communicating with the employees related to a given work-practice. Based on the problem definition, it is important to facilitate a level of company standards in work-practice. By visualizing the work-practice through mapping it into a model the advantages from visualizing it, and enabling it to achieve the best possible environment for knowledge creating in the company, in interplay with the other functionalities needed. As described earlier in the thesis complexity and unique processes is one of the reasons why traditional process improving tools are having a hard time being integrated in the AEC business. Many processes has to be designed anew due to the uniqueness and put in new relations, and is traditionally documented through many different medias as written, diagrammed, graphical or in folders e.g. where it is stored in separate plans, company manuals, industry standards and technical standards e.g. (Koskela, 1995) but no combined process. To map the work-practices it is important to note the following. (Koskela, 1995):

- **Facilitation of human understanding.**
  So the process is able to be communicated in a common representational format.

- **Supporting process improvement**
  As a basis for analyzing processes.

- **Support process management**
  To compare and merge actual processes against to-be processes.

- **Support automated execution**
  Integrating IT to compute autonomous processes as a basis for controlling behavior.

It founds a basis for communicating processes to collaborate internally and externally, share and understand. Ballard and Koskela postulate that by focusing on this practice and engineering these mapped processes through conversion, flow and value generation to create work-practice transparency will result in design success. (Ballard Koskela, 1998) This can also be viewed as a one of explicit steps in the knowledge creations process, (the combination step) by combining both a visualization of processes and applying necessary knowledge to perform the process.

PROCESS MAPPING IN THE CONSTRUCTION BUSINESS AND THE DYNAMIC REQUIREMENTS

An important aspect of the problem description is that it needs to fit C.F. Møllers strategy of having shared processes and cultures, and the IT-solution must facilitate this notion. But processes in the construction industry differ due to factors like communication and construction complexion at the projects.

But is a difficult practice due to a split between project and business based processes. In the theory of how processes and business processes are conducted, it is said that consultant companies in the construction businesses are much indeed split between two process cultures. Business based processes have characteristics of being on-going and repetitive, where project based processes is temporary and unique. (Brusoni et al., 1998.) Companies develop their own routines based on business activities, which are based on recurrence of the activities. These processes are prone to be standardized because of their small difference in form. Project based processes is characterised by little routine that is difficult to form systematic repetition, and is problematic for process improvement and standardization. (Gann, Salter, 2000).

In modern organizational and process improving science business and project based process optimizing is seldom brought together, often business processes are used on project processes. (Nonaka 1994, et al)

In relation to the defined problems as viewed in the problem tree section, time is a limited recourse. Project groups do not have excess time to define a depth going scope of work, but has to rely on previous experiences and brief meetings with the co-operators to define it. Because of the complexity of construction, two projects do not look alike. Detailed process standards, differences in project and business bases processes would not fit due to those factors. It is important to facilitate dynamic processes, that can be standardized but with enough dynamics to be molded into specific projects, where previous experiences can be lodged into. To fit the construction business and support the current processes Senescu defined parameters that need to be braced in order to facilitate a successful mapping and usage of process mapping in the construction business, and that the IT-solution must enable. (Senescu 2011). These parameters are needed to facilitate the theory needed to empower an optimal knowledge creating environment (Next page).

Scalability
Complexity in the construction business varies, but in general is substantial. Due to this a vast numbers of process activities, which can in theory be mapped. This will create an intangible web of information, that renders the map useless. But with scalability functionality it will be possible to scale the information and reduce it. Not being overloaded by information, but only get information relevant for the employee.

Embedded
By embedding the information enables the employees to organize and communicate processes. This can happen through the Save and Open function of old information. This enables the employee to find, apply, manipulate or communicate old maps of processes.

Social
Mapping the processes do also require that employees can communicate around the maps, to create new meaning (According to Nonaka) and by that an environment that facilitates communication next to a view of the process can enable the employees to post comments about information and make it possible for users to integrate with the maps and rate the map for levels of usability and productivity.

Modular
As described in the beginning of this section, the processes in the construction business is unique and it is necessary to make elements of the mapping modular to make it faster and easier to mold unique processes based on some form of standardization which would be based on the modularity. This modular aspect can come from clusters interconnecting activities that can be dragged and dropped in the context needed. In practice this could mean that a series of activities were so connected that the possibility and need for a customized arrangement of these activities were unlikely, or that the company is not interested in the possibility of customization due to strategy, policy or alike.

Computable
In some cases the computer must be able to help automating the flow of information. That can be in the aspect of combining information, increasing readability e.g. This is also a part of the combination process during the SECI model, and will bring the huge advantages of utilizing IT, with mapping the processes.

PROCESS MAPPING AND REENGINEERING

Mapping processes is called Business Process Modeling (BPM). This is an activity of representing processes in a company so the current processes can be examined and enhanced. This activity is called Business Process Reengineering (BPR). (Dodaro, Crowley 1997) A Forbes 500 report containing the 500 most successful companies in the USA, claims that 60 % have or is planning to reengineer current processes in mid-90ties, and declares BPR an very important issue for developing the company (Hamscher, 1994).

In order to do BPR you have to map and analyze the current processes internally and rethink how to improve them holistically where all processes is interrelated to each other. One of the first people to think about business processes and the reengineering, hence analyzing business processes was Adam Smith in his magnum opus, Wealth of Nations from 1776.

"One man draws out the wire, another straights it, a third cuts it, a fourth points it, a fifth grinds it at the top for receiving the head; to make the head requires two or three distinct operations; to put it on, is a peculiar business, to whiten the pins is another; it is even a trade by itself to put them into the paper; and the important business of making a pin is, in this manner, divided into about eighteen distinct operations, which, in some manufactories, are all performed by distinct hands, though in others the same man will sometimes perform two or three of them."
Adam Smith about Division of labor in Wealth of Nations 1776.

Even though this is more than 200 years ago, analyzing work-practice can give an increase of productivity. In Adam Smith's case his estimates was an increase of 240 to 4800 fold increase. (Smith, 1776) Even though increases in productivity by applying it to companies like C.F. Møller today are they unlikely through a happen with BPR, but there still are substantial possibilities for productivity gains. His idea of splitting work-practice down into small activities like a piece of math to analyze it was then revolutionary and is the foundation of modern BPR. It is with this notion that the focus on improving the processes in the company arises.

In relation to the problem definition of achieving best possible total quality, it is in the aspect of the internal process efficiency to obtain a shortened and effective process. Analysis of the current processes can lead to an increase of productivity, and crystallization of knowledge.

VISUAL PROCESS MAPPING AND THE IT-SOLUTION

In order to perform a BPR it is necessary to map the processes. The system must contain a framework for mapping the work-practice. There has been created many tools for mapping the processes visually like BPMN (Business Process Model and Notation), EPC (Event-driven Process Chain), IDEF0(Icam DEFinition) , SOMF (Service Oriented Modeling Framework) e.g. Many of these tools derives from software development, but is also being utilized in many other industries.

It is widely discussed what is the best BPM technique. In this thesis further work will be focused on BPMN and IDEF0 notation techniques. Both techniques have its advantage and disadvantage compared to the goals for the IT-solution.

BPMN - Business Process Model and Notation

Is an international de facto standard of modeling business processes, for providing businesses to understand their internal processes as a graphical representation. The purpose of the notation is to facilitate understanding between organizations to increase performance collaborations and the business transactions between the businesses, in order to adjust to changes in processes as quickly as possible. BPMN is not owned by a company but an institution OMG, that also develops other worldwide standards like UML.

The scope of BPMN is to make the notations understandable for all business users, from the process analyst to the technical developers responsible for implementing the technology, and the people managing and monitoring the processes. The keyword is simplicity and to withhold an intuitive design that gives the users a quick overview of a business process.

It represents the merging of best practice internally in the company and defines the notation and semantics of collaboration, process, and choreography diagrams in one. BPMN helps standardize the business processes, and is a simple technique of communicating process information to employees and areas affected. BPMN shows a flow of processes that shows what processes that gets preformed and what the end results of the process flow are. It is modeled by standardized symbols, and contains sub-processes where hyperlinks transfer the view to a decomposed sub-process. (http://www.bpmn.org/)

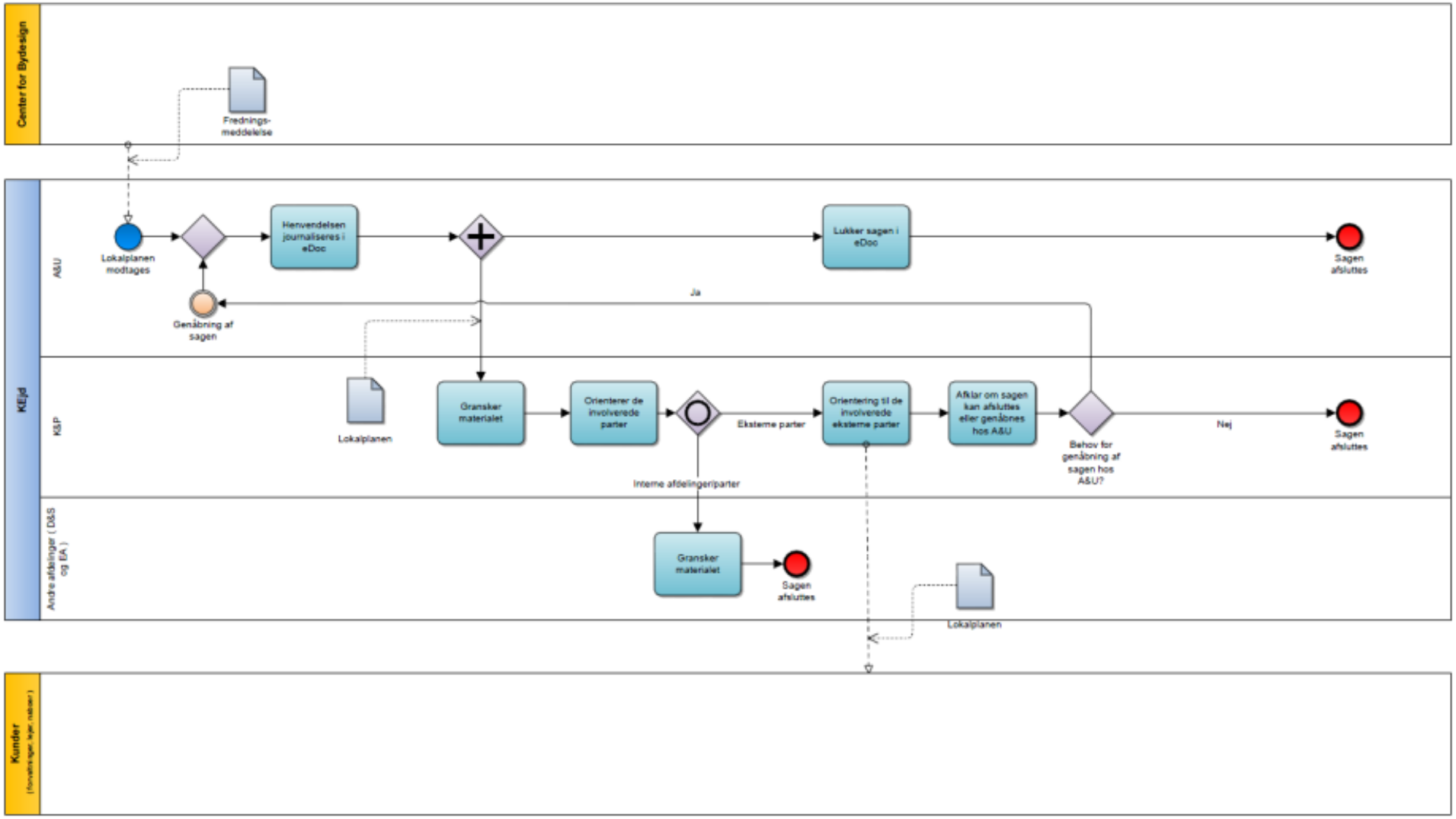
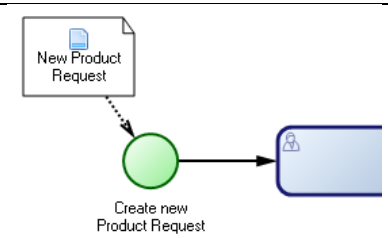
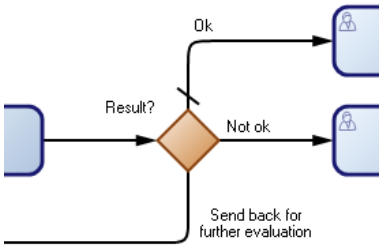
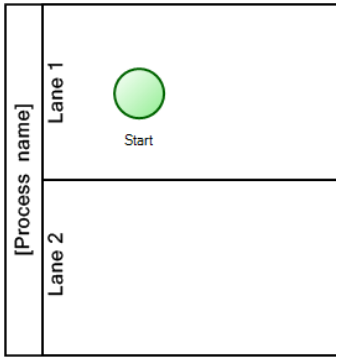


Figure 23: An BPMN Example (Københavns Egendomme)

The symbols and objects of BPMN have different meanings and rule-sets according to placement and function, and it is not always possible to combine every symbol as you would like. A brief introduction of the symbols:

Events: The event is an element that starts or ends a process. There can also be an intermediate event, that symbolizes that something happens between the start and end event. There can be multiple events in a BPMN.	
Gateways: A gateway is an element that connects entities. It can connect a single or multiple entities, and it can paralleled merge or fork paths.	
Activities: An activity that represents a single unit of work performed. The level of detail for the activity is defined according to the relevance.	
Swim lanes and Pools: Often the swim lane is portrayed in a pool. A pool is representing organizational boundaries, where the swim lanes can represent functions or roles.	

http://www.omg.org/bpmn/Documents/6AD5D16960.BPMN_and_BPM.pdf

IDEF0 (Icam DEFinition 0) Function Modeling

Back in the eighties the United States Air Force developed a technique for increasing manufacturing productivity through a systematic application of computer technology. This was called the ICAM program, where Icam in the IDEF0 is an acronym of Integrated Computer Aided Manufacturing. The program was a structured approach of applying computer technology to understand processes to improve manufacturing productivity.

The ICAM program identified the need for communicating and analyzing the functions processes, as a result of this IDEF (ICAM Definition) method was developed. In the beginning 3 methods was developed to assess the need for modeling functions 0, information 1 and dynamics 2. In this thesis we will look at the IDEF 0 models. http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADB062457&Location=U2&doc=GetTRDoc.pdf

The IDEF 0 methodology was formed as a baseline for communication vehicle used for planning, developing and implement subsystems in Aerospace companies. Today it is used in a wide variety of businesses to model decisions, actions and activities of an organization or system. The main thought with IDEF 0 is to promote effective and simple communication between the analyst and customer, and make it manageable to define scope of the analysis.

The modeling shows what functions is preformed and what is needed to preform those functions. IDEF0 is a representation of organized activities and relations between those, not shown in with the factor of time, but sequential. The concept of IDEF0 is based on box and arrow diagramming (Figure 24), designed on the notion of effective and simple communication. (NIST 1993)

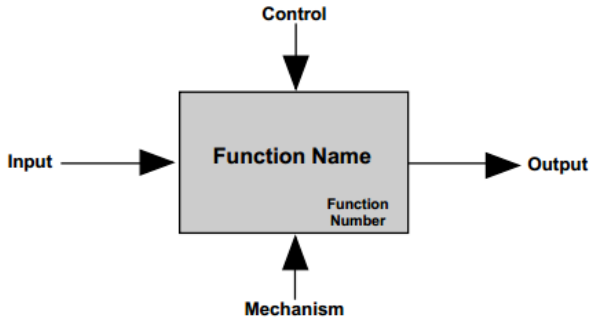


Figure 24: Basic concept of IDEF0: (Systems Engineering Fundamentals, 2001)

Today IDEF0 is released as a standard for function modeling by National Institute of Standards and Technology (NIST) which defined a rule-set for that standard to ensure simplicity and effective communication, containing:

The labels

Are used to describe boxes and arrows in a short and precise meaning. All labels must be unique and no duplicated names.

