DEGREE PROJECT IN TECHNOLOGY,
FIRST CYCLE, 15 CREDITS
STOCKHOLM, SWEDEN 2016

Efficient information and knowledge distribution in high-tech production units utilizing graphical user interfaces

JAKOB FALL

REBECCA KLINC

KTH ROYAL INSTITUTE OF TECHNOLOGY
SCHOOL OF COMPUTER SCIENCE AND COMMUNICATION

Abstract

This study aims to examine potential efficiency gains within a manufacturing unit by implementing processes for knowledge and information distribution. A specialized software tool, implementing processes for knowledge and information distribution, was developed and then examined to see if any efficiency gains could be accomplished. The scientific questions to be addressed were: Will well-defined strategies and processes for information and knowledge management lead to higher efficiency within a manufacturing unit? Is a specialized software a useful tool and how should it be designed to facilitate efficient information and knowledge management? With the help of information management theories, interviews and a field study five main problem areas were found. To counter the problem areas and approach the technical aspect of this study human-computer interactions theories were used to develop three prototypes in an iterative process. The third and final prototype was evaluated by using user testing and interview questions. We found that well-defined strategies and processes for information and knowledge management lead to higher efficiency within a manufacturing unit. By using the specialized software tool it will be easier to facilitate efficient information and knowledge management and that general rules on how to create such a software exists. Due to the result and reactions from the employees our recommendations is for FLIR Systems AB to conduct an implementation study using our software as the frontend.

Keywords: Information management, Human-computer interaction, Prototype, Efficiency gains, Knowledge management, Management information system

Sammanfattning

Denna studies mål är att undersöka eventuella effektivitetsvinster inom en tillverkningsenhet genom att implementera processer för kunskaps- och informationsspridning. Ett specialiserat verktyg, som implementera de processer för kunskap och informationsspridning, har utvecklats och sedan granskas för att se om några effektivitetsvinster kan åstadkommas. De vetenskapliga frågor som skall besvaras är: Kommer väldefinierade strategier och processer för informations- och kunskapsspridning att leda till ökad effektivitet inom en tillverkningsenhet? Är en specialiserad mjukvara ett användbart verktyg och hur ska den designas för att uppmuntra effektiv informations- och kunskapshantering? Fem problemområden identifierade med hjälp av teorier om informationshantering, intervjuer och en fältstudie. För att förbättra de problemområden och närma den tekniska aspekten av denna studie användes människa-datorinteraktionsteorier för att utveckla tre prototyper i en iterativ process. Den tredje och sista prototypen utvärderades med hjälp av användartester och intervjufrågor. Vi fann att väldefinierade strategier och processer för information och kunskapshantering leder till högre effektivitet inom en tillverkningsenhet. Genom att använda ett specialiserat verktyg underlättar det för en effektiv informations- och kunskapshantering. Vi fann även att allmänna regler för hur man designar en sådan mjukvara existerar. Utifrån resultatet och reaktionerna från de anställda är våra rekommendationer för FLIR Systems AB att genomföra en implementationsstudie med hjälp av vår programvara som interface.

Nyckelord: Information management, Människa-datorinteraktion, Prototyp, Effektivisering, Knowledge management, Management information system

Acknowledgement

This study wouldn't be possible without the help of FLIR Systems AB and we are therefore greatly thankful. Great thanks are specially dedicated to Petra Wahlgren who dedicated time and shared knowledge. We would also like to thank every participant at FLIR who contribute with time and inspiration.

Table of Content

1. Introduction

Introductory chapter to familiarizes the reader with the topic. Initially the background of the study is described followed by the purpose and the scientific questions. For the purpose of context, the reader is introduced to the section of FLIR that will be studied.

1.1. Background

In today's globalized world with increasing competition the need for efficiency is increasing. In 2013 the hourly compensation cost in manufacturing was more than 25 times higher in Sweden than in China (Conference Board, 2013). To ensure continued competitiveness it is vital that high cost countries streamline their operations. We believe that two factors can be seen as a key to achieving this: reducing waste and taking advantage of the competitive edge.

A prerequisite for reducing waste is to study and understand how the company works. The aim is to identify which processes generate value and which does not. Increased efficiency is the result of improving value adding processes and removing or mitigating the effects of process that does not add value.

For increased efficiency processes should also be adapted to maximize the impact of the competitive edge. A Swedish company would for example use processes that maximize the impact of the generally higher level of education of its employees. In addition, the relatively less hierarchical structures could be utilized to ensure that knowledge and ideas can be used regardless of from whom or where within the organization they originated. By consciously playing to one's strengths and mitigating the impact of weaknesses it can increase efficiency and reduced waste.

One area where the approaches above can be applied is information and knowledge distribution. Companies today generate vast amount of information which is distributed in numerous ways. Popular methods include phone calls, emails and meetings. These methods are appropriate for communication between individuals but less within entire companies. To ensure that information reaches all that needs it strategies and systems designed for the purpose becomes necessary. Such systems distribute information smoothly and support managers in decision making and communication with their employees. Implemented correctly they will increase the performance of the organization.

The same applies to knowledge. As companies grow large and international sharing knowledge becomes harder. For this exchange to work the company needs to put in place strategies and systems for knowledge sharing. This can help increase efficiency and spread best practices (TIU, 2007).

1.2. Purpose

The purpose of this study is to examine the potential efficiency gains within a manufacturing unit by implementing processes for knowledge and information distribution. The efficiency gains are to be accomplished by software and support processes.

In detail the purpose of the study is to understand the information needs of the personnel and how knowledge is shared. An examination will be carried out to determine the current processes for information and knowledge distribution. The results will be analyzed with the purpose of determining what factors prevent and which create the possibility for efficiency.

The result will be used to develop software. The purpose of the software is to assess the usefulness of such a solution for improved information and knowledge distribution. The software will be tested in conjunction with employees of the manufacturing unit. The results will be used to examine if specialized software is a useful tool and if any efficiency gains can be accomplished.

1.3. Scientific question

From the purpose stated above the following questions were formulated. The first addresses the information and knowledge distribution aspect, while the other is of a more technical nature:

- Will well-defined strategies and processes for information and knowledge management lead to higher efficiency within a manufacturing unit?
- Is a specialized software a useful tool and how should it be designed to facilitate efficient information and knowledge management?

1.4. Area of study

This study has been carried in cooperation with FLIR Systems AB which manufactures high end IR cameras in Stockholm. The manufacturing plant is divided into several departments. The departments are Production, Production development, Sourcing, Warehouse, Order, Shipping and Quality inspection. The production department is further divided into three flow teams: surveillance, uncooled cameras and cooled cameras. To reduce the scope, the study focuses on a section part of a flow team within the production department. The flow team studied was cooled cameras - ATS. Within this group all different roles participated.

The production unit being studied has a fairly complicated organizational structure. For smooth and efficient operations information needs to flow friction free and reach the relevant individual at the correct time. At the moment information and knowledge are not purposely and properly managed. Since it is rarely managed mistakes and waste related to information and knowledge distribution is commonplace. Lastly since it is rarely discussed and managed the know-how on efficient information distribution is often lacking.

There has been much research focusing on the strategies and processes of streamlining of companies. This research has however focus on other factors such as innovation, distribution, manufacturing and others. Little research has focused on strategies for efficient information and knowledge distribution and it implementation. Since the positive effects might are substantial it is relevant to investigate and expand the field.

1.5. Relevant Terms

- **A**cceptance **T**est **R**eport (ATR): Report that details the tests that has been performed. The report includes a description of the test, specifications if applicable and the results. The ATR is included with the camera when it is delivered and is approved by the flow team manager.
- **E**nterprise **R**esource **P**lanning (ERP): Is business management software to collect and store data from many sources. Functions include product planning, cost, order management etc. Within the manufacturing unit FLIR uses SAP for planning, placing orders, monitoring stock levels, replenishing materials and keeping track of cameras produced.
- **B**ill **o**f **M**aterial (BOM): A list of all material and the quantity of each that is used within a product.

1.6. Ethical aspect

In order to answer the scientific questions several interviews will be conducted with employees at FLIR. To ensure that the answers given at the interviews will not affect the employees in a negative manner it is important that their identity is kept secret. In addition, it is also of importance that answers or information that can be clearly linked to an individual is excluded from the report. The ones that have been interviewed have been informed that their answers will be utilized and that we will keep their identity secret. Thus transcripts of the interviews will not be presented but rather an edited answer sheet of all interviews.

2. Theory

In this chapter relevant theories are presented and described. Theories focuses mainly on information management systems, knowledge management and human-computer interaction.

2.1. Information and Knowledge Management

Information management focuses on the collection and distribution of information within an organization. The goal is to identify methods that allow the information to be utilized in the most efficient way possible. Knowledge management is similar and is concerned with the distribution and management of knowledge. The aim is to utilize knowledge within the organization in the most efficient way possible.

2.1.1. Data, Information and Knowledge

Since this study is concerned with the information needs and flows within a manufacturing unit it is relevant to include a definition of data, information and knowledge and how they relate to each other. The descriptions made here will henceforth represent the meaning of data, information and knowledge.

Data on its own lacks any meaning (von Euler-Chaplin, 2008). Without context and interpretation, the significance of data is unknown and it cannot be utilized in any way. For example, data on temperature of a machine is only relevant if it is put into a context, namely which temperature range which is expected.

Information is data put into a context and interpreted (von Euler-Chaplin, 2008). Information in itself bears meaning and is often meaningful to the organization if used correctly. An example is the temperature data above which if collected in quantity and related to expected temperatures gives useful information into the status of the machine.

Lastly knowledge is refined information (von Euler-Chaplin, 2008). An example is the information concerning temperature of a specific machine. If information is processed, in essence analyzed, new information or more precisely knowledge can be obtained. This can be by comparing different machines to predict when a machine is likely to fail or by analyzing the information attain where during the cycle the stress on the machine is the greatest.

It might seem that the differences between data, information and knowledge are insignificant in practice. However, it is of great importance for this study as the purpose is efficiency in information and knowledge distribution. Hence understanding what information and knowledge is and its creation is of vitally importance.

2.1.2. Management Information Systems

Information systems (IS) are systems implemented within a company with the purpose of delivering information and communications to facilitate planning, organizing and decision making within the company (Kornkaew, 2012). This information is most often collected and distributed using computers, software and personnel employing information technology. The IS field include several areas that are of interest during this study including Management Information Systems (MIS), Knowledge Management (KM) and implementations like Enterprise Resource Planning (ERP)

Management Information Systems (MIS) are an adaption of the Information System aimed at supporting operational, tactical and strategic decision making (Business dictionary, 2016). When Implemented the MIS converts data into information which is distributed to the relevant manager within the company. This information is presented in form of pre specified reports and displays that are often delivered on a pre-determined schedule (Hasan et al., 2013). MISs were originally developed for financial applications, for example; accounting, order entering and budgeting (Ronen & Pass, 1992). The uses of MISs are becoming more widespread due to several new challenges.

There are several developments in the last years that have increased the need for efficient MISs (Hasan et al., 2013). Examples include shorter product life cycles and swift market changes (von Euler-Chaplin, 2008). Both put increasing pressure on managers to make quick decisions meaning that the need for high quality information delivered in a timely manner condensed into a form that is easy digestible. The trend of multiple sites working together and external partners also involved increase the need for error free and efficient transfer of information to assist in decision making (Kornkaew, 2012). Furthermore, in a world of increasing competition having the right information at precisely the right time is a key to competitiveness (von Euler-Chaplin, 2008). With a multitude of different computer systems within the company and vast amounts of information it is essential to manage information and how it is distributed (von Euler-Chaplin, 2008). Lastly increased information about the business will increase managers understanding and make it possible to better utilize company's resources (Hasan et al., 2013). The phenomena described above are applicable to a manufacturing setting. Thus manufacturing should be a suitable application for MISs.

Manufacturing Management Information System (MMIS) is a MIS which is further adapted to assists managers to make decisions within the scope of manufacturing. Functions can be order entry, shop floor control, Bill-of-Material (BOM) management, shop floor control, aggregate planning, inventory control and cost evaluation (Ronen & Pass, 1992). Other uses could be monitoring work-flows and bottlenecks, order progress and similar.

The key factor of an effective MMIS is that only the most necessary information that is presented (Ronen & Pass, 1992). It is only necessary to understand the particular part of the world that is of interest (von Euler-Chaplin, 2008). Insufficient filtering on which information is provided is often attributed as the primary factor of failure for MMISs (Ronen & Pass, 1992). Graphical-User-Interfaces (GUI) is also described as an effective tool (Hasan et al., 2013). Furthermore, careful analysis of the manufacturing unit and other factors such as intra-organization political analysis, examining organizational culture and social considerations also increase the likelihood of success (Kornkaew ,2012).

In addition to providing the right amount of information several other factors are described as problematic when implementing a MMIS. These include the large amount of data that is collected in a manufacturing unit. This data is often dynamic and constantly changing. The environment is complex and changes quickly introducing uncertainty (Ronen & Pass, 1992). The data is sometimes not reliable. Furthermore manufacturing units tend to be informal environments where official procedures are disregarded in favor of informal undocumented procedures and rules (Ronen & Pass, 1992). Lastly implementing MMISs is associated with major changes in the workplace. Because of this it is vital to gain the approval of the employees when implementing it. Otherwise the impact would probably be insignificant (Kornkaew, 2012).