Gradual exposition

To minimize the amount of communication the detail are gradually exposed due to a hierarchical structure, where the general functions are located at the top and successive levels of sub-functions are placed beneath.

Level of detail
Limits the level of detail pr. successive function to a maximum of six sub-functions, and only bounded context.

Minimum of control
All the functions must require a minimum of one control.
http://www.idef.com/IDEF0.htm

The visual diagramming contains:
The arrow
A direct line that is constructed of x numbers of arrow segments that channels flow from one place to another. If the arrow has an arrowhead it conveys the flow to use, if there is no arrowhead it channels the flow from a source. There are 4 forms of arrows. The visual difference is the location that they connect to the function. The arrow connecting to the left, is the input arrow. The arrow that exits from the right is the output arrow. The arrow that connects to the top is the control, and the arrow connecting to the bottom is the mechanism arrow.

The arrows indicate what is needed to execute the activity shown as the box. The arrows represent the following:

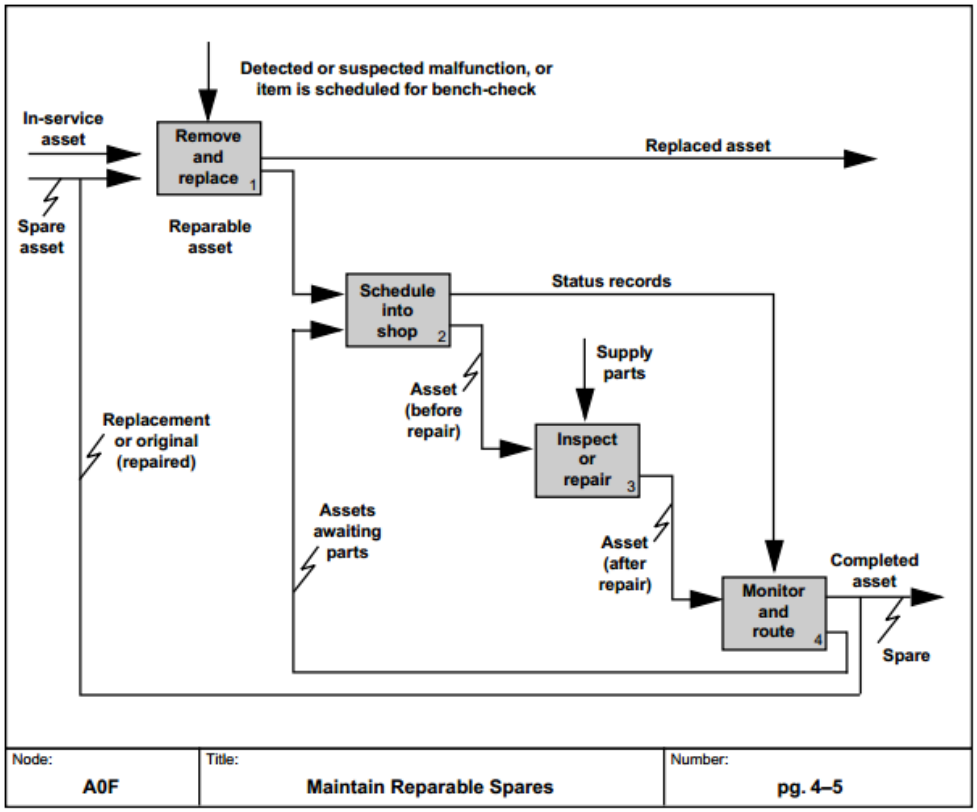


Figure 15: Shows an example of how IDEF0 could be diagrammed. (Systems Engineering Fundamentals, 2001)

Input arrow: Input to execute (Existing As-built drawings e.g.)
Output arrow: Converted material by the function. (New drawings e.g.)
Control arrow: Control elements (Laws, rules, goals, strategies e.g.)
Mechanism arrow: What mechanism resources needed to convert the input (IT-systems, manpower e.g.)

An arrow changing direction must be diagrammed in 90 degrees bend, with no sharp corners (Figure 15).

The box
To contain the function is the box. The box has a name and number to identify the function, and is represented by a rectangle.

Function
Is the activity, process or transformation that is identified by a label that describes what the function must

Fork
Is the junction of the arrow divided into multiple arrows.

Join
A junction where the arrow merges into one, with other arrows to form a single arrow. (Systems Engineering Fundamentals, 2001)

BPMN and IDEF0

The two methods distinct from each other in many ways. IDEF0 is the oldest technique and maps the "functions" and how they are dependent on each other, but is not shown in an exact sequence. It shows the performers of activities or remains silent on who performs the activity as shown on (Figure 15). It also simplifies how the function is done by the numbers of performers that preform the function, and is shown by multiple arrows, where the function remains sole.

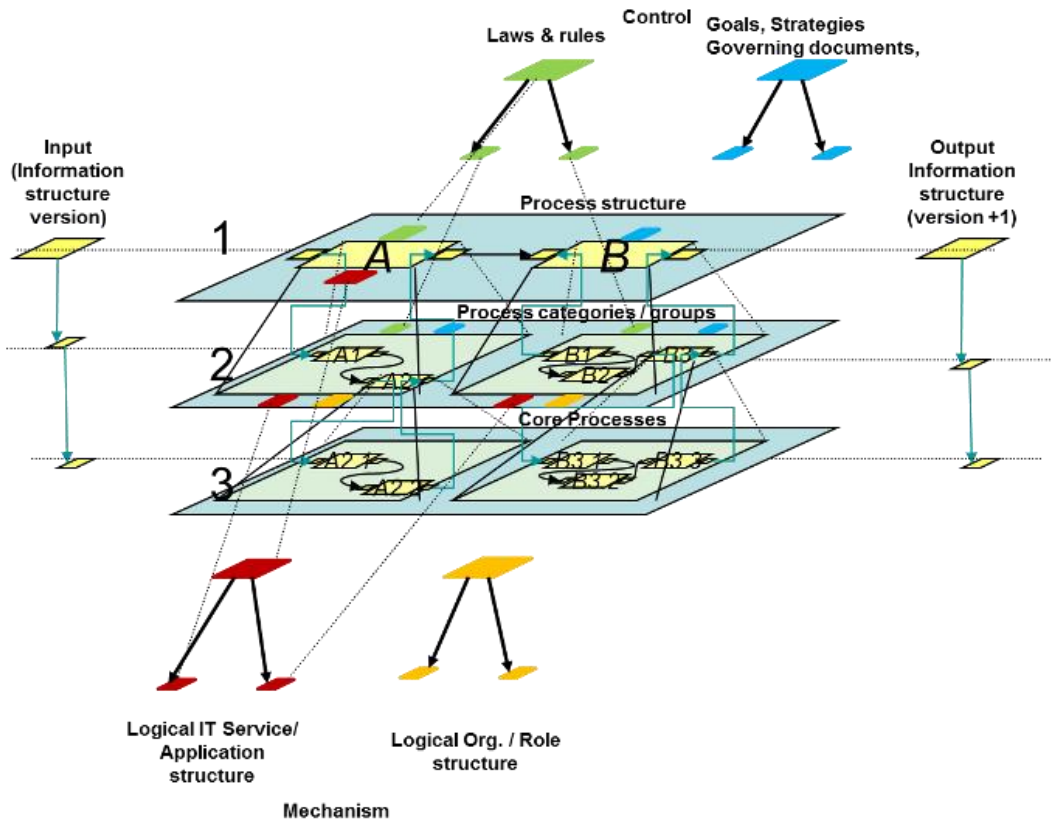


Figure 16: : Shows the hierarchical structure of IDEF0 and how the numbering works. (http://www.efaros.com/_/rsrc/1335189856859/home/process-models/idef0-vs-bpmn/BP7.png)

When BPMN maps a business process it uses swim lanes and pools showing who performs the activity, in what organizational context. If an activity is performed by more than one, it shows up accordingly performer's swim lane. The arrows show the flow of activities from left to right and this indicated the actions executed by the performer at the same time. BPMN is said to have it strengths related to visualize As-Is architecture, because it is possible to arrange all the information related to the mapping. The advantage of IDEF0 is the To-be aspect, and is an approach of isolating the different aspects of the business process, to give a good overview of the architecture to analyze it, in separate models. To define how the techniques are best utilized is a question of context, due to the different characteristics of IDEF0 and BPMN.

The IDEF0 approach is employed, and encourages the analyst to think of the general action for itself, and the need for exchanging information, goods e.g. between the functions. This makes it more prone to be designed more creatively and with less detail, important in the To-be architecture. As the mapping progresses it becomes more and more necessary to know the underlying processes.

When the goal is to capture As-Is business processes, it knows who and what is performed according to sequence. The BPMN mapping is great at capturing this. The downside is that it does not encourage the analyst to think beyond the core processes, and why the company is performing the actions in the first place. The actions in the BPMN technique does not label the arrows connection the actions then becomes less transparent compared to IDEF0, hence the possibility of labeling the arrows.

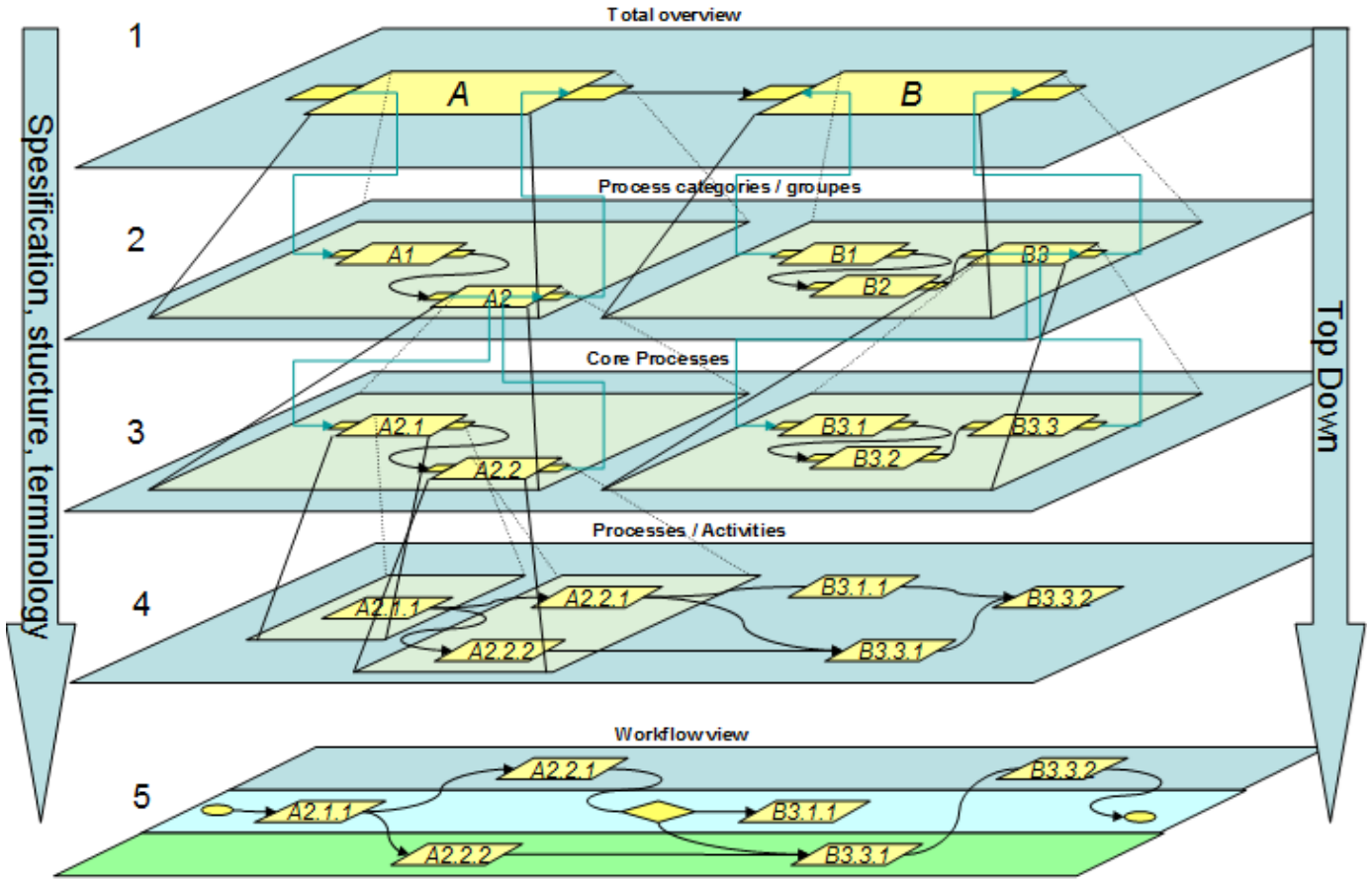


Figure 17: This shows the top down combination method (http://www.efaros.com/home/process-models/BP5.png)

The combined approach

To make it possible to take the advantages of To-be modeling and As-Is a combination of the two techniques has been created. It has been recommended to map the To-Be architecture with IDEM0 to give the analysis freedom to map the best possible processes without having to note the mass of data from whom, and when the activities are performed. For a final overview and presentation the BPMN can visualize the greater level of details, with the downside of the information can concur cluttered, where the contrast is the IDEF0 where the information is revealed in hierarchical succession. http://www.efaros.com/home/process-models/idef0-vs-bpmn.

Related to the IT-solution, then it is the To-be maps (IDEF0) that is visible for the employee, the As-is will be used as a underlying analyzing tool for the specialists, to map current processes, that is going to be transformed to IDEF0 maps.

The combined approach can underpin the requirements defined by Senescu. IDEF0 is by its nature scalable, and it is possible to integrate BPMN into this system of scalable hierarchy. The scalable hierarchy also gives the option to include a cluster of processes into the customized process, making it modular. An example of this could be that in a given process the project output needs the activity of making plans. Instead of defining and reinventing the whole process, a standardized cluster can be utilized and put in a project. When or if a group member needs to look into the project process to work out how the plans must be created, he can click on the standardized cluster and view the process. If the standardized activity cluster gets modified by a process specialist due to optimization, this cluster gets updated accordingly e.g. The other requirements as the Social, Embedded, Computable is a system design feature that needs to bet met during further design,

MAKING A COMPLEX SYSTEM OF VISUAL PROCESS MAPPING USABLE

As written above the best way to integrate process mapping with the functionalities of both to-be and as-is, it is necessary to combine both IDEF0 and BPMN diagramming. According to both the problems defined in the depth analysis and the strategy analysis it is of very importance that the system will facilitate usability based on readability, besides its main functionalities. The research showed that the employees are burdened with IT that require many steps to perform, like the journalizing function at the intranet at C.F. Møller which consisted of many steps that easy could make at least 30 seconds to journalize a single mail. This had its consequence, due to the fact that the Copenhagen office did not utilize the system; one of the reasons was lack of usability. Because of this it is of high importance to make the process maps usable we need to define what usability is and what is needed to make something usable.
Usability is defined as making a part of the system acceptability, and applies to the artifacts that are in contact with individuals. A system that is usable is a system that meets a satisfied level of needs and requirements of usefulness within the available body of resources. (Nielsen 1993)
Attributes of usefulness (Next page):

- **Learnability**
  How quickly do I learn to use this system?
- **Efficiency**
  Will it make my current work-practice more efficient?
- **Memorability**
  Can I memorize how to use the functions?
- **Errors**
  Is the software free of errors?
- **Satisfaction**
  Do I feel satisfied when using this?

For further development of the IT-solution, it is critical to conduct usability testing to make sure that the attributes are fulfilled according to end-user claims. This is done, because the experts, having extensive knowledge about usability theory, but do not have adequate understanding of end-user work-practice and context. But as defined in the earlier chapters, users are supporting the platform with context, creating a foundation of user-problems which the IT-solution is built upon, and supplying the system with a form for usability. (Nielsen 1993) Related to the making process maps usable the same attributes are applicable, and it's on those notions that the usability of the maps will be applied.