After a MMIS has been implemented it is necessary to evaluate how effective it is. A useful method suggested is the Technology Acceptance Model by Davis (Hasan et al., 2013). The model includes two determinants to describe the acceptance of an information system Perceived Ease of Use (PEOU) and Perceived Usefulness (PU). PU is the degree that the user believes the system would enhance their performance. PEOU is the degree that users believe that the system could be used without effort. Other factors that could be studied to determine success would be quality of information, of managerial decisions and the support that the MMIS provides (Hasan et al., 2013).

2.1.3. Knowledge management

Knowledge management (KM) is a concept that arose in the early 1990s. The method can be explained as organizing an organizations knowledge and information holistically (Koenig, 2012). Where MIS manages information the purpose of KM is to manage the knowledge that the information forms. Studies have shown that the adoption rate for KM is highest in high-tech industries (Kremp & Mairesse, 2002). This since, when implemented, KM allows for more efficient use of the company's intellectual property and higher degrees of innovation (TIU, 2007). A commonly quoted description is that of Thomas H Davenport (1994):

"Knowledge management is the process of capturing, distributing and effectively using knowledge"

Thus the goal of KM is to identify, capture and then evaluate the significance of the company's knowledge and information. For the information and knowledge to benefit the organization it is translated into information assets that can be distributed within the company. Within KM information is divided into three types (Koenig, 2012):

- Explicit: Information or knowledge that is in tangible form. This can include databases, documents, video or similar. In this form distribution throughout the organization is achievable.
- Implicit: Information or knowledge that is intangible but could be made explicit and then distributed.
- Tacit: Information or knowledge that is intangible and is extremely difficult to convert to tangible assets. An example is experience which is hard to convert into explicit information.

There are several barriers within organization that hinder free flow of the information described above. Research has identified several factors (TIU, 2007). The most significant is described as lack of communication between departments, sometime referred to as "silo thinking". Others is the tendency of some employees to hoard important information and that much of the information and knowledge is stored in unstructured sources. This could be emails, spreadsheets or papers that are not easily utilized by others within the organization. Key personnel with important knowledge leaving the organization are also considered a risk.

There are a number of methods which are used within KM to facilitate sharing of knowledge and information and mitigating the impact of the above. The most effective method is considered face-to-face meetings (TIU, 2007). Others are databases or wikis and after-action reports describing lessons learned and aspects to be considered next time. Other methods include peer-reviews and using teams with different backgrounds within the company, for example people from marketing R&D and sales working together (Koenig, 2012). Lastly using alerts that broadcast questions on the company intranet can be used to reuse and spread knowledge (TIU, 2007).

Lastly the benefits of KM are many but described as the most important is spreading and establishing best practices (TIU, 2007). Others include increased innovation due to more knowledgeable employee and more cooperation between departments. In addition, due to better control and knowledge about the company IP it can be utilized more efficiently (Koenig, 2012). It also allows the companies to more efficiently respond to customer demands this due to better information flows within the company, for example from marketing and sales to product development (Koenig, 2012).

2.2. Human-computer interaction

Within human-computer interaction focus is on how people interact with computers and not on the computer system itself. Most theories within the branch works as tools to optimize programs based on the user. The most notable aspect of HCI is the people centered approach it takes, rather than a machine-centered one. Theories within HCI are primarily used in this study in the development of the software that supports information and knowledge management.

Machine- and people-centred views

View	People are	Machines are
Machine-centred	Vague Disorganised Distractible Emotional Illogical	Precise Orderly Undistractible Unemotional Logical
People-centred	Creative Compliant Attentive to change Resourceful Able to make flexible decisions based on content	Dumb Rigid Insensitive to change Unimaginative Constrained to make consistent decisions

Figure 1: Different approaches of machine and people-centered design

2.2.1. Usability

Within human-computer interaction usability is a frequently mentioned term. This is due to the fact that if a system is hard to use it is redundant, but if it is too simple it won't provide enough functions to generate any value for the user. The focus on an interface is the input, what is asked from the user, and the output and what is displayed to the user (Benyon, 2010). These functions needs to be clear in order to see how a certain action generates a displayed view. When designing a user interface the twelve design principles needs to considered. The design principles can be divided into three different groups regarding different aspects (Benyon, 2010).

- Learnability: Focuses on how easy it is to learn a system and then to remember it when used later.
- Effectiveness: Focus on ease of use and navigation the system.
- Accommodation: Principle to increase the flexibility off the program and making an attractive design.

2.2.2. Prototypes

Prototypes are widely used and a tool to assist developers with testing the feasibility and usefulness of an idea. Mackay and Laffon (2007) define a prototype as:

"The concrete representation of part or all of an interactive system."

They continue to point out that the fundamentals of a prototype is that it is a tangible artifact, not an abstract representation of an idea that will require interpretation. Prototypes can be applied to many different fields but that of interest for this study is Interactive System Prototypes (ISP). These prototypes must include the full interface that the user interacts with but can exclude the backend functions such as algorithm and other software functions (Mackay & Laffon, 2007).

Prototypes give the developers the possibility to evaluate the interface before the end of development. Thus costly mistakes can be avoided since changes to the design can be implemented before the end of development (Mackay & Laffon, 2007). In addition, prototypes can help minimize attachment to a certain idea. As the effort of creating a prototype is less, it is also easier to discard an idea. A prototype also allows people with non-technical background to participate in development, even though technical expertise can be necessary to implement the prototype. Allowing a more diverse team the product is often more nuanced and more aligned with the market (Mackay & Laffon, 2007). Since the cost of discarding a prototype is lower it is also possible to test bolder ideas. Lastly prototypes allow the designers to interact with the potential users. More than giving rise to insight to the need of users it also gives developers the possibility to involve users in the development (see section 2.3). These benefits can be applied to ISPs and all other types (Mackay & Laffon, 2007).

The four dimensions of prototypes:

Laffon and Mackay (2007) describe four dimensions along which prototypes can be analyzed. These are representation, precision, interactivity and evolution.

Representation:

Representation describes the form of a prototype and can be divided into high-fi and low-fi prototypes. When discussing ISPs the term offline prototypes often replace low-fi and online-prototype high-fi. Since ISPs are used exclusively in this study the term offline and online prototypes are henceforth used.

Offline prototypes do not require a computer. This includes paper sketches, illustrated storyboards, card-board mock-ups and video. The most salient characteristics of offline prototypes are that they can be created quickly, are cheap and are easily discarded. They are often used for quick iteration in the beginning of the design process to test ideas and expanded and develop the design.

Online prototypes are computer assisted prototypes and are often implemented later in development. These include animations, interactive video, computer programs or interface created in interface builders (see section 2.4). Due to the generally greater effort of implementing and therefore higher cost, online prototypes are generally used to reduce design space and home in on the final design.

Precision:

The precision relates the level of detail of the prototype to the purpose of it. Purpose of the prototype can be described as which dimension of the design space one is exploring. Generally, details communicate that the design of that part of the interface is final. Instead testers of the prototype will focus on evaluating the part of the prototype which is not as detail and refined. Thus by varying the level of detail of the prototype the developer can evaluate different aspects of the idea being refined.