Often a lot of effort is put into modeling process maps, and the maps can be seen as very overwhelming for individuals, other than the creators of them. Frequently it is because the maps contain so much information that it is not possible to scale it down to fit on standard sizes of paper or shown on a computer screen. (Berg von Linde, 2001) With the functionalities of an interactive environment as the IT-system must facilitate, it will be possible to handle the information with expanding and collapsing menus of different visual form, which can ease the burden of information. To achieve usability to the map, demands of handling the ways of modeling it, this requires a two-step process of a process designer mapping the process, then handing the map to an information designer that can make the map usable in terms of making it neat and readable for individuals not specialists in the area of process mapping. This will result in an iterative process that will end when the map has a satisfying usable design according to available resources and the attributes of usability. (Berg von Linde, 2001)

To ensure the highest level of theoretical usability different approaches will be listed in this section. The theories are meant to be integrated into the IT-solution to facilitate the process mapping system to be treated into a framework that certifies the usability.

Feldman's Fog Factor

To measure the usability of the process maps, a rule called the Fog Factor can be utilized. It is used to analyze and evaluate the readability of IDEF0 diagrams. This was conducted to make a set of rules to secure the highest level of readability, and to diminish information overload. The rule is a factor that is defined by the number of input visible on the diagram. The actual factor is the summed inputs, based on boxes, arrows and joints that must not exceed the threshold of 50. (Feldman, 1998)

Table 1: The definition of the fog factor (Feldman, 1998)

Factor	Maximum threshold
F1. Number of boxes on the diagram	6
F2. Number of input arrows entering each box	3
F3. Number of control arrows entering each box	4
F4. Number of output arrows leaving each box	3
F5. Number of arrows forks or join	No maximum
F6. Number of arrow crossings	No maximum
Fog factor = F1 + F2 + F3 + F4 + F5+F6 < 50	

This methodology can be intergraded in the IT-solution with providing the individual with areas of entering data and parameters, that can define a maximum of elements put into the map. Then an automated process can calculate the fog factor ongoing and ensure that the rule-set will be met. (Feldman, 1998)

Gestalt laws

Generally this would be defined as common sense, but it is important to ensure that the law has been complied with. The law is founded upon knowledge about cognitive visual reactions. It is generic principles that are used to design the diagrams. The law is defined by actual IDEF0 standard created by NIST in 1993, where a section explains how it is possible to increase readability (NIST, 1993)

Incorporating the gestalt laws is not as easy as the previous, because many factors are associated with arranging the elements accordingly. Either it can be incorporated if enough resources are available, or during the implementation of the system, there must be put special emphasis on obeying the laws during mapping the processes.

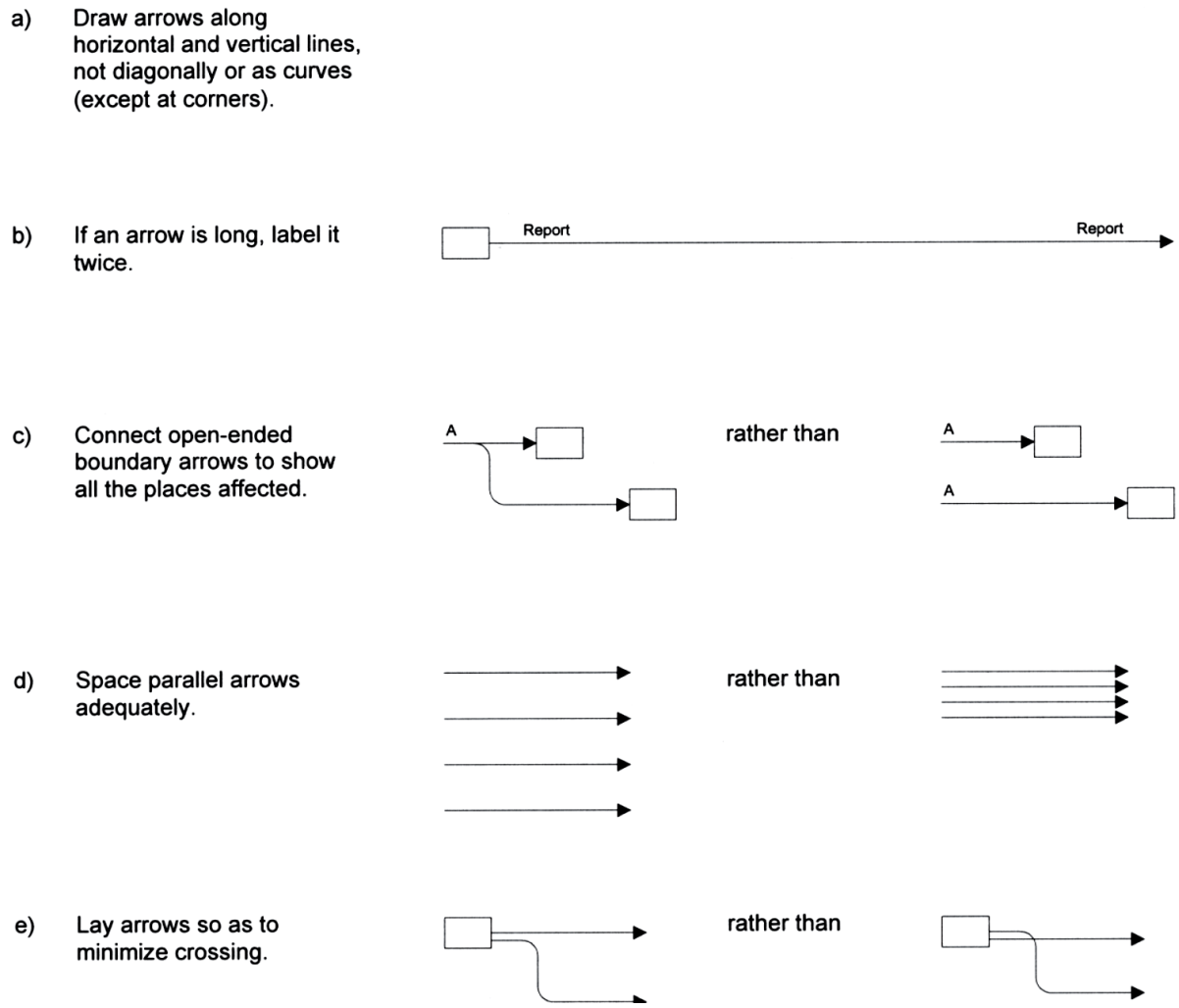


Figure 18: Examples of the Gestalt laws (NIST 1993)

Table 2: Dynamic Process mapping Function list (Author 2013)

Process mapping function table	Short description	Based on theory(ies)	Found at
To-be mapping IDEF0	Mapping processes with IDEF0 To-be	Card, Nielsen / Berg von Linde / Efaros / NIST	
As-is mapping BPMN	Mapping processes with BPMN As-is	Card, Nielsen / Berg von Linde / Efaros / OMG	
Hierarchical scalable structure	Possible to scale level of information	Senescu / Nonaka / Card	
Dynamic use of process clusters	Manipulate clusters of processes to speed up mapping of unique business processes	Senescu / Nonaka	
Dynamic use of templates	Can use custom made templates	Senescu / Nonaka	
Feldman Fog Factors	IDEF0 factor to increase usability	Feldman	
Gestalt law	IDEF0 laws to increase usability	NIST	
Embedded export / import function	It is possible to export and import work	Senescu / Nonaka	

CONSOLIDATION OF FUNCTIONS OF THE PROCESS MAP SYSTEM

To consolidate the listed functions required based on the theory, which is based on the problem domain a function model has been created to show an overview of required functions.

The main functions are located in the Process mapping system, which is based upon four underlying sub functions that each either counters the issues presented in the problem description, or supports the goals defined.

Mapping

The system needs to facilitate mapping processes by utilizing the IDEF0 and BPMN system. IDEF0 must be usable for the knowledge domain specialist that can define To-be situations. The As-is mapping with BPMN must be an underlying function to compare the processes if the current work-practice is aligning itself towards the To-be system. The scalability requirement is integrated in the IDEF0 technique as described.

Modular

Clusters of processes and activities for utilizing company standard processes, and for saving time in creating fast project specific process maps.

Readability
Sets of rules and laws must be incorporated into the system functionalities, to ensure a high degree of readability to certify the usability of the knowledge maps.

Embedded (Export and loading functions)
It must be possible to save the work internally in the knowledge base, and possible to export it to different formats. This is due to the likelihood that either a section or similar of a process could be communicated to co-operators and clients, for them to understand the company processes and general scopes of work, as a mean of reducing misunderstandings. And to give the possibility of external feedback to gain increased company knowledge according to Nonakas knowledge creating theory. The system must facilitate the export to either a native format, PDF or other popular picture formats to suit the external format demands, and for the employees to open old maps to analyze e.g.

Social
The social requirements will be met at the groupware section, which the whole system will be integrated around, and supported by the process mapping system.

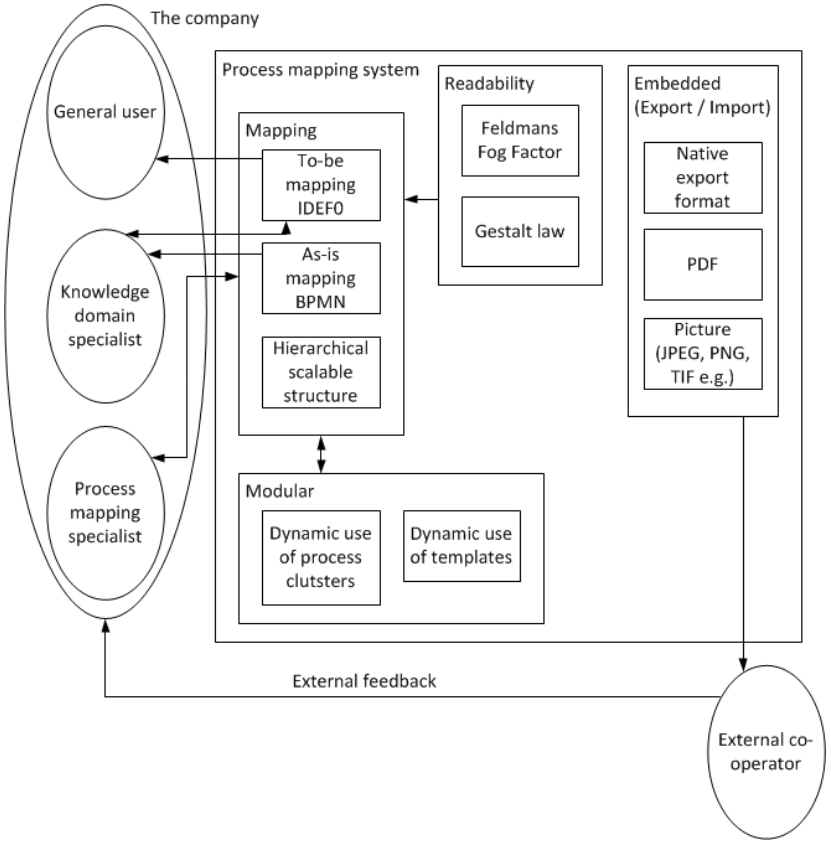
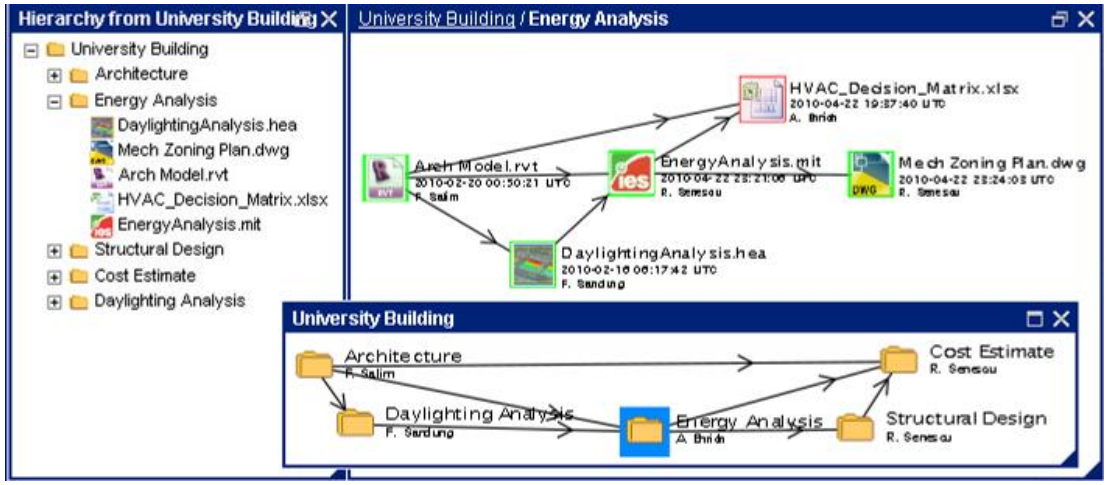


Figure 19: Consolidated Function Model for the process mapping system (Author 2013)

POSSIBLE EXISTING SOFTWARE SOLUTIONS TO FACILITATE FUNCTIONAL DEMANDS

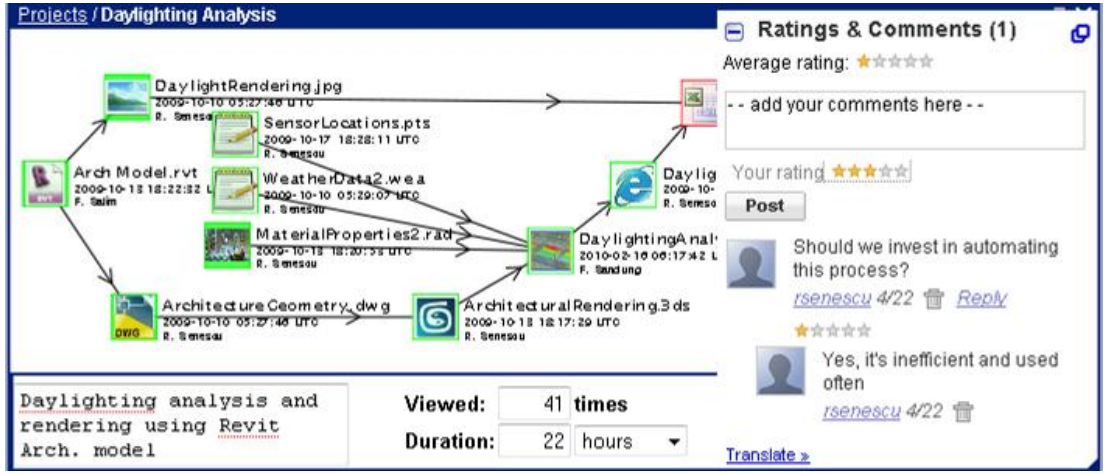
According to the author's investigation done by interviews, company visits and searching the internet, no existing software has been developed that interlinks with the functional requirements of synced communication to interact simultaneous with the process mapping. Only one piece of software is somewhat close to fit the functionality requirements but it is only a conceptual prototype. Besides that traditional process mapping software can be utilized to map the process, but limits the dynamic collaboration with people located in different locations, and does not have usable features required, but it is possible to map and export the data.



Picture 4:Shows Senescu's DPC tool's hierarchical feature to the left (Senescu 2008)

SENESCU'S DESIGN PROCESS COMMUNICATION (SENESCU'S DPC) TOOL

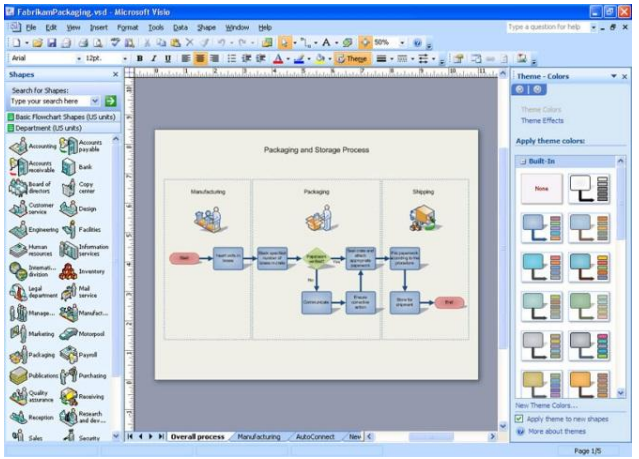
Is based on a dissertation of a doctorate in philosophy Reid Robert Senescu. It is a conceptual tool that builds similar requirements that is also defined earlier in this chapter. Based on his empery and notions he created this tool to help communicate processes in the AEC industry, but is mostly focused on collaboration with external partners rather than internal. Because this is a conceptual prototype it is not functional or programmed, hence not having a price. This would be a great starting point for developing an AEC specialized process mapping tool that can contain all the required functionalities, but it will be the most expensive solution listed, and difficult to price. (Senescu 2008)



Picture 5: Shows Shows Senescu's DPC tool's social interaction, where it is possible to rate and comment processes. (Senescu 2008)

Microsoft Visio Premium 2010 Tool

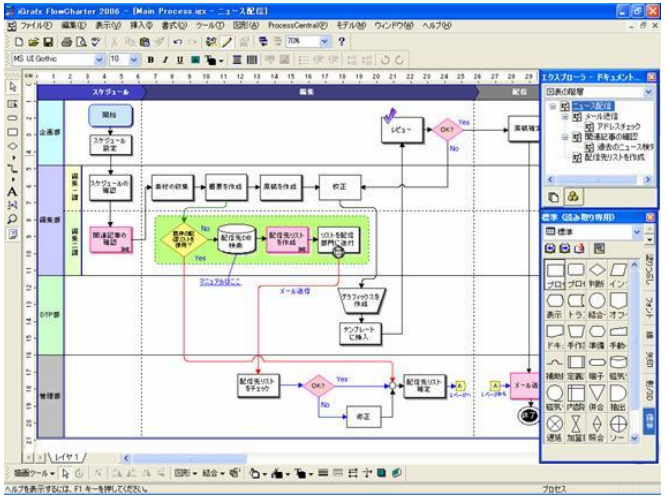
Is a part of the Microsoft Office suite and an application for drawing with 2D objects. The premium release of Vision contains intelligent rule support that make it possible to include rules like the Feldman Fog Factor e.g. and validation together with diagram breakdown functionality. The program is not designed to work as a specialized tool for the AEC industry, as a general diagramming tool, that can handle many kinds of notations and diagramming methods. The extra features in the premium release are mostly based on developing IT-diagrams, and the functionalities have to be modified to fit the AEC business style of diagramming. The tool does not facilitate any social collaboration internally, but has to be exported into a groupware tool e.g. for screening.
(http://support.microsoft.com/kb/896660) / (http://office.microsoft.com/en-us/visio/)



Picture 6 Microsoft Visio (http://www.fileplaza.com/getimages/getMicrosoft-Office-Visio-Professional.jpg)

iGrafx Flowcharter w. IDEF0 2007

A Danish developed solution that basically has most of the same functionalities like Microsoft Visio. It has been made for the purpose of designing and drawing 2D objects to illustrate processes or alike. The basic program Flowcharter is the main program, where the basic diagramming features is based, where the IDEF0 functionality is an add-on. This means that the method is specially integrated into Flowcharter and the functionalities that the IDEF0 contains are fully integrated. This means that the hierarchical and scalable structure requirement is fulfilled, but only partly because it only affects the IDEF0 methodology. As Visio the program does not allow for collaboration internally, and has to be exported through another system to be screened.(http://www.draware.dk/producent/igrafx/produkt/idef0/)



Picture 7: iGrafx Flowcharter (http://i.impressrd.jp/files/images/fsv/fsv-img2302.jpg)

The programs will be compared from a functionality requirements viewpoint, which only will be a very general rating, hence a deeper analysis is required to assess if the process mapping tool is the right facilitator. The green color counts a whole function; the yellow symbolizes a semi-acquired functionality and counts for half a functionality.

Table 3: List of required functionalities according to process mapping solution (Author 2013)

Groupware function table	Senescu's DPC Tool	Microsoft Visio Premium 2010	iGrafx Flowcharter w. IDEF0 2007
To-be mapping IDEF0			
As-is mapping BPMN			
Hierarchical and scalable structure			
Dynamic use of process clusters			
Dynamic use of templates			
Feldman's fog factor			
Gestalt Law			
Native export format			
PDF format			
Picture format			
API			
Total functionalities	9	8,5	8
Price pr. license	Na.	$1000 $	2350 $
~Price pr. functionality	Na.	118 $	294 $

Functional Results

Because the prerequisite argument was that the social element of process mapping were "outsourced" to the groupware solution, it is not a direct part of the functional requirements. But Semescu's DPC tool supports this with rating and comments, which allows for a more easy feedback to current processes, and has to count subjectively. The existing solutions Visio and Flowchater is somewhat similar in the sense of functional requirement fulfillment. Visio has a better API (Application Programming Interface) which allows for improved integration with the groupware solution, if needed, and is the thing that differs the most. Besides that it is a measure of the price. If measured on the price. pr. functionality Flowcharter is the most expensive, being more than double as expensive. Because Senescu's DPC Tool is not an existing solution, but has to be developed the price is very difficult to predict, but has the possibility to be edited to fulfill all the requirements, in return of a big expense, and must be considered to be the most expensive solution.

SUB-CONCLUSION

This part of the IT-solutions functionality bases itself on the capturing and transferring tacit to explicit knowledge in the organization, hence making it more tangible. A process like work-practice can be a series of abstract activities which requires manipulation from more than one source. Expressing work-practice can be difficult to do in words, and it can also be a difficult task receiver to remember. By expressing the work-practice explicitly as a map, it enables the employee to find the specific process for the needed work-practice mapped by the system, but without the possibility to directly change the information. The system will remove the traditional "handbook way" of expressing work-practice, which often requires that the employee has to read an 80 pages comprehensive handbook manual to find a small fragment of information needed, leading to adding non-value time added to the project.
Manipulation of process mapping and creation of new knowledge must happen through both the Knowledge domain specialist, and the process mapping specialist. The knowledge domain specialist or specialists has the specific knowledge required to communicate and create new, while the Process mapping specialist main concern is to keep the map operational and usable, on the aspect that the IT-functions will not be able to facilitate all the aspects of usability and operationally required, and supply the analyze with knowledge about process optimization.

The increase in total quality happens through sharing and creation knowledge throughout the organization. This happen by expressing knowledge through processes maps that can help explain tacit elements of the activities in the process map. This also links to other activities and components, which can be connected to the process maps, which enables the maps to be combined with knowledge or information from other sources, like the BIM wiki, internet e.g.. This increases the overall output and quality of knowledge of the company, which economy is based on and generated its turn-over on. This will support a better internal process and increase the total quality by efficiency of internal processes, because the quality of the output is based on actions that are built on better decision foundations.

A tool that must contain all of these functionalities, does not exist to the authors notion, but can either be a custom made solution similar to Senescu's DPC Tool, that could be developed to facilitate all the required functionalities. This would be a big investment for companies like C.F. Møller or Whitespace, where other non-specialized solutions would be to prefer. Available non-specialized solutions like Microsoft Visio or iGrafx Flowcharter w. IDEF0 2007 could be utilized. The main problem is that they do not support the social aspect and is mostly drawing programs that lack the full dynamics, which is required to modify and interact in processes that seldom are linear, in cases where project specific processes must be defined.

THE COMPANY HANGOUT - THE SOCIAL ASPECT OF SHARING PROCESS BASED KNOWLEDGE

Being able to store company knowledge at a local database or in the sky (cloud computing), through knowledge maps is just one area of supporting the company knowledge creation. Research has shown that the usage of such is only utilized as a secondary source, after employees tries to attain knowledge from their colleagues. A survey was conducted at Massachusetts Institute of Technology MIT, which showed that engineers and scientists was five times more likely to ask a colleague for information than an impersonal source like a database, file cabinet and alike, Which the results of the depth analysis showed as well. This also matches other similar surveys.

The research revealed that people deemed four features important in the relationship with their colleagues, enabling them to find their required knowledge. If one of these features were not present in a relationship, the likelihood of knowledge sharing did not occur. (Cross, Parker, Prusak, Borgatti 2001)

- **Knowledge: Knowing what other persons know and when to turn to them.**
  To initiate a search for knowledge, it requires knowing who contains the knowledge. This enables us to seek a specific person out, that are in hold of the knowledge we seek, even if it initially is not the right person to contact, we correct and adapt over time.

- **Access: Being able to gain timely access to that person.**
  If you know a person that contains the knowledge that you seek, the relation that you have with that person is of great importance to extract knowledge from him/her. It requires that the person sought out has sufficient time, and can be approach by the seeker of knowledge at the right time. The relation concerning the access of the individual's knowledge is based on the physical proximity, organizational design, and the collaborative technology.

- **Engagement: Willingness of the person sought out to engage in solving the problem, rather than dumping information.**
  After being able to access the knowledge, the seeker of knowledge must be able to encourage the holder of knowledge to share it. It happens through explaining the problem to the knowledge holder, enabling him/her to shape the problem in the head, and relate to the problem and access the request, rather than dumping the information without care of context.

- **Safety: A degree of safety in the relationship that prompted learning and creativity.**
  One of the most frightening thoughts for people related to their professional careers is the admittance of lacking knowledge. Within relationships with other the colleagues, feeling safe is very important in order to acquire new knowledge. Being able to express the lack of knowledge in conversations will often result in acquiring new.

While the features were present, other factors did also affect when and how the employees make the contact to colleagues for seeking knowledge. Often factors like education and age similarity, physical proximity, time and formal hierarchal position e.g. would predict the contact made. (Cross, Parker, Prusak, Borgatti 2001)This focus is made to enlighten the vital aspect of knowledge creation, which it is not only a pure technological aspect, but about human relations needed to facilitate it, and one must take employee behavior in account. It is that behavior that demands transaction into the Social Networks, where computing can support the transition of information between employees in the company. By supporting the four features that will enable people to not only use the impersonal knowledge, but utilize the personal knowledge lodged in the colleagues in the company that the IT-solution must facilitate.

To enable the IT-solution to facilitate the four features for knowledge creation in the company, initiatives must be lodged into to solutions that are based upon those. The following section will try to explain what initiative promotes the four features, and will be included into the proposed IT-solution.

INITIATIVES TO FACILITATE KNOWLEDGE WHEREABOUTS

One of the first steps to generate knowledge creation in the company, is to facilitate a system that can pinpoint who knows what. This can enable the employees to gain an understanding of the company's collective knowledge. This happens through a focused integration of the employee at the beginning of the arrival to the company, to quickly being updated into IT-systems and company culture. This rarely happens in real life as defined in the depth analysis. The will give the opportunities to ask the right person about the many questions that are most likely to occur during the first period. (Cross, Parker, Prusak, Borgatti 2001) With the IT-solution having a system to show work-practice and being able to display who the knowledge domain specialist is, and where to find the information related to the system, can make it easier for new employees to find the right knowledge, and the right person to contact.
At C.F. Møller a CV and competencies are available at the intranet, which have been merged with the login profile at the intranet. But only a few has filled in the data needed to make it usable, and is not available for the general user, only the office and project leaders have access.

INITIATIVES TO FACILITATE KNOWLEDGE ACCESS

Companies in general, but especially companies like C.F. Møller where locations of offices are spread across northern Europe, struggle with accessibility of the colleagues from locations other than the individuals own. Technology can help increase the accessibility by providing the offices with technical tools for communicating knowledge, like synchronal and asynchrony communication devices like mail and instant messaging. But besides the technical tools, a big factor to why the accessibility is low across the offices is due to organizational structure and culture. Aspects like this are defining who is accessible to whom. This must be created in accordance to the thesis goal, facilitating the employees to use each other, and to make it visible of who contains what knowledge. This will make it more easy and "attractive" to make contact to the knowledge specialist to achieve the knowledge across the whole company throughout countries and cultures.

According to C.F. Møller strategy, there has been created lighthouses of knowledge (Employees with specialist knowledge) across the company, with special expertise in a giving knowledge domain. It is important that those lighthouse individuals are accessible in several aspects. They must be less burdened with administrative work, to make space for sharing their knowledge, and they must be encouraged to support both the process mapping functions and utilizing groupware technology in order to communicate as effective as possible, if not face-to-face communication is possible. A lack of these aspects can result in isolated clusters of "knowledge lighthouses" not being able to share their knowledge, hence being inaccessible, and limiting company based knowledge. (Cross, Parker, Prusak, Borgatti 2001)

INITIATIVES TO FACILITATE KNOWLEDGE ENGAGEMENT

To engage the employees in knowledge sharing, it must happen through the use of technical tools that allow for functions like the digital whiteboard e.g. This allows for dispersed engagement in a common problem. Employees must post issues knowledge needs at a project wall (could be a similar function to the Facebook semi-public feeds) e.g. where people were able to interact by replying, in order to create a common base for engagement. Other functionalities supports engagement like video-conferencing, group-instant messaging e.g.

INITIATIVES TO FACILITATE KNOWLEDGE SAFETY

Safe relations is a crucial factor regarding creating the highest level of knowledge. By being worried about admitting lack of knowledge or expertise, employees are not willingly to ask for help, which is a big psychological issue because it triggers defensive behavior. But with safe relations that is formed a basis of trust, can be the base of a shared knowledge. The "knowledge lighthouses" that forms the basis for knowledge sharing, must focus on trusted relation between the other employees if sought out be asked for knowledge. Especially because the "knowledge lighthouses" contain complex knowledge, where trust is needed between other employees in the company must be very safe, for the knowledge sharing process not to be superficial. (Cross, Parker, Prusak, Borgatti 2001) The IT-solution must facilitate trust between group members, office members and organizational members. This can be facilitated through: (Cone, 2007) / (http://www.knowledge-managment-tools.net/groupware.html)

- **Transparency**
  By increasing transparency, which shows the rationale for your actions. This can happen through interplay with the process maps, to explain in what context the issue is located. The process mapping system can also be used to externalize thought processes, which can help the questioned to gain context about the issue.

- **Appreciation**
  People familiar with social technologies like Facebook, know the famous “like” button. A simple yet important action to appreciate knowledge, insight or similar shared. A similar system must be incorporated into the IT-system to “like” professional posts, to increase appreciation for each other, and give incitement for people to share knowledge, for the tradeoff of social appreciation. This also gives insight into what matters to the individual colleagues, and can help decode the social playbook that is required to achieve trust. A system of rewards in form of a special badge or similar can be utilized as a recognition of the work, as another tool to provide users of the system incitements to contribute.

- **Empathy**
  It is important that the groupware facilitate the employees that use the system to be connected to areas of their interest. They must be attached to affiliated projects or similar, and in general attached as listeners, and encourage the fact that that they are not obligated to respond or judge unless they feel that it is necessary. This can build empathy to the project and its members. Besides that the trust obtained in the groupware, trust can foster people to show uncertainties, which can foster even more trust.

- **Rapport**
  In order of building between people, it is necessary to look beyond people and their functions at the companies, and make their personal life more visible. By doing so, will it be made easier for the employees to bond socially, which builds trust. By incorporating profiles similar to Facebook and Linked-In technologies can give the rest of the employees a sense of the person’s history and interests, and make it possible to talk about non-work related subjects at the IT-solution. The profile can give a focal point for the colleagues to see an individual as something more than a “drone” at the company.

INFORMAL AND FORMAL COMMUNICATION

It is crucial to support informal collaboration, by groupware systems. Groupware is computer software that is designed to help employees communicate conferencing and co-ordinate and help them to achieve common tasks. (Johnson-Lenz, 1990) There is no doubt that to support knowledge creation within the company, informal communication is a crucial factor. Informal communication is the basis for the socialization phase in the SECI process, which is about expressing the tacit knowledge through socializing with another individual. This transfer of knowledge then happens through informal sources.