Interactivity:

Common to all ISPs is that they include some level of interactivity. It describes the level of interaction but also how the users interact with the prototype. For a prototype to be effective it does not have to be interactive but must be perceived as interactive by the user. Thus, the developer only has to simulate interactivity. Non interactive prototypes are referred to as fixed prototypes and the most interactive as open prototypes. Interactivity is where the biggest effort should be focus when working with ISPs since this determines much of the perceived quality of the system. To achieve success deep understanding of the user and their work practices are necessary to design interaction that satisfy the user's needs. In conclusion, when working with interaction the context of use and user should be considered particularly important.

Evolution:

Evolution refers to the different life spans of prototypes. There are three major kinds; rapid prototypes, iterative prototypes and evolutionary prototypes. The purpose of rapid prototypes is to explore a specific idea or concept and are tested, evaluated and discarded. Iterative prototypes are tested, evaluated and changed according to results. They evolve through several design iterations. They can be used to test different dimensions of the design space or to refine a single dimension. Evolutionary prototypes is a special case of iterative prototypes. They are developed through several iterations but here with the explicit purpose of changing the prototype into being part of or the entire final product. Generally rapid prototypes are used in the initial phase of development followed by iterative prototypes.

2.3. User centered design

User centered design is one of the cornerstones of HCI. It is presumed that by placing the user in the center of the design process it maximizes customer satisfaction. This is achieved through initial analysis of user requirements through testing and evaluation using prototypes. The prototypes help the designer contextualize the real world use of the system and improve the understanding of the users, their requirements and usage. Since the prototype is not abstract they can, in contrast to traditional requirements analysis, evaluate the requirements in the context of the actual system. Thus one is not only relying on the designer's ability to abstractly understand the need of the user since one can make real world test and evaluations to better his understanding. (Mackay & Laffon, 2007)

2.3.1 Participatory design:

Participatory design is a type of user centered design where the final user is actively involved in the design process. This is accomplished by treating users as partners throughout the process. Examples are discussing ideas, brainstorming and testing prototypes with the user. Users are well suited to understand the context that the system will be used in and the subtle aspect of the problem that needs to be solved. The designer's primary task is to consider different solutions for the problems described by the users and considering benefits and trade-offs to combine these in a suitable fashion (Mackay & Laffon, 2007).

2.4 Interface builders

Interface builders are software specifically designed to assist developers in creating ISPs. Generally, the software includes a number of elements that can be combined together to represent a graphical interface. This includes, dialog frames, sliders, buttons, picture frames etc. Commonly the developer then combines the element using drag and drop to construct the look of the interface. Different interface builders provide different levels of interactivity, some supports working button and sliders while some only allows the user to switch between different views. The purpose of an interface builder is to allow the developer to focus on the task of developing the look and feel of the interface without the need to develop the backend that runs the simulation. Examples of Interface builders are Balsamiq[1], FluidUI[2] and Justinmind[3].

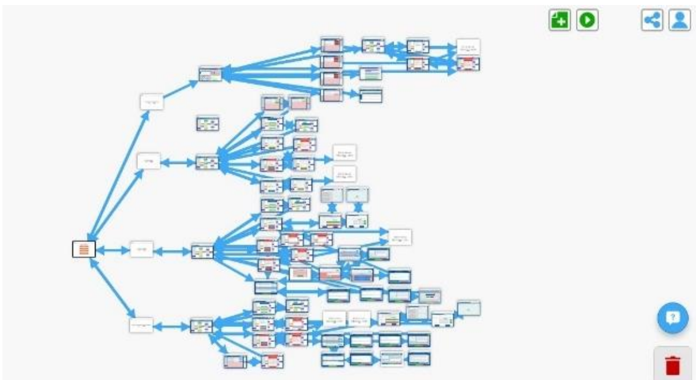


Figure 2: Example project in FluidUI

2.5. Evaluation

When creating interactive interfaces an important aspect is evaluation. In order to create study with result that are able to be evaluated a framework needs to be followed and then the precision of the result needs to be established.

[1] https://balsamiq.com/
[2] https://www.fluidui.com/
[3] http://www.justinmind.com/

2.5.1. DECIDE framework

This subsection is based on the framework described by Sharp, Preece & Rogers (2011).

- **D**etermine the overall goals that the evaluation address
- **E**xplore the specific questions to be answered
- **C**hoose the evaluation paradigm and techniques to answer the questions
- **I**dentify the practical issues that must be addressed, such as selecting participants
- **D**ecide how to deal with ethical issues
- **E**valuate, interpret, and present the data

The DECIDE framework is used to guide evaluations that are driven by goals in order to answer scientific questions. The six items in the framework exists as a checklist when working with evaluation and guides carefully through the study in order to be able to evaluate it thoroughly. By creating clear goals, that are used for determining the scope of a study which is the first step of planning an evaluation process. The evaluation method is chosen depending on the gathered data needed to answer the question, when a study is conducted on interfaces user testing is used rather than fields studies.

2.5.2. Heuristic evaluation

Heuristic evaluation is a usability evaluation that doesn't involve the user. During the evaluation a specialist goes through a checklist much resembling the 12 design principles when focusing on usability. Nielsen's 10 heuristics are formulated from an analysis consisting numerous usability problems in the mid 90's (Nielsen, 1995a). Since then Nielsen have updated the heuristics and specified them to be more applicable on many different interfaces. Nielsen's 10 updated heuristics are (Nielsen, 1995a):

- Visibility of system status
- Match between the system and the real world
- User control and freedom
- Consistency and standards
- Error prevention
- Recognition rather than recall
- Flexibility and efficiency of use
- Aesthetic and minimalist design
- Help users recognize, diagnose and recover from errors
- Help and documentation

Nielsen describes the heuristic evaluation method as the most informal of usability testing due to the fact that it tests the system as a whole, rather than the different functionalities within the system (Nielsen, 1995b). The positive aspect of a heuristic evaluation is the fact that it is less time consuming. The method can be implemented on offline prototypes and usually works better due to the fact that users tend to miss certain aspects when using an offline prototype or if the prototype isn't stable enough for users to evaluate it (Nielsen, 1995b).

The drawback of a heuristic evaluation method is the fact that is only focuses on usability and not at all on user experience and therefore misses a lot of the user feedback (Nielsen & Phillips, 1993). The evaluation is supposed to be conducted by specialist in usability, but it can be used by non-usability specialists as well, keeping in mind that the result will deteriorate. When done by a specialist more usability problems are found than by user testing (Nielsen & Phillips, 1993).

3. Previous studies

This chapter focuses on earlier researches linked to this study. The goal is to gain insight on different approaches and knowledge when evaluating prototypes.

3.1. User experience

In order to create a functional user interface fulfilling its needs, a common starting ground is to design for user experience in order to get a good design. Within the branch of user experience there are several different dimensions regarding design. In the study *Interactive user experience design: creating an effective online experience* (2007) Park reviews the different dimensions and with the goal to integrate a the most important dimensions in order to gain new knowledge to create a new approach regarding user experience. The main result of the report can be summarized by one quote:

"the interactive user experience refers to an integrated visual, functional and inter-communicational experience".

The model chosen to create their web-page was Interactive User Experience Design, abbreviated as IUED. Park assumes that there is equal importance in the three aspects, which might not be true for all functions in an interface. This should be taken into consideration when creating one.

When creating a user interface focus should lie on visual design, functional design and inter-communication design, at least as an approach. Visual design focuses on what the user sees and can be represented as a layout form in early prototypes in classifying as low-fidelity. Functional design focuses on the level of control a user has and focuses on the actual function the interface has. The level of control varies between being able to click on a menu in order to navigate and being able to manipulate simulations. The third aspect is the inter-communicational design and it focuses on user to user communication.

The results of the study were considered to be a success, even though some aspects could have been improved. The conclusion of the results was that when creating an interactive interface were to keep the level of interactivity and three aspects of experience in mind. When evaluating a design, dividing the question into these categories will help improve the design while iterating it.

3.2. Lean

Lean is a common philosophy when working with management and focuses on reducing waste, identifying value streams and specifying them in order to enhance the natural workflow. As well as applying lean philosophy on production it can also be applied to information systems. John Maleyeff attempts to "*...provide insight into the management of an internal service system derived from a perspective of Lean management...* "in his article *Exploration of internal service system using lean principles* (2006).

The main thesis of the article is that standardization of an internal information system should also result in a flexibility, which is an important aspect of lean. This is motivated by the fact that if something is standardized to a given extent than atypical situations will easier be recognized and therefore it can be handled with a higher flexibility.

Within the different internal systems there were a few significant common characteristics which include: the flow of information between different departments, information isn't necessarily double checked once submitted and the systems functionalities varies in how they are set up due to the fact that there is not a universal solution.

A hand pick of the most common problems with an information system, that are applicable on our research are:

1. The lack of a standard procedure
2. The system is not well defined

3. Data and other information are inaccurate
4. Little or no flexibility exists
5. There is inadequate training

These weaknesses need to be taken into regard when creating a system and many of them focuses on usability and user experience. A user friendly and well-designed system would allow little training in order to able to use it, canceling out the second and the fifth point. Inaccurate information isn't necessarily caused by the system itself, but can be the result of the system ranking low in usability due to low flexibility or the lack of standard procedure.

3.3. User testing

In the study *Web Evaluation: Heuristic evaluation vs User Testing*) Tan, Liu & Bishu (2009 compares the evaluation methods heuristic evaluation and user testing in order to see which usability problems can be found.

User testing focuses on a scenario based type of test where the user tries to complete a certain task. The task might be time limited or have some other criteria in order to classify as a success. When deciding between different options, that all fulfill the design principles, a user testing is the only method to decide between the options due to the fact that personal preference will decide which option is preferred by the user. User testing often find detailed usability problems that are needed to complete a specific task.

When conducting user tests an important step is the planning stage which is when the user gets information regarding the scenarios, the evaluation and the functionalities the program has. Before the actual test the user should have seen a walkthrough of the program in order identify its functions. During the actual testing the users thought and reactions should be recorded, it is important to note reactions such as facial expressions and body language in order to gain even more insight on how the program is perceived.

Drawbacks with user testing are that the evaluation is limited to the scenarios evaluated, which can lead to the missing feedback regarding certain functionalities. The entire process of user testing also takes time due to the fact that an introductory presentation of the program will need to be held for all participants and the reflection after the test is done.

The research came to the conclusion that even though heuristic evaluation catches more usability problems it shouldn't be used as an alternative to user testing, but rather as a complement. Whereas heuristic evaluation can catch more problems regarding general evaluation and program as a whole, user tests are used to get feedback regarding more detailed problem such as the location of a button which is rarely used. A prerequisite for heuristic evaluation leading to catching more problems than user testing is for the specialist to be fairly familiar with the background of the interface.

4. Method

The method of the study was designed to answer the two scientific questions of the study. Interviews with employees, analysis of current process and impact analysis of the software was being used to answer the first question. If increased efficiency is the result of specific strategies and process was answered by analyzing the differences of the current situation and the impact an implementation is most likely to have.

Assessing if specialized software is a useful tool to facilitate said distribution was answered in a 3 step process. The users were interviewed and an initial prototype was created which was then refined through an iterative process. The user was then asked to use the final prototype to solve a number of problems. The problems were all related to information and knowledge distribution. Lastly the users were interviewed to ascertain their opinions on the possible efficiency gain of using the software. The results were then compiled and analyzed to answer the scientific questions.

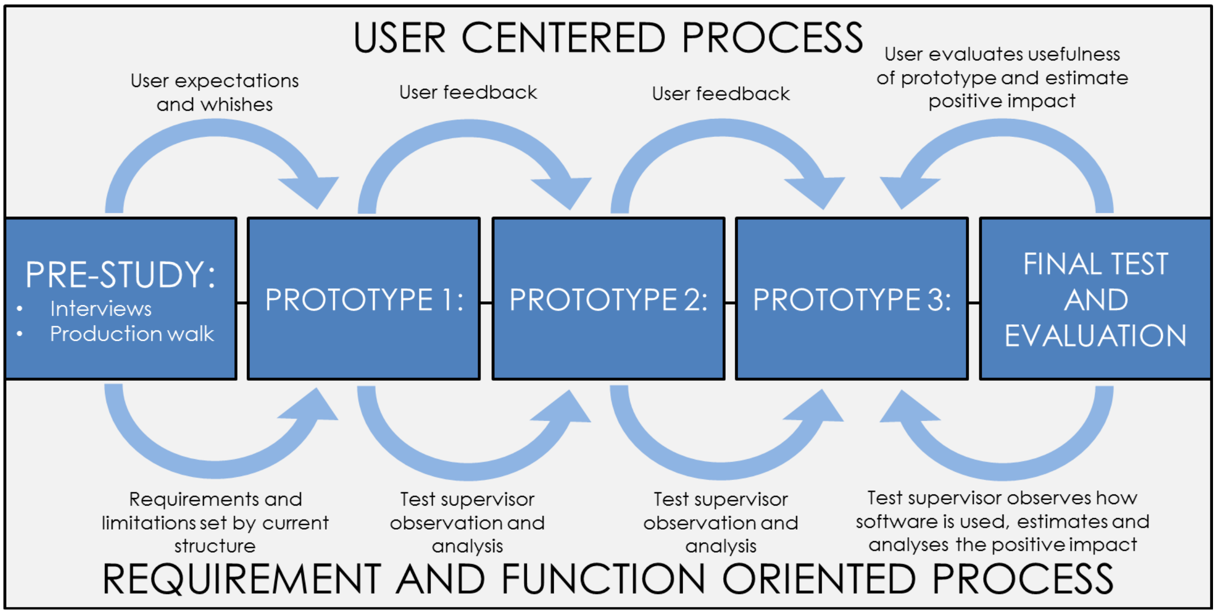


Figure 3: Structure of the study

4.1. Conclusion from theory and previous studies

In order to create a concept for FLIR three prototypes were created, from an offline to an online one. By doing this both main functionality and detailed preferences were optimized. In order to avoid getting caught up in too many details from all the people interviewed focus was put on feedback regarding: usability, functionality, visual design, communication and the management aspect of information needed.