Formal communication is also important; it is in this aspect that knowledge according to Nonaka gets crystallized in the transfer from tacit to explicit knowledge. It can be time-consuming, but it helps contribute to the company's knowledge memory when scripted into documents or alike, and it can help fixate responsibility. In the functionalities it is necessary to form a basis for both forms of communication, to support an effective SEKI process.

THE JOHARI ASPECT OF KNOWLEDGE

Most people can probably relate to the issue of not knowing what is not known. This is a typical issue when starting at a new job, new project or similar. (Interview Niels Fuglesang), An example could be that if you are not aware that an specific wall needs to be fire proofed according to the construction code, you will not fire proof the wall, and obviously it is crucial that you get that discovery. If you do not know what knowledge you do not know, then it is impossible to gain that knowledge other but pure chance, or trial and error, which properly happens more often that one would think. This aspect is crucial to promote an active knowledge creation method in a company to make the employees more aware of this.

When knowledge is created between individuals, the knowledge output is based on how the interaction is performed by those. This interaction is a form of relationship which quality is defined by what and how each individual contribute to the relationship. The relationship requires that both individuals know themselves, and the level of how much knowledge they want to reveal to each other. This founds the basis for a sound knowledge creating relationship. This exchange of information between individuals can be categorized and has been combined in the conceptual tool, the Johari Window.

The Johari window was created by Joseph Luft and Harington Ingham in 1955 and is a tool to help people understand how their relationship with others affects the knowledge perceived. It is with this tool possible to define an individual`s ability to self-disclosure, and openness to feedback and perceptiveness. This is shown in the "window" which is a matrix on what is known to self and others and what is not known to self and others. **Error! Reference source not found.**

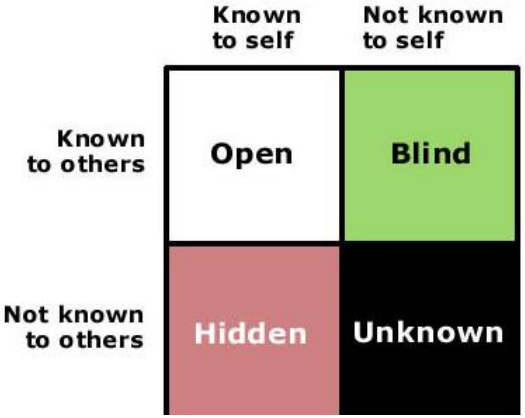


Figure 30: The Johari Window (http://underside.files.wordpress.com/2011/02/johari-window-mbaknol.jpg?w=584)

The window is a metaphor for looking through a window, and seeing how the structure of knowledge is represented in relation to the individual and others. The window is based on two axis one defining what is known and unknown to others, and one defining that is known and unknown to the self. The results are four smaller windows, or areas. (Luft, 1982)

- **The open area: What is known to self and others.**
  This area is the knowledge known to self and others, meaning that people know that you know knowledge about a specific area. In this enables people to collect knowledge from you. How people get their knowledge in this area is by CV and competence tools that get published in companies or at internet sites like LinkedIn where an individual's knowledge get visible.

- **The blind area: What is unknown to self and known to others.**
  This area represents the knowledge you have, that you do not know you contain, but others know you have. To get this knowledge into the open area, the people must be knowledgeable of that fact that they must supply feedback, to enable this transition.

- **The hidden area: What is known to self and unknown to others.**
  In some cases individuals want to hide knowledge from other people. This can be related to political motivated factors at the company, or to conceal the lack of knowledge. In this case expressing the lack of knowledge, trust must be present and the individual must on own initiative reveal the lack of knowledge, so the other people can help the transaction from the hidden area to the open, which is called disclosure or exposure.

- **The unknown area: What is unknown to self and others.**

  This is the area where knowledge about knowledge is unknown, and because of this difficult to obtain. This area is important to convert into the open area which happens through a willingness to seek and receive knowledge. Discovering this area requires invitations to construct critique on the basis on feedback on exposure, which can trigger discovery. The unknown in the relation to the theories of Nonaka is the tacit aspect of knowledge.

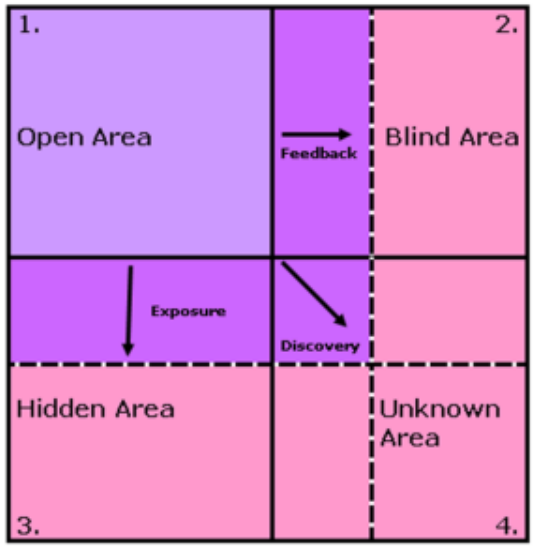


Figure 31: : How to get knowledge into the open area (http://probings.files.wordpress.com/2012/07/johari1.png)

From the Johari perspective in order to transform the knowledge lodged in the unknown area or the tacit knowledge into the open area, it requires feedback and exposure to the discovery. The IT-solution must facilitate a system that enables the employee to show what knowledge he/her contain, by that also showing what they do not contain, hence exposing their lack of knowledge. The knowledge supplied by a CV or a list of competence is only exposing a general view of the knowledge of the employee. The system must then foster a system that can facilitate more exposure of knowledge contain and lacking.

The IT-solution must facilitate functions of feedback in many levels. At a general level feedback to project leaders and vice versa, what went well, and what went bad during the project, which according to the theory of the Johari Window leads to discovery or creation of new knowledge. At a more detailed level, process maps can help colleagues giving feedback on process maps e.g.

Table 4: Groupware / ESN system Function list (Author 2013)

Groupware function table	Short description	Based on theory(ies)	Found at
Profile and group creation	Creation of profiles and groups	Cross, Parker, Prusak, Borgatti	
General information	Input of general information at profile	Cross, Parker, Prusak, Borgatti	
CV & Competencies	Input of CV and competencies	Cross, Parker, Prusak, Borgatti	
Specialist badges	Possible to gain or give specialist badges	Cross, Parker, Prusak, Borgatti	
Desktop (PC/Mac)	Possible to gain accesses from a pc / mac	Senescu	
Smartphone app (Android/Apple)	Possible to gain accesses from a smartphone	Senescu	
Tablet (Android/Apple)	Possible to gain accesses from a tablet	Senescu	
Database file structure / transferring	Files located in database structure	Luft, Ingham	
Versioning	Files contains versioning	Luft, Ingham	
Official content marking	Marking of official content	Luft, Ingham	
Private messaging	Can communicate asynchronal	Nokaka / Muina, de Castro, Saez	
Instant messaging	Can communicate synchronal	Nokaka / Muina, de Castro, Saez	
Announcement messaging	Top management can communicate broadly	Luft, Ingham / Nonaka	
Feeds	Real time information feeds from colleagues	Luft, Ingham / Nonaka	
Praise and Like functionalities	Can praise and like colleagues status	Cross, Parker, Prusak, Borgatti	
Endorsement of competencies	Possible to endorse colleagues competencies	Cross, Parker, Prusak, Borgatti	
Event handling	Possible to create and manage events	Nokaka / Muina, de Castro, Saez	
Polls	Can perform polls in groups or general	Nokaka / Muina, de Castro, Saez	
Video conferencing	Can collaborate through video conferencing	Nokaka / Muina, de Castro, Saez	
Whiteboard	Can collaborate through whiteboard	Nokaka / Muina, de Castro, Saez / Card	
Mind-maps	Can collaborate through mind-maps	Nokaka / Muina, de Castro, Saez / Card	
Influential leaderboard	Show user influence based on activity e.g.	Cross, Parker, Prusak, Borgatti	
Search function	Search for employee, competencies, project e.g	Luft, Ingham / Nonaka	
Ticker function	Steady flow of activity throughout the office	Luft, Ingham / Nonaka	
Password protected areas	Possible to lock certain areas or groups	Luft, Ingham	
Syncing of external mails	Synchronize mails from external individuals	Nokaka / Muina, de Castro, Saez	
Analytical tools	Can analyze activity	Luft, Ingham / Nonaka	

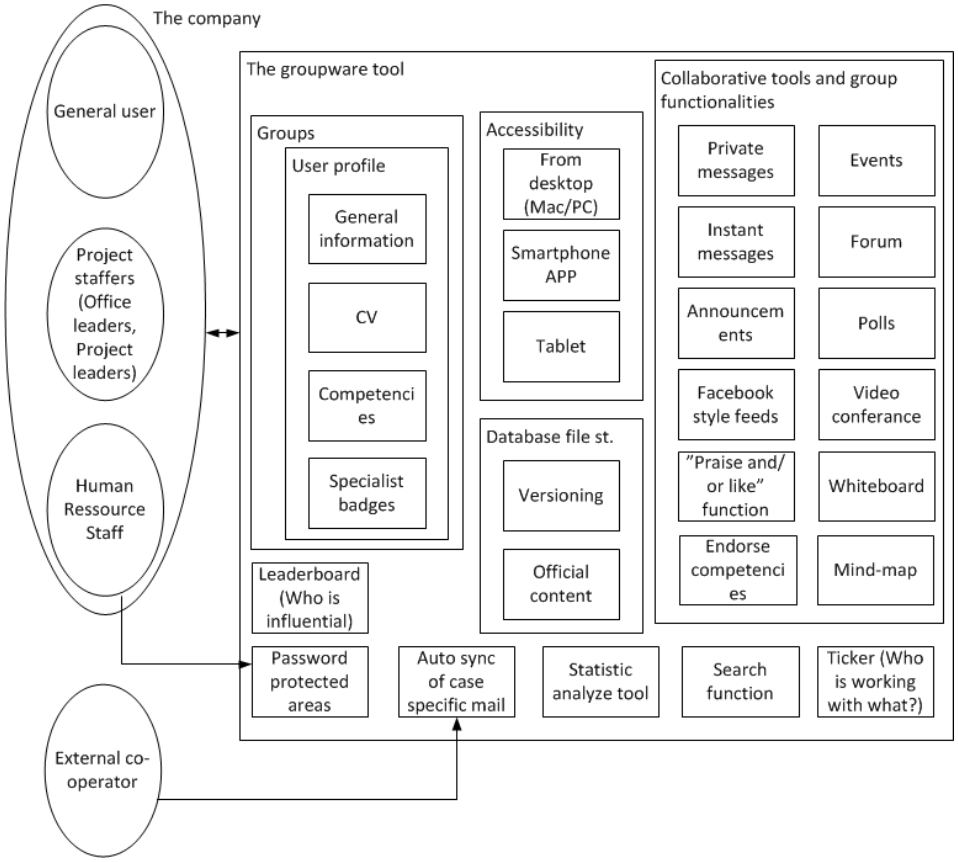


Figure 32:Function Model of the Company Hangout (Author 2013)

CONSOLIDATION OF FUNCTIONS OF COMPANY HANGOUT

These consolidations of functions show a categorization of the different functions that are required in this case to support the work-practice and ensure a sound environment of knowledge creation.

The group functionalities require that it has profiles attached with general, CV, competencies information and specialist badges to support the social engagement to the system, which leaderboards, endorsements of skills or praise/like functionalities that can spread the social trends to other users. It needs password protected areas because not all information can, and must be shared to everybody, and at last a statistic analytical tool for analyzing employee behavior.

According to Johari Window theory, a ticker is needed to show unknown knowledge to the employees. A database structure must also be present where official content can be added to make knowledge searching easier due to the possibility of attaching more meaning to files through Meta data.

To ensure the SECI process of knowledge creation collaboration tools must be present for the employees to convert their tacit to explicit knowledge and back, and the system must be available from the desktop to smartphones and tablet PCs.
To ensure that external information get in to the system the system must facilitate auto syncing of e-mail from external clients.

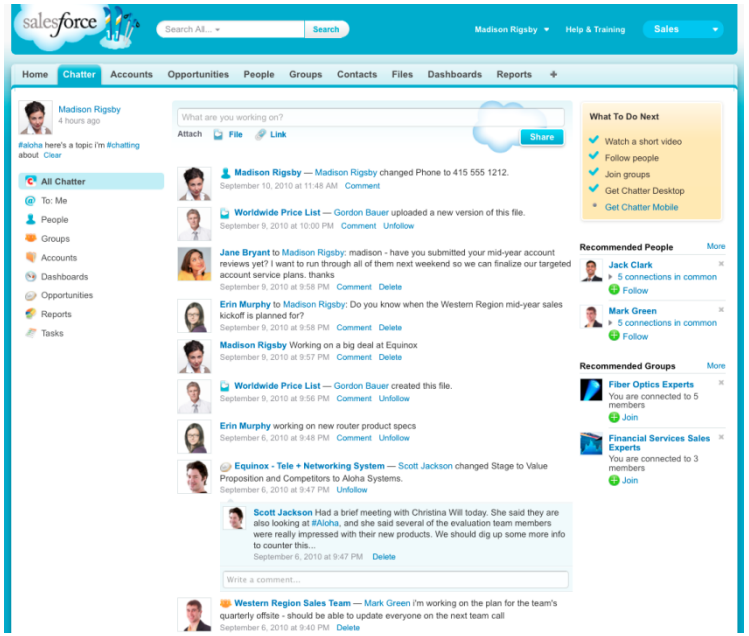
POSSIBLE EXISTING SOFTWARE SOLUTIONS TO FACILITATE FUNCTIONAL DEMANDS

The author's investigation by interviews and searching through the internet, he found that there was no currently functioning software solution that contains both the process mapping functionalities and the groupware functionalities, as earlier described. The following section is either groupware or process mapping software which has to be used separately or through customizing it, to be used combined. Neither does any AEC specialized tools exist with functionalities. This means that generalized tools will be considered to meet the functional requirements. In the rest of this section tools will be listed, that meet the requirements and are easy to use and have a variety of functions that allows employees to collaborate in the companies, and easy to use.

ENTERPRISE SOCIAL NETWORKS TOOLS

Today many products for group collaboration in a company context are available on the marked. In this section the author will try to give an overview of existing products that can comply with the demands for functionalities defined in the previous chapter. The software most likely to fit the functional demands is the section of groupware tools called Enterprise Social Networks (ESN). This is a tool that focuses on the use of social networks like we know it from Facebook and LinkedIn, and the social relations in-between. This social network consists as a modification of the company intranet and other classic company software that facilitates communication and collaboration, and is creating visibility of the company for the employees. ESN focusing on following employees in what they do, and sharing their experiences. events, subjects and social event streams.

In the next section, a company visit has been conducted to explore the possibilities, advantages and disadvantages about developing an in-house ESN solution.