The evaluation method user testing was used for all prototypes and the users were told to give any feedback they had. Heuristic evaluation was not used, this mainly due to the fact that we are not specialist and would probably miss a lot of the usability problems. When using heuristic evaluation, it would be better to have 3-4 specialist. However, finding them and introducing them to the system was deemed to be too time consuming, especially if they would have to sit through three prototypes.

The design of the software was directed by the 12 principles of design described in chapter 2.2. The design process which were chosen were user centered design described in chapter 2.3. To test the design a number of prototypes were created and refined thru an iterative process. The prototypes where designed and tested according to the 4 dimensions of prototypes described in chapter 2.2.2 and created using an interface builder, see chapter 2.4.

During each iteration the DECIDE framework was followed in order to have goals and question which can be evaluated. The items: determine the goals, explore the questions and evaluate, analyze, interpret, and present the data are done in chapter 5. Deciding how to deal with ethical issues is discussed in section 1.6.

The information management aspect of the research was in part a literature study where relevant theories described in section 2.1 are combined with the interview results. This was done in order to gain perspective on how to reduce misunderstandings and missed information.

4.2. Pre-Study

The first step of the study was a pre-study which include two separate parts. The first was interviewing the employees of the flow team. A field study was also performed with the purpose of surveying the structure of the flow team, responsibilities of different roles and the current information and knowledge distribution regime.

4.2.1. Interviews

The interviews were conducted at FLIR's offices and 10 interviews were conducted. All roles within the flow team were represented by at least one employee. This to ensure that the needs of all roles were properly understood. All employees were asked the same questions. Asking the same questions gives the possibility to understand how views differentiated between people and roles. This difference allowed us to understand how the software was adapted to fit each role. It was also an efficient way to identify possible sources of misunderstandings. Questions focused on the structure of information and knowledge distribution, how well it works at the moment and possibilities for improvement. Others questions included their role within the organization today, how the production flow was structured and asking them to describe which information they handled on a daily basis. Answers were noted and interpreted by the interviewers, the answers were not transcribed. The interview questions can be found in appendix A.

4.2.2. Field study

The field study consisted of a production walk and studying the employees as they work and asking questions if something needed to be clarified. The production walk and studying employees was carried out to answer several questions. Firstly, how does a camera flow through production and what is the involvement of the different roles? How does the employees communicate with each other and how do they share knowledge? Also interesting was which tools and aids that was used to facilitate and enhance information and knowledge distribution within the production. Focus was also on finding current structures or aids that could be used as a basis for the software design. The results were compiled and analyzed. They were used when designing the prototypes and to identify areas of improvement and weaknesses of the current regime.

4.3. The Iterative process - Prototyping

The 12 principles of design of an interactive system where used when the software was designed. The software was not fully implemented but a number of prototypes were created through an iterative process. The prototype was used to test the interaction aspect of the software. Backend of the software was not evaluated or designed since it is outside the scope of the study. In conclusion the goal was software with high PU and PEOU.

The prototypes were designed to handle as standardized situations as possible, which in itself would generate a higher flexibility if needed. This was done according to Lean principles which reduced the number of problems occurring when using an information system.

When the prototypes were tested and developed the four dimensions of prototypes were used. This to ensure that the goal with every prototype was meet. The goals were formulated by the developers to examine a new aspect of the design every time it was iterated. Which aspect to examine was formulated by the developers.

Developers mainly relied on the results of the pre-study, requirements of the production but also studied users using the prototypes. The developers focused mainly on adding, removing or improving the functions of the program. Developers were also concerned with making sure that the software meets the requirements formulated during the pre-study. These requirements were mainly related to process that is used to manufactured the cameras. Developers also focused greatly on the information and knowledge distribution aspect. The division was however not absolute and some user feedback resulted in new functions and requirements. Some interaction and design changes were also the result of ideas of the developers.

The evolution of the prototype was driven by user feedback and the ideas of the developers. Using user feedback is the cornerstone of participatory design which was the method used. Users were asked to mainly focus on the interaction and usability of the existing functions. These included among others design, usability of current functionality and the relevance and usefulness of information provided. The participants were the ones already interviewed, with the exception of 2-4 employees. By contacting FLIR long before the evaluation it was possible for them to find both the time and location, at the premises, to conduct interviews and user testing.

4.3.1. First prototype

The result of the pre-study and literature studies was used to create a first prototype that the employee at FLIR tested. The purpose of the first prototype was to provide a concept check. The goal was to create a basis for an information system that meet the information need of the employees and could easily be learned. User testing was used to gather feedback. Since it was the first time the system was tested the system they were to some degree guided by the test supervisor.

Design:

To provide structure to the design work the design principles of usability were used. Focus was mainly on learnability and to some degree accommodation. Effectiveness was not a priority for this iteration.

The choice to focus on learnability was motivated by the goal to minimize waste. If users quickly learn how to use the system, they can complete their task in as little time as possible. High learnability also allows the user to quickly understand the software and give relevant feedback. The goal was to increase the user's desire to use the software, a basis for the success of the software. Results from the pre- and literature studies were used to ensure high learnability. Tools, processes and structure at FLIR identified during the pre-study were combined with relevant theory. These were adapted and represented in the software prototype with the help of the theory.

Another focus was good accommodation. Design and design elements used by FLIR was implemented to increase recognition. For example, the color theme of FLIR were to be used, in this case was blue and gray. Furthermore, it helped users to visualize and understand how the program might look and work. It was also considered to determine how flexible the program must be to be used effectively by different users.

Lastly, little focus was given to high effectiveness. The prototype was a concept check thus functions and information provided was the focus not navigation, security and safety. It was assumed that results provided by pre-study and theory were unsuitable to understand how interaction and navigation was to be designed. This would be determined by user feedback throughout the iterative process.

Prototype:

The 4 dimensions of prototypes were used when the prototype was designed. This was done to ensure that the prototype meet the goal established for this iteration.

For the first iteration an offline prototype was chosen. The offline prototype consisted of paper notes where different screens of the system had been sketched. The sketches included buttons, input fields, dropdowns etc.

An offline prototype was chosen since high precision was not desirable. The first iteration was a concept check. The nature of a concept check means that the likelihood of major changes is significant. In addition, low precision was motivated by the desired to get lots of user feedback. Lastly since testing was focused on generally testing functions and information provided an offline prototype with low precision proved sufficient.

The interactivity was rather low. Users interacted with the prototype by clicking representations of buttons etc. When an interaction occurred the view was changed by the test supervisor replacing the note in front of the user. The purpose of the iteration meant that this was sufficient interactivity.

If the first prototype were to evolve into the second prototype or be replaced, by another concept check, was determined by the user feedback during testing.

4.3.2. Second prototype

Prototype 2 was a more advanced prototype and was created in the interface builder FluidUI. The interface improved interactivity and could therefore be used without any assistance. The goals of the second iteration were to improve the design, add, if any, new functions and improve the interactivity of the prototype. The main focus was improved interactivity and visual design.

Design

Effectiveness was the main design focus of prototype 2. Effectiveness is a set of design principles that emphasizes the importance of easy to use, easily navigable and safe software. With prototype 1 it was established which functions users need and how maximize learnability for these functions. The purpose of Prototype 2 was to determine how these functions should be bonded together. Emphases were mainly put on two aspects. How views should be linked to make for easy and natural navigation. Also which elements and how should these elements be placed to assist this effort? Security and safety were also to be addressed by designing the software to prevent damaged caused by malicious acts or mistakes.

Some effort was also put into increasing accommodation. As the prototype evolved the design were improved to more resembles the final software. This was the result of both user feedback and ideas by the developers another aspect of accommodations that was also considered was the flexibility of the software.

Lastly some improvements were made to the learnability of the design. This was primarily the result of user feedback while testing prototype 1.

Prototype

An online prototype was used for the second iteration. An online prototype with improved interactivity was necessary since navigation and user interaction was to be the focus.

Precision was increased in relation to the first prototype. This applied to: interaction, design, function, information available and more. This was accomplished using user feedback and ideas by developers. Improvements to design, information and functions were incremental. The biggest increase in precision was interaction. This as it was the focus of the prototype and limited effort had been put into it in developing prototype 1.

Interactivity also changed for this iteration. Using FluidUI meant that users interacted with a computer using a mouse. The level of interactivity perceived by the user therefore increased. Even if increased it interaction was lower than for the final software. Since no logic or backend were implemented the views remained the same. Interaction was simulated by linking between a number of static views.

The first prototype evolved into the second prototype. The goal of this and the iterations to come is that incremental changes are made to the prototype to generate the final product, in this case. The prototype is thusly evolutionary.

4.3.3. Third prototype

The emphasis of third iteration was, unlike the previous iteration, not to focus on some specific aspect of the design. The purpose of the third iteration was improving the design using all 12 design principles. The properties of prototype 3 can be assumed to be similar to that of prototype 2. Representation, Interactivity and Evolution is the same. Precision is however increased using the 12 design principles. Prototype 3 was created by using the result from prototype 1, mainly functionality, and prototype 2, mainly visual design. Changes to the design and prototype originated from user feedback, observations and ideas of the developers.

The final test and evaluation was carried out to determine the effectiveness of the prototype and strategies for information and knowledge distribution. This process involved several steps. Firstly, users were asked to solve one or several tasks using the prototype software. Secondly they were asked to familiarize themselves with the current iteration. The users were then interviewed.

Each user was given a specific task. The task was relevant for their role within the organization. The tasks selected were ones that had previously been identified as common causes to waste or problems. The users were asked to solve them without the help of the tester. If they could solve the task within a reasonably set time limit it was considered a success. The way that the user solved the problem was also examined.

After the task had been solved the user were asked to familiarize them with the prototype. The users were then interviewed. The interview had two main goals: To evaluate the perceived benefit of the software if implemented. Asking similar questions as during the first interview and comparing them to see if the software would lead to improvements. The interview questions can be found in Appendix B.

The final test and evaluation were carried out at FLIR’s offices. Nine employees participated. Seven of the participants had previously tested prototypes and therefore were familiar with the system. Two employees had not previously tested the system and were selected to test the learnability of the design.

5. Results & Iterative process

This chapter describes in detail the results of the study. The results of the pre-study leading up to the first prototype is explained and the iterative process using the DECIDE framework as a guide. Lastly the results of the final evaluation of the third prototype is presented.

5.1. Results of the pre-study

The pre-study includes two separate activities. The first was interviewing the employees of the production unit. A field study was also performed with the purpose of surveying the structure of the flow team, responsibilities of different roles and the current information and knowledge distribution regime. The results of this pre-study are described in the section below. The results of the interviews and field study has been combined and not presented separately. For a summary of interview results, see appendix C.

5.1.1 Hierarchical structure and roles within the production unit

The structure of the production was determined through a field study and interviews with employees. Observing how people and asking them to describe how they communicated within the unit made it possible. The resulting structure is illustrated in figure 4. Work tasks of the different roles within the workflow are detailed below:

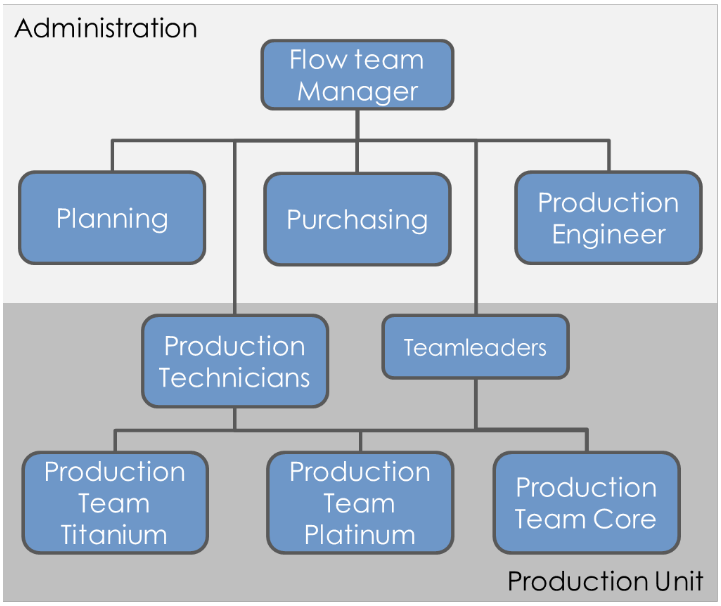


Figure 4: Organizational chart, FLIR cooled - ATS

- **Flow team manager:** The flow team manager is responsible for the flow team. Responsibilities include informing other departments on progress or problems, managing personnel, prioritizing and production development.
- **Planning:** The planners are responsible for starting and handing over production orders to the production teams. They are also responsible for deciding in which order cameras are to be manufactured and setting date of completion. Finally, planners handle communication with customers and sales offices concerning progress of orders placed.
- **Purchasing:** Within this flow team purchasing is handled by planners. Purchasing is responsible for placing orders to replenish materials used by the productions team. They monitor the stock levels and place orders when appropriate.