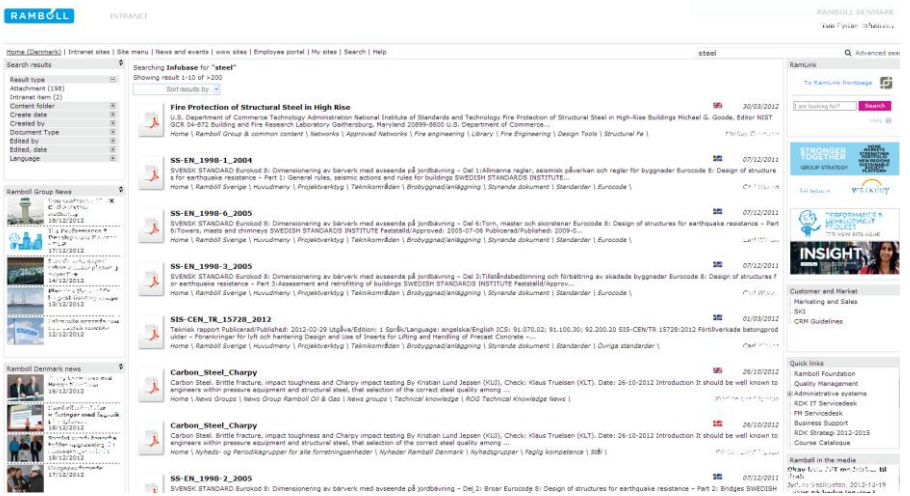


Picture 8: Chatter ESN Tool (http://www.zdnet.com/i/story/60/01/039463/chatter-central.png)

SPECIALIZED AD-HOC ENTERPRISE SOCIAL NETWORK TOOL – RAMLINK

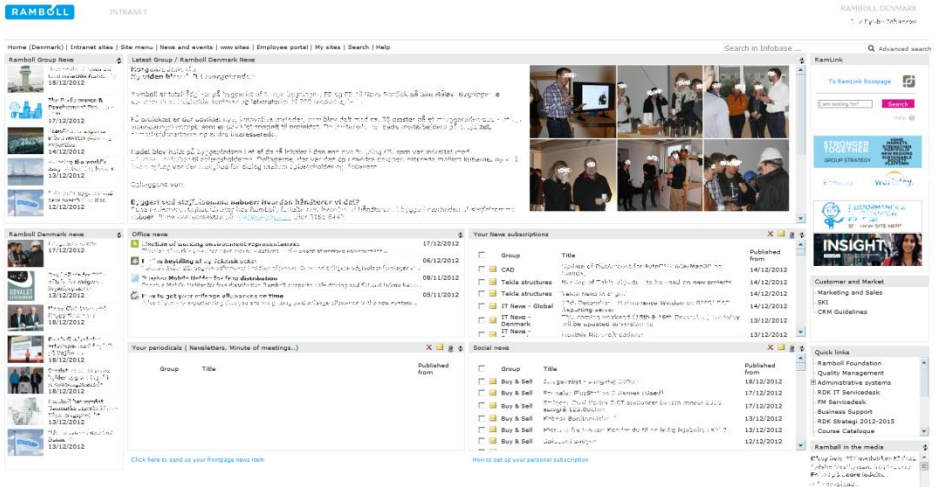
One of the Danish developed ESN tools for the construction is called Ramlink, developed by Rambøll a Danish engineering advisory company with approx. 9000 employees developed its own system to cope with the organizations many offices which is spread around the world. The system was launched about 2 years ago, because their previous intranet solution made it difficult for employees to find information, due to each department had their own system, which made it difficult to locate the needed information. This made Rambøll start developing their own ESN tool which goal was to support the current business processes that included finding the right people and projects in the concern.

Another goal was to make sure that the employees fill in the information at the ESN and that the system encourage the employees to do so. That was why Rambøll got inspired by social networks like Facebook where user-content is the main source of information shared. (http://www.version2.dk/artikel/ramboells-ramlink-videndeling-la-facebook-17003).



Picture 10: Intranet frontpage (Author 2013)

A company visit at Rambøll - Aalborg, revealed that the system was not completely used as intended. The Ramlink functionality was located at a global intranet like frontpage, that presented general company news and alike, in the right top corner a search function, and link to Ramlink was located. The interviewed employee at Rambøll Tim Fynbo Johansen mentioned that the system was only used in rare occasions, when highly specialized skills were needed, and was not located at the department he was located. Often the project group was located close to each other, so it was easy to ask the colleagues for questions related to the project, and not use Ramlink. For the interviewee the main functionality was to use

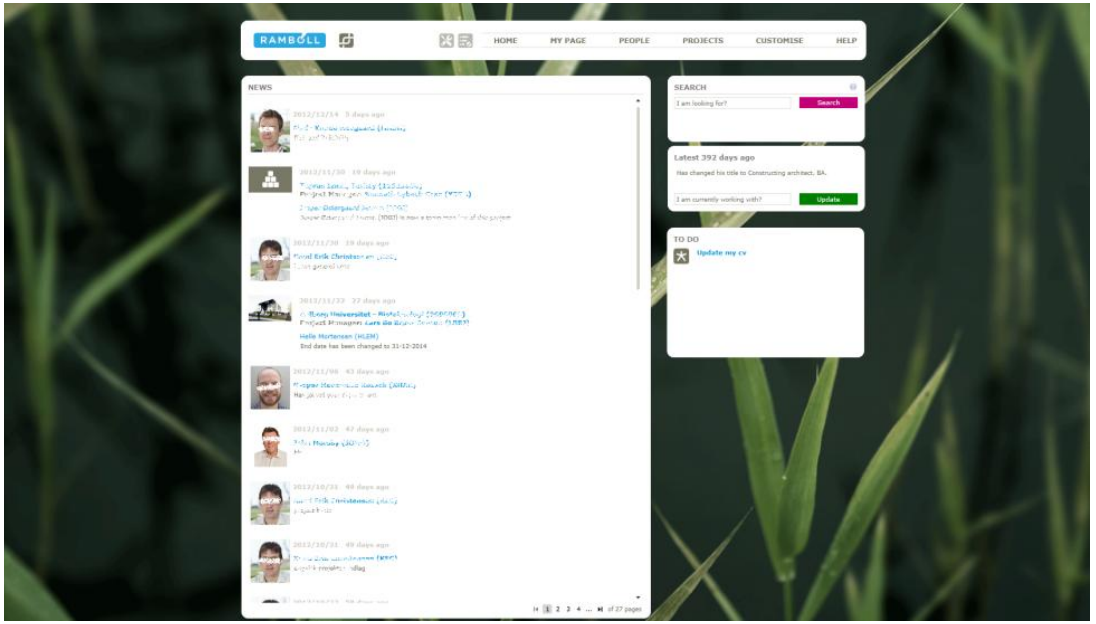


Picture 9: Infobase search on steel (Author 2013)

Ramlink as a CV database, not much more. A brief presentation of Ramlink showed that employees did not use the part of supplying Ramlink with updates or similar, but was mainly showing employees that thought they were using a search function, but in reality was posting a profile update.

Another thing was that besides Ramlink, the employees where “encouraged” to share knowledge with each other in a parallel system, that contained had similar functionalities where information was not user-created, but specialist-created. An information search function located on the intranet makes it possible to find specialized information about themes like steel or concrete e.g. and help navigate the employees to pages which contained the specialized knowledge. This knowledge domain pages had a group of listed experts on the subject, and vast amounts of information on the subject. This system was employed a long time before Ramlink got introduced, and is maintained by the knowledge domain specialists, that keeps the knowledge page actively up to date. This means that, if an employee does not have a colleague to ask for specialized information, he can find the information about the specialist at two places.

Another issue is related to the theory of the Johari Window. If you do not know what you seek, you will not seek it out. Because Ramlink is a separate function that you have to enter to withdraw information, you must have an idea of what you are looking for, and the information present at Ramlink is often information, that you did not think was important to you. Because of this the interviewee proclaimed that the real usage for sharing information between useres, is not fulfilled due to people not feeling obliged to enter information, and the information is not shared because people do not enter Ramlink besides looking for specialist people in rare occations. (Interview with Tim Fynbo Johansen) A highly reliable anonymous source proclaims that the system has cost at least 9 million DKK to develop.



Picture 11: Ramlink frontpage (Author 2013)

This interview highlights how important it is to ensure that the ESN system or similar, are used by the employees, and the system gets integrated into the current work-practice. Developing a system like this from the bottom-up is an expensive and time consuming process that requires many aspects of user-context is considered, and can be difficult to integrate. If this is not done, the investment could be lost, and the system is either not used at all, or only a small part of the system is utilized.

The solutions do seldom provide with much custom-ability regarding a more focused usage of the ESN system. (http://www.itpro.co.uk/643351/enterprise-social-networks-come-of-age-says-ovum) The same goes for the analysis which focuses on giving a new aspect of expressing, discussing, modifying and adapting processes through process-maps due to a heavy load of heavy knowledge-based processes in the AEC business, which none of the listed systems provides.

List of existing ESN Tools

The ESN tools chosen for review are based on some of the most popular solutions available as of now according to Forrester Research. (http://www.informationweek.com/thebrainyard/news/240000678/yammer-chatter-tibbr-ranked-top-social-activity-streams). The developed ESN system listed are run externally in the cloud, and have limited maintenance. The tools listed; do not differ in their general functionality. All of the tools contain the social network methodology, where it is the wall of feeds, to projects, employees e.g. that founds the basis for them. The difference is in the detail, which will be visualized in the end of the section, where a full list of features shows what each solution provides according to required features. (

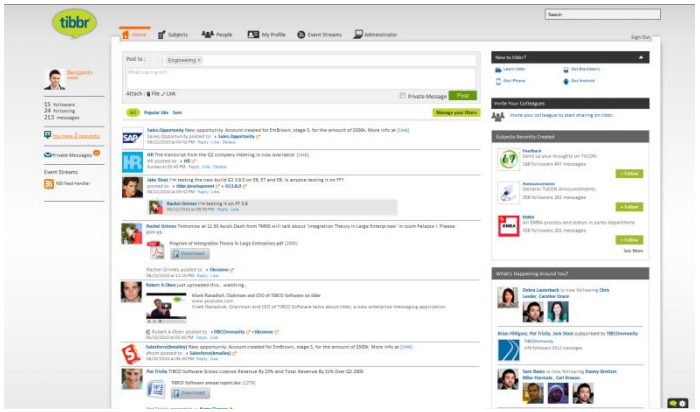
Table 5: List of required functionalities according to existing ESN solutions (Author 2013)). The table shows what functionalities the software supports marked as green. Yellow is the mark which shows that the software somewhat support that function and counts for a half function, and the red color marks that the feature is not present and counts for zero feature.

Yammer

Is a tool for internal communication in companies. It is also an ESN, but was launched as a micro-blogging service and gradually evolved into a full-fledged ESN service. Yammers have many features, but it revolves around the information shown in the "main wall" where feeds show from subscripted co-workers or cases. Yammer is the cheapest and it fulfills most requirements of the listed tools. More specific results can be seen at the Groupware function table (https://www.yammer.com) / (http://www.netzwelt.de/news/89981-einfuehrung-persoenliche-facebook-yammer-erstellen.html)

Chatter

This is a private social network with "real-time collaboration", which basically is the same functionality as the other ESN systems. The system communicates project information actively through a real-time news stream where users can follow the news flow from a co-worker or a particular case. The users can form groups and post files and links to the groups to be reviewed by other group members. Chatter is a basic ESN system, which includes all the standard ESN functionalities required, but not much more than that. (http://www.salesforce.com/chatter/features/) / (https://www.chatter.com/eu/)



Picture 12: Tibbr (http://www.cmswire.com/images/Main_Wall.png)

Tibbr

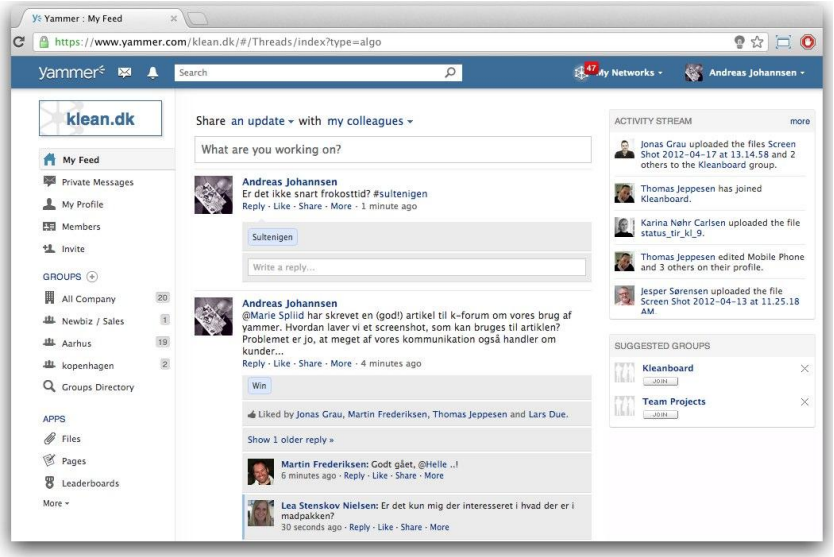
Tibbr is developed by TIBCO software and launched in January 2011. It is a social network solution for the workplace, where its forces are the possibility of integration of feeds, input and output from outside programs, and social media platforms. It can real time synchronize RSS feeds, Facebook feeds and mails. Of the many popular tools already used in companies, it is possible to integrate them through Tibber App store. From here it is possible to distribute apps like Fileboard, Teamly e.g.
One of Tibbr main forces is that it has a highly customizable API which allows the user to extract data from Tibbr.
(http://www.zdnet.com/blog/howlett/tibco-launches-tibbr-enough-to-make-enterprise-2-0-viable/2800)

Table 5: List of required functionalities according to existing ESN solutions (Author 2013)

Groupware function table	Yammer	Chatter	Tibbr
Profile and group creation			
General information			
CV & Competencies			
Specialist badges			
Desktop (PC/Mac)			
Smartphone app (Android/Apple)			
Tablet (Android/Apple)			
Database file structure / transferring			
Versioning			
Official content marking			
Private messaging			
Instant messaging			
Announcement messaging			
Feeds			
Praise and Like functionalities			
Endorsement of competencies			
Event handling			
Polls			
Video conferencing			
Whiteboard			
Mind-maps			
Influential leaderboard			
Search function			
Ticker function			
Password protected areas			
Syncing of external mails			
Analytical tools			
Total functionalities	23,5	15	20
Price pr. employee a month	Free to 3 $	Free to 15 $	12 $
~Price pr. functionality	0,092 $	1 $	0,6 $

FUNCTIONAL RESULTS

The table shows that Yammer contains the most functionality required, next is Tibbr, and last is Chatter. The main difference is between Yammer and Tibbr, is the integration of social functionalities, is possible to integrate those through Tibbr app store, but it is only semi integrated through this. Yammer facilitates the social functionalities to a greater extent than the other solutions, but has a somewhat critical weak spot regarding the integration of other communication forms like emails. It is possible, but not fully integrated to sync mails into Yammer, where Tibbr has a seamless integration of e-mails. But the general overall solution leader for these functional requirements is Yammer. Cheap price and a great social integration of the software are the feats that separate it from the two other solutions.



Picture 13: Yammer (http://www.kommunikationsforum.dk/log/multimedia/klean%20yammer%20shot_png.jpg)

SUB-CONCLUSION

By implementing a non-specialized ESN tool it can facilitate many of the required functionalities that are required. If better integration from other software is required, all of the listed ESN tools have an open API which allows for interaction from other software systems. One of the most customizable friendly API's was supported by Tibbr. This could be a crucial factor if looking past the complete number of functionalities and price. A general view on the differences between both a custom and specialized developed systems versus the non-specialized tools is the price. The prizing of the ESN software ranges from 3 to 15 $ pr. employee pr. year. Which is considerable lower than developing a system like Ramlink, due to the 9 million DKK development + implementation + maintenance will surpass the cost of subscription of one of the listed systems, with a customized API. For the same price of developing Ramlink, 9000 employees could use Tibbr's ESN service for at least 13 years. To improve the company's knowledge creating environment, the ESN tool will be the "glue" in how the process map functionality will be integrated into the current context. By integrating social and collaborative theories, will give the employees incentive to utilize and contribute to knowledge creation, with the mapping tool. Without the ESN tool, the process mapping tool will just be another gimmick, collecting dust, not proper utilized, similar to Ramlink, which is not desired. Hence the importance of implementing this two pronged solution, that support the sub problem definition of facilitating both usable knowledge and increasing the level of overview for everybody assigned to the project.

THE PROPOSED IT-SOLUTION

In the beginning the thesis defined what problems the current IT-setup raised, and then theory was applied to work out solutions to counter the problems, which lead to functionality requirements the IT-system had to contain. In this section the IT-solution based on the previous notions is created, as a way of increasing total quality defined in the problem definition.

The system has been separated into two functionalities. The first and main functionality is the mapping of processes, as a system to facilitate better knowledge creation in the organization. The secondary part of the solution must facilitate the collaborative functionalities, that can ensure that the best environment for using the process map functionality through the ESN system. One of reasons for splitting the IT-solutions functionalities up into two was because there was no existing solution that possessed both functionality domains. The previous sectors gives a foundation for choosing the right systems for the companies, and this section maps the possible IT-solution in the context of the case, C.F. Møller and work-out how it can change and improve current work-practice. Besides mapping the new IT environment, it will also explain and document how the IT-solution will be working, through Storyboarding, which is a tool from Contextual Design Methodology, in describing how the new setup will work in the old context. The last part of the proposed solution will be a plan to help implement the IT-solution, about what must be considered from implementation an perspective.

- **New IT-infrastructure**
- **Storyboarding**
- **Plan for implementation.**

NEW IT-INFRASTRUCTURE

During the best intentions, the company IT-systems drives sup-optimizing, redundant and ad-hoc IT responses, as seen during the former sections. The larger the IT-portfolio grows in the company, the more it will suffocate innovation and increase the operation costs (Silverstein, 2010). It is important to be able to manage an increase of complexity in new business, due to increase in client and legislative requirements e.g. The new IT –infrastructure has the possibility to facilitate this and to ensure a better knowledge creating environment. This happens through automation of gathering resource data and combining it with timeframe data in a project, to enable the project leader to preform analysis of the project, or spot trends. This will provide the project leader with the possibility to make the best decisions for the project by the new system help creating new "building blocks" of new knowledge. To support this, a better integration of current and new IT, creates a new environment.

With new IT tools affecting the employee, a new environment is created. This environment is built on the previous notions, diagramed in the previous chapters. The new map consists of a possible new setup that includes the process mapping and the Enterprise Social Network tools, in the context of existing IT-architecture. The overall goal with mapping the new IT-infrastructure has been to make a basis for consolidating information on the ESN tool through its API. The major differences from the former architecture, is that the file storage is integrated with the ESN, and the ESN is accessible through the cloud and maintained externally from the provider. The knowledge mapping tools data gets collected into the SQL server where the ESN API get collected data from. The level of data that are possible to extract from the SQL server is unlimited, and the views that the Autopilot software can supply is endless, but according to the providers of Autopilot, one way sync of data from Autopilot to the SQL server, is the best.

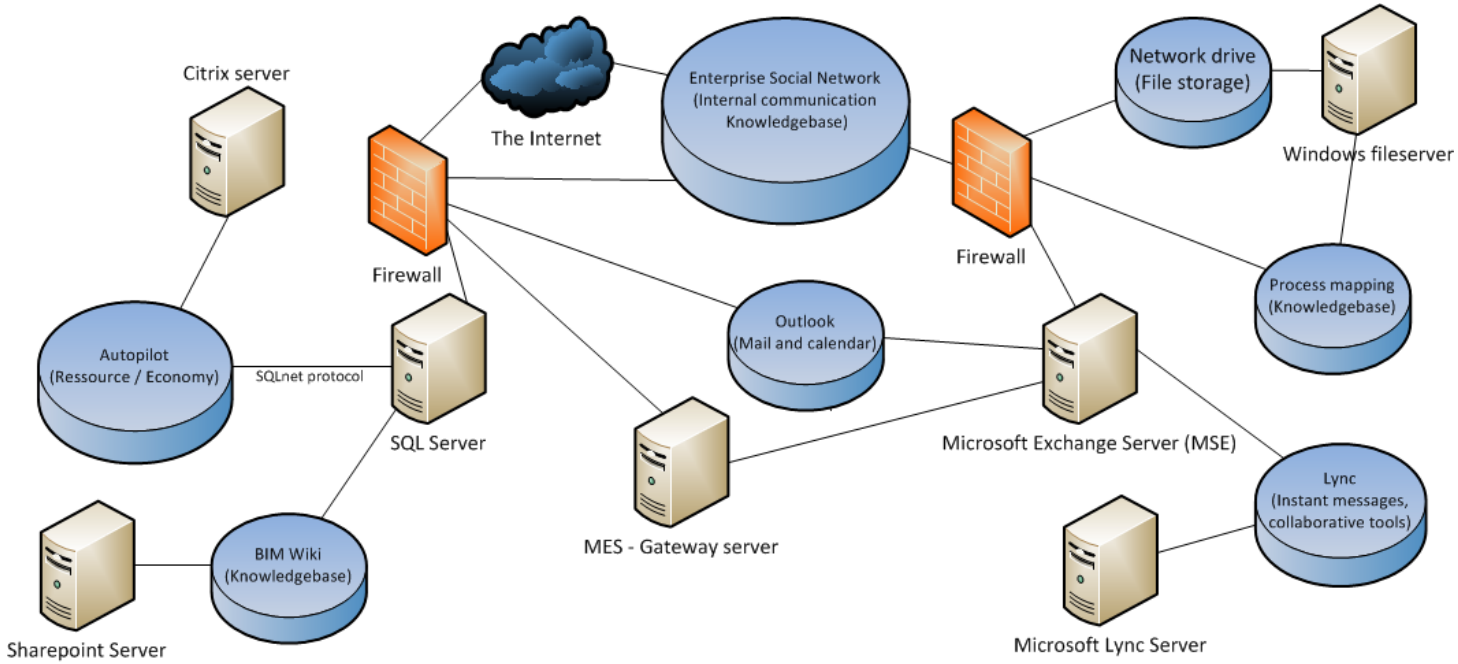


Figure 203 New IT-Infrastructure at C.F. Møller (Author 2013)

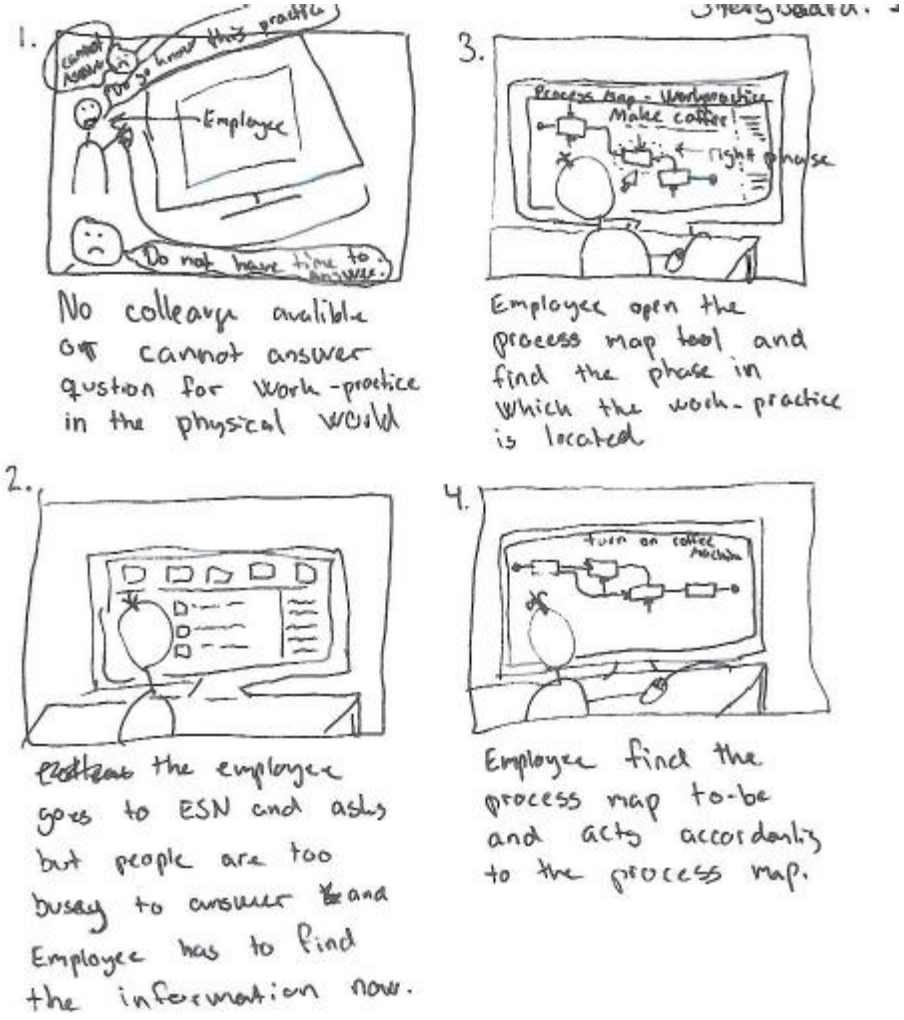


Figure 21: Storyboard 1: Gaining knowledge about a work-practive (Author 2013)

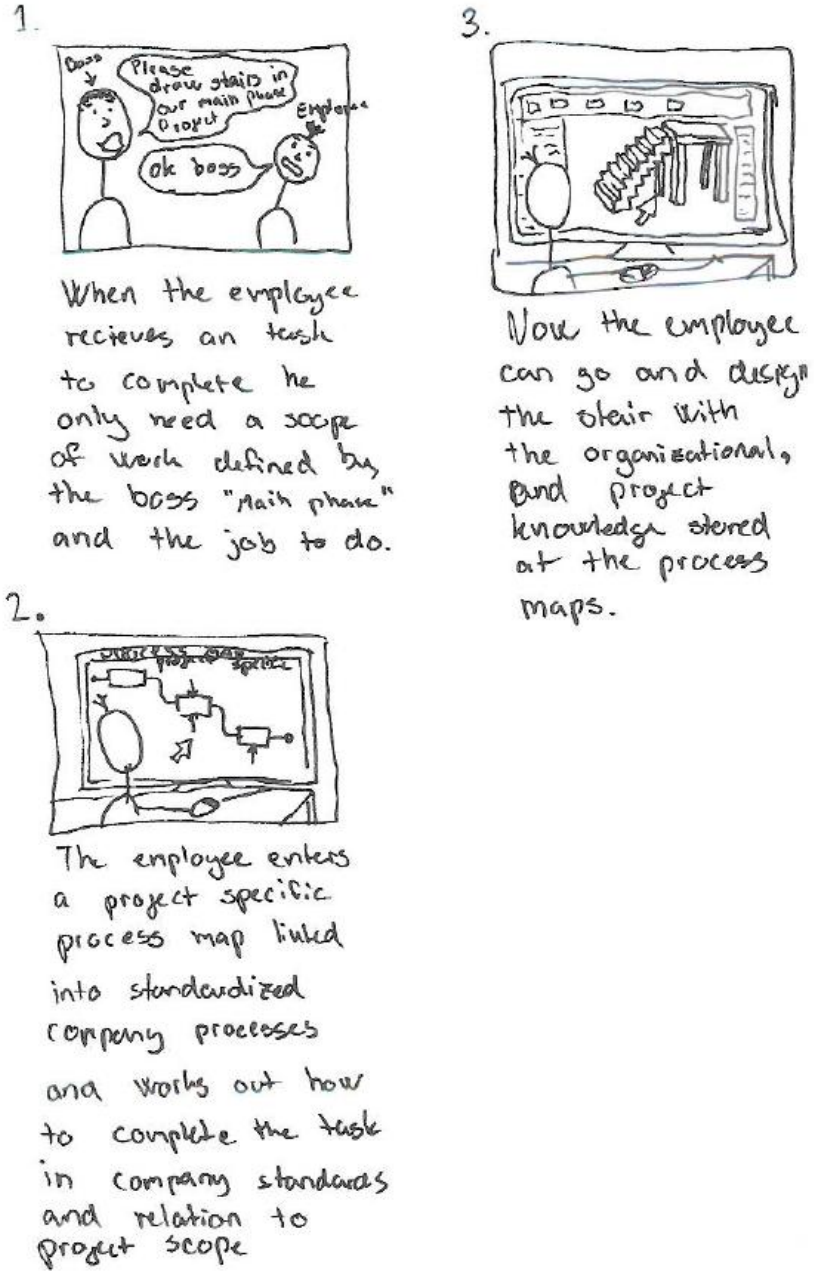
STORYBOARDING

This technique is a part of the contextual design methodology as described in the technique section in the beginning of this thesis. This tool is used for describing how the new setup will work in the old context, taking the current work-practice into account, and what needed to be executed in order to complete the task. By drawing sketches and adding text it describes what happens and will give further details to how the system must function.
Storyboarding in the thesis context is a way of explaining how the new system functionalities can support the work-practice.

This will also mark the end for documenting the system according to the demarcation section described in the beginning of the thesis.

Storyboard 1: Gaining knowledge about a work-practice

This storyboard displays how the employee gains knowledge about a work-practice, he is not aware of. When no colleague has time or knowledge about this work-practice, he can enter the ESN system and ask colleagues at different locations. But due to the limited timeframe, the employee cannot wait for the colleagues to answer; he goes to the process maps to locate the work-practice knowledge needed. This ensures that the employee gets the company standardized knowledge about the work-practice, and eliminates the time wasted on re-invention of an already existing work-practice. The will also reduce the level of mistakes.



Storyboard 2: Completing the task assigned by project leader

This storyboard shows how a task can be completed more effectively by having mapped a work-practice.

When the project leader assigns a task, the employee does not need a lot of information to complete the task according to company standards and scope of work, which either is described in a customized project specific process map, or a generalized company standard of work-practice. These reduces the need for communicating details, and make it less time consuming for the project leader to get tasks done by the project group members. It also reduces the risk of misunderstandings and errors, by always having the right knowledge available at the right time.

Figure 22 Storyboard 2: Completing the task assigned by project leader

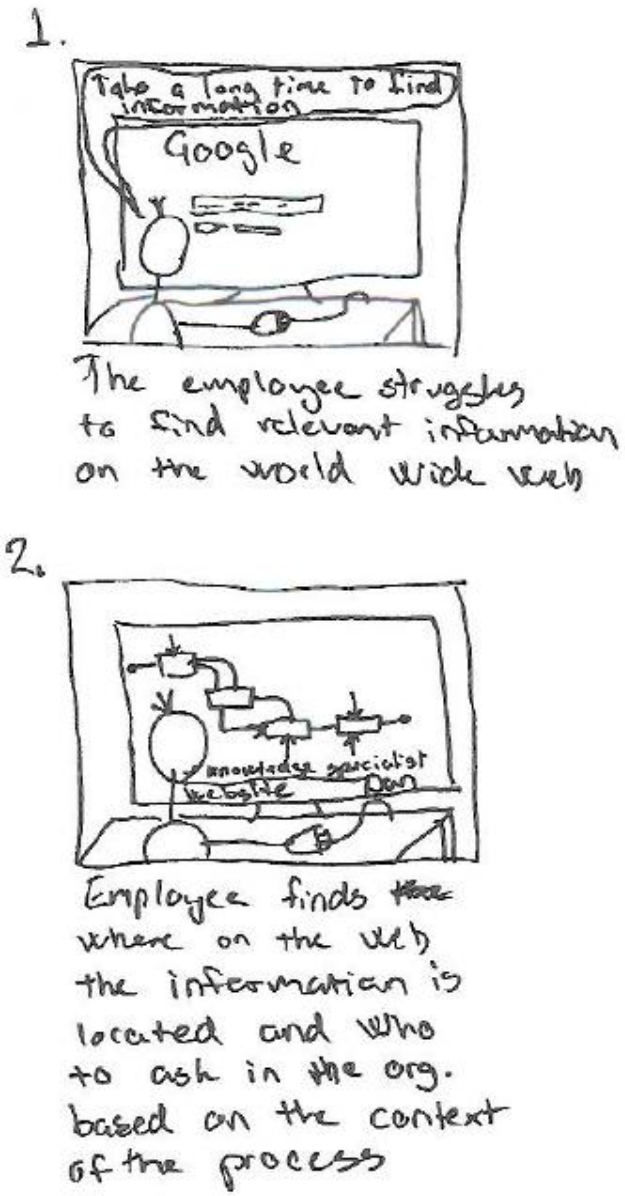


Figure 23: Acquiring the right information at the right time. (Author, 2013)

Storyboard 3: Acquiring the right information at the right time.

This storyboard shows that by utilizing the process maps, the information required to perform the task is located at the process map. This specifies where the knowledge is located and, how to get hold of it. This would either be a domain knowledge specialist, name, phone and mail e.g. or the link to either a place on the web where de information is located. This will help employees to reduce errors and time to acquire the knowledge, and by that increase internal efficiency.

Storyboard 4: Project overview

As described earlier, a project leader often has many elements to get control of during a project. By integrating information from other specialized tools like Autopilot into the ESN system, this can help supply the necessary information within a project to create knowledge, which on this basis makes the right decisions.

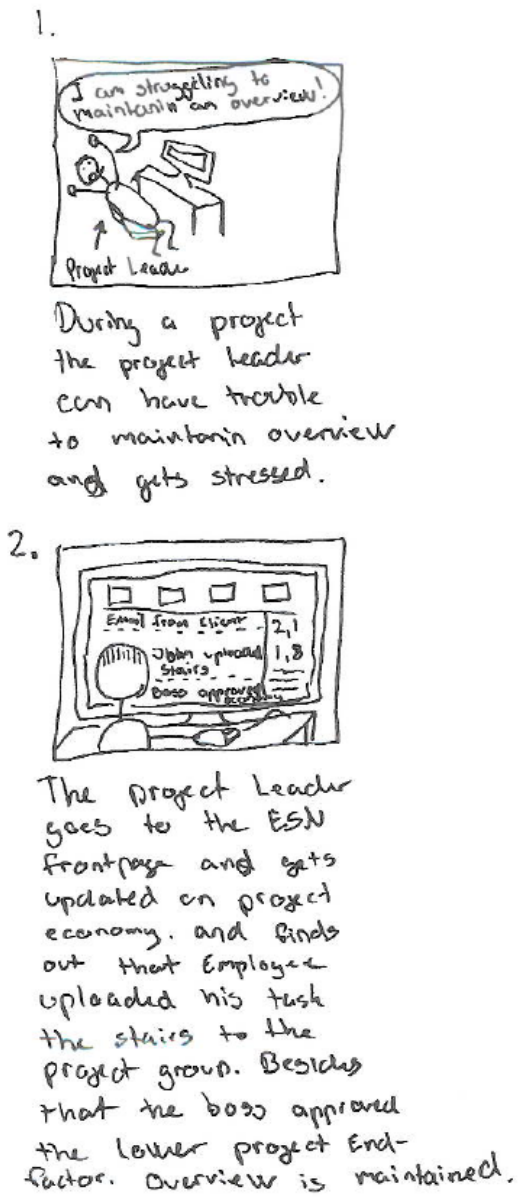


Figure 24: Project overview (Author, 2013)

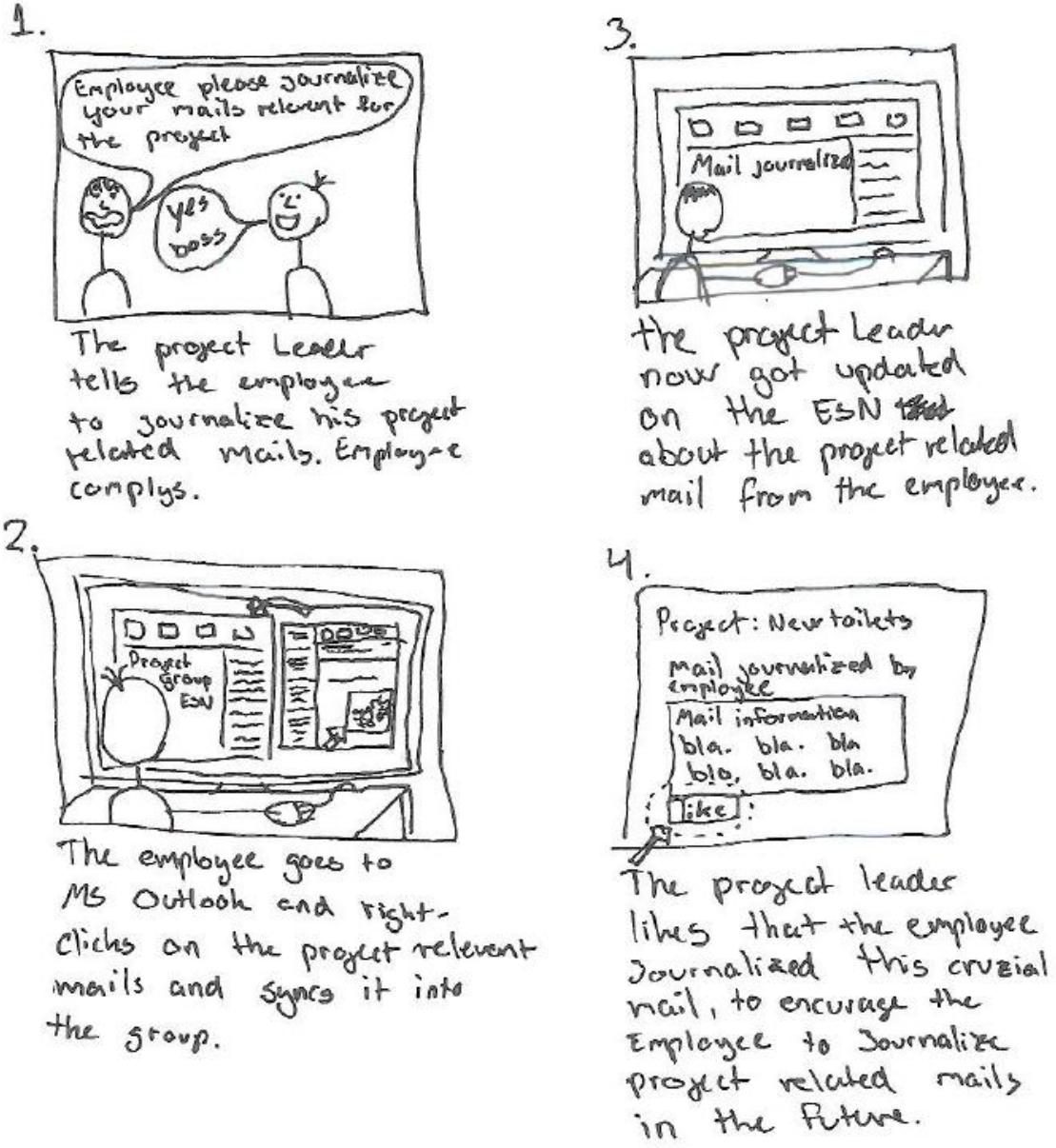


Figure 25: Social integration (Author, 2013)

Storyboard 5: Social integration

C.F. Møller had a difficult time, making their employees journalize mails into the intranet, and offices in general did not utilize the intranet to the full extent. But by making it easier to journalize the mails into the ESN system, and make it possible for the project leader to socially motivate the project group members through social functionalities in the ESN system, it will create a larger incitement for the employees to journalize the mails, which can save company money in the event of legislative claims.

This storyboard marks the end of the development of the IT-solution, which aimed to give a proposal to counter the issues defined. We have now defined how the functionalities could work during the current work-practice, as a way to document how it can increase total quality in the company, focusing on quality and output of regarding creation of knowledge.

PLAN FOR IMPLEMENTATION

To end the MUST method, and before making a conclusion, a plan for implementation is created, to give an brief overview for companies what to focus on in terms of implementation. During the specifications of functionalities the system level of Usability has been an important factor. This factor makes it more easy to implement, because it limits the time needed for learning the IT-solution to know, and encourages people to use the solution as a tool to be more productive in executing their tasks.
The forces of implementing the ESN solution will be that, it works similar to systems that people already know like LinkedIn and Facebook, where the latter has more than half the Danish population registered. (http://thomasbigum.dk/2012/02/nye-danske-facebook-tal/) Then one could assume that most employees would be more able to utilize both the functions and the system due to the similarity to Facebook, which then will limit the implementation.
Utilizing the process mapping part of the solution, is most likely to be the most difficult to implement. It will need radical change in how people work with knowledge, and require that the users have to get skilled with the mapping tool.
Sometimes people had seen an IT-solution implemented when the technical aspect was installed, not when people fully operationalized the system. Experiences show that the biggest problems occur, due to resistance against the system, among other organizational and management characteristics.

When implementing a system like the proposed, change do happen in the organization, if implemented. And it can take a long time to make those changes. And it is the process where the system and organization through the employees affects and changes each other. These changes will result in problems, and it is necessary to predict and counter the problems when they occur. A management tool for adapting to the changes can happen through change management. This is a way of management where the implementation management focuses on resistance against the implementation from the employees due to internal and external conditions. If a company would implementation an IT-solution like the proposed, five themes must be considered for implementation (Jensen, 1999):

- Organizational roles and structures
- Communication and internal marketing
- Training and education
- Performance management
- Management practice and management involvement

Chapter 7 CONCLUSION

For many years organizational science has attempted to be integrated into the construction industry with little success, resulting in lack of productivity gains compared to other industries. Explanations for this are that in order to increase productivity through organizational science, it requires situations where repetition is high and a stable environment is present.
Construction projects in general do not share these characteristics, and are in almost all cases different. Construction is getting more and more complex, and in order to control these complexities, more systems are introduced to constrain the complexity. The more complex a system gets the more it affects the psychological complexity, and this again affects the cognitive performance demand of the employee.
This thesis has focused on construction advisory companies that act in this complex environment, and bases their output on knowledge creation, and how to control knowledge, in order to facilitate a transition from the current practice to increase total quality.

In order to control this complexity in the construction industry, and to make a sound environment for creation of knowledge, three solution areas were pointed out to facilitate this. Creation of knowledge, usable knowledge and representation of knowledge, these areas where derived from the analysis and was deemed areas of focus in order to counter this dilemma.

C.F. Møller has throughout the years increased its IT-portfolio; due to arrival of new methods like BIM (Building Information Modeling). Due to this and continuing change in laws e.g. which makes it difficult to avoid mistakes and miscommunication. This was seen in both cases with C.F. Møller and Whitespace, as described in the depth-analysis chapter. The current IT-infrastructure at C.F. Møller did only support the transfer of information between IT-solutions, to a very small extent. This increases the requirements of skills and knowledge about each IT-solution, in order to make knowledge from the information extracted from each of them. In general this practice is not supporting project group members to maintain an overview during the project.

By connecting the specialized IT-portfolio information and the ESN system, overview is more easily maintained. The Autopilot information about project End-factor, Man-hours, Project group members e.g. can be presented into the ESN system. This is done so project group-members is up to date about project status, and can help create knowledge based on a mixture of information combined in the ESN system, instead of the current practice, where employees have to attend to mail, Autopilot, intranet e.g. to create knowledge unassisted of IT.

In order to facilitate a better knowledge creation environment, the second part of the solution helps storing knowledge in the form of work-practice mapping. This will help Nonakas SECI process, and work as an extra visual tool that can help for a better understanding of the company's work-practice, that is aligned with a general practice. This allows for employees to argue if processes could be done differently, hence more effective, and could serve as a catalyst for improving internal productivity.

Usability has a huge impact on the level to how the employee utilizes company IT-portfolio. If it is complex and do not make their current work-practice more easy, they simply will not use it. This was seen at both C.F. Møller and their intranet system, and Rambølls, Ramlink.
In order to make people use an IT-system, changing the company's practice; requires that the employees actually use the system, as according to Stacy and Kant. With implementation and with focus on usability and centralization of tools and their information output through the ESN system, a more usable system that facilitates social interaction in order to make the employees have an interest and motivation for creating knowledge.

Besides that usability will not only make the employees use the software, it will also limit the cost of implementation. If the new IT is easy to work-with and supports current processes, people will be prone to utilize it, and will not need to have instructions to how it is used.

With a combination of these three notions, functional requirements has been used as the basis for choosing between different existing and "To-be developed" solutions. By implementation of both an ESN system and a system to create a better support of knowledge creation, it is the author's idea that it can help construction advisory companies like C.F. Møller, Whitespace and even Rambøll to control the chaos of the current processes. The solution meets the requirements defined by the current strategy from C.F. Møller focusing on a shared cloud-based platform, like the ESN systems described, and a high level of usability and knowledge sharing. In short:

The thesis forms a foundation for functionality specifications for a future system, which in a broader sense supports current practice that will facilitate a better use of information technology to create an environment which ensures increased total quality, by focusing on internal processes with this two parted system, by process based knowledge sharing.

PERSPECTIVES

As the history has shown construction will not get less complex in the future, and the industry has to adapt to this. Increased legislative demands in nearly all aspects of the building in order to strive for the perfect building, and in terms the government legislative possibilities, plans in Denmark is already put through for increase in heat loss laws in buildings for 2015 and 2020 (http://www.bygningsreglementet.dk/br10_02_id5181/0/42). The latter will have huge demands of insulation, ventilation, windows and doors. Products will be developed and require further specialized knowledge about embedding them in the construction, and have a causal effect through the whole process of creating the building, from the early programming phase – to demolishing.

As defined in the thesis, existing solutions are present, and can be utilized to support the issues presented by the report. But continuous development of ESN tools could result in an increased use of process mapping models in the same manner as Senecu's DPC tool, which provides a social instrument that can map processes which is customizable. And is great at creating unique dynamic processes, where processes can be easily modified and put together, and still be understandable. This would create an even better environment for knowledge creation, making it more accessible for ordinary users to participate, and enhance co-operation.

But the tendency is that the numbers of specialized IT-systems rising, it becomes increasingly more difficult for the general employee to be updated with the required functionalities, and both need for gaining knowledge about work-practice in general, and use of new IT, is crucial. It will demand an ever increasing level of compatibility between the IT, and usability, not to withdraw the employee from the value-creating processes.

As of now global development by BuildingSMART of products like IDM (Information Delivery Manual) has put focus on including highly specified scope of work, related to the data model IFC (Industry Foundation Classes), and BPMN process mapping. The plan has its grandeur but is lacking operability, and need many years of development before it can substitute traditional transition of information, as paper based, e.g. Besides that it is focused on being a form of scope-of-work, where the actual data elements needed from a co-operator is defined, rather than a generalized description, where the thesis focuses on internal processes. The internal process maps as described in the thesis will need to be combined with such specification in the future, to meet up with the open standards, to meet the probable requirement of IDM in a future scenario.

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GLOSSARY

AEC – Architectural Engineering Construction

API (Application Programming Interface) - An interface that allows for a piece of software to interact with other software,

BIM – Building Information Modeling - *"Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle."* National BIM standard – USA - (http://www.buildingsmartalliance.org/index.php/nbims/faq/)

BPE- Business Process Engineering - A business management strategy developed to analyze and processes inside an organization.

BPMN – Business Process Modeling Notation - A graphical representation for displaying business processes.

BPR – Business Process Reengineering - A business management strategy developed to analyze and processes inside an organization.

CAD – Computer Aided Design - The use of computer systems to assist in creation, modification, analysis or optimizing of design. - (http://books.google.dk/books?id=zXdivq93WIUC&printsec=frontcover&redir_esc=y#v=onepage&q&f=false)

Cloud computing - Is an internet service that supply a service, like software through the internet. In general it can be said that cloud computing is when the software is not installed on the computer, but is located on the web, where it can be interacted with.

IDEF0 – Icam Definition 0 - A graphical representation for displaying business processes.

IDM – Information Delivery Manual - A method of describing business processes and providing detailed specifications about the information needed at a certain time to a certain user.

IFC – Industry Foundation Classes - An open international partly ISO standardized file model, used to exchange of Building Information Modeling exchange outside native file models.

LFA – Logical Framework Approach - A management tool for designing, monitoring and evaluating development projects. Also known as Goal Oriented Project Planning (GOPP)

SECI model – Socializing, Externalizing, Combining, Internalizing Model
A theory created by Ikujiro Nonaka as a way to view knowledge creation, through transferring knowledge between the tacit and explicit states.

Usability design - Is designing usability to ease the use and learnability of a human made object. According to Nilsens law, these five usability goals is needed to be fulfilled to gain usability. Learnability, Efficiency, Memorability, Errors, Satisfaction. (Nielsen 1994).

Work-practice - A process of how work is conducted