- **Production engineer:** The production engineer is responsible for the production equipment and aids used by the productions teams. This includes both maintenance and long term production development.
- **Production technician:** Within the flow team studied there are two production technicians. These are responsible for technical issues related to the cameras. For example, a production technician would handle difficult problems with cameras and if necessary report the issue to R&D and other concerned departments. They are also responsible to introduce changes in the product to the production team. Examples range from introducing new software or parts in production, keeping instructions up to date and changes in the manufacturing procedures. They cooperate closely with the R&D department.
- **Team leaders:** The team leaders act as the intermediary between the production teams and the flow team manager. They are informed by the manager of the goals of the day and where the personnel will work. The team leader then informs the members of the production team. They are also responsible for relaying the thoughts and concerns of the production unit to the manager.
- **Production teams:** These are the personnel responsible for building the cameras. They are managed by the team leader. They also communicate with planning, purchase, production engineers and technicians.

5.1.1. Workflow of the production unit

The Production flow described is that of the Core production team. The camera flows through four phases before completion which is illustrated in figure 5. The workflow description is the result of interviews with employees and production walks. Employees was asked to illustrate how the workflow looked, their responsibilities etc. This was combined with observations of the physical production-flow within the unit. A detailed description of the phases can be seen below. Please see relevant terms in the introduction:

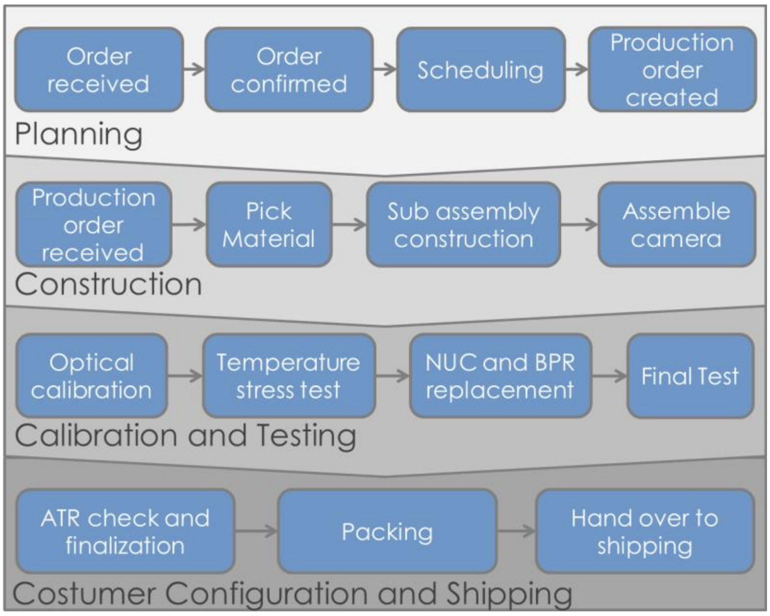


Figure 5: Production flow cooled cameras - ATS

Phase 1, Planning: This phase is carried out by the administrative section of the flow team and primarily involves the planners.

- **Order received:** When an order has been made and approved the production unit is notified.
- **Order confirmed:** The planner go through the order to check that it is correct and that the order can be delivered. If there are any technical issues that needs to be resolved before confirming the order the planner relies on the production engineer or technicians.
- **Scheduling:** When the order has been confirmed the planner schedules when the camera is to be manufactured so that it can be delivered at the specified delivery date.
- **Production order created:** On the basis of the schedule a production order is placed with production at an appropriate time.

Phase 2, Construction: Phase 2 is carried out by the production unit assisted by the production engineers and technicians. Progress is reported to planning and via the team leader to the flow team manager.

- **Production order received:** The planner places a production order which is received by production. When orders scheduled to be fulfilled earlier has been completed the production unit confirms the order and starts production.
- **Pick material:** The order contains a BOM which is used when picking the material necessary to build the camera. When all the material has been picked a transaction I made in the EPR moving the material from stock to WIP.
- **Sub assembly construction:** The production unit begins by assembling a number of sub-assemblies. These can be assembled in parallel by several employees or in series by one employee.
- **Assembly of camera:** When all sub-assemblies has been completed they are combined.

Phase 3, Calibration and Testing: Phase 3 is carried out by the production unit assisted by the production engineers and technicians. Progress is reported to planning and via the team leader to the flow team manager.

- **Optical calibration:** Cameras with optics are calibrated using specialist equipment. After the calibration is completed numerous is performed to ensure that the optics is performing according to specification. All results are notified in the ATR.
- **Temperature stress test:** To ensure that the camera will be functional at different temperatures it is tested at -32°C and 65°C. The results of the tests performed are notified in the ATR.
- **Non-Uniformity Correction and Bad Pixel Replacement:** To ensure image quality the IR detector undergoes calibration. The results are notified in the ATR.
- **Final test:** Test designed to test the finished system. Includes image quality test, function of optics etc. The results are notified in the ATR.

Phase 4, Customer Configuration and Shipping: Phase 4 is carried out by production unit with the assistance of the administrative section of the flow team.

- **ATR check and finalization:** Before the camera is delivered the ATR is checked so that all tests have been performed and the camera operated according to specification. The camera is also configured to match customer specification.
- **Packing:** When the ATR has been approved and the camera configured the ATR is signed by the workflow manager and packed into its case with applicable documentation and accessories.
- **Hand over to shipping:** The camera is transferred from WIP to stock as a finished camera and turned over to shipping and export.

5.1.2. Current information and knowledge management regime

There are several processes, tools and aids implemented for information and knowledge distribution. The most significant are listed below.

Production overview:

One tool that is used at FLIR today is a production overview. This is a whiteboard divided into several sections. Every section represents a step that the camera flows through to completion. It is only an overview and do not detail the progression within the step. Some steps take several days to complete. Every camera in production is represented by a note with basic information about the camera. This includes serial number, customer, delivery date, how is responsible for the camera and status. If a problem occurs this is signaled by a short error description. The description is often written with a red whiteboard marker. How is responsible is seldom specified. As the camera progresses it is moved along the different sections of the board. In this way it is possible for personnel to see where in the production flow that the cameras are currently at. There are also sections on the board for technical problems and lack of materials. The whiteboard also functions as a billboard for important information.

Progress cards

Progress cards details the progress within the steps off the production overview. The progress card is an A4 that is unique to each camera. This unique copy accompanies the camera throughout the manufacturing process. All the steps that must be completed before delivery is listed. These steps are listed in chronological order. When a step is completed it is marked by the operator putting their signature next to the description. This signals that they have completed the step.

ATR

The ATR is the test protocol used for all cameras in production. Every camera is accompanied by a unique copy of the ATR. There is one ATR template per camera model. Listed in the ATR are the tests that are to be performed along with what values are considered a pass. A paper copy or a excel version of the ATR is used. The tester inputs the test result in the ATR. The ATR and Progress card is the primary tools to keep track of cameras while being produced. The ATR is primarily an information tool but convey some knowledge.

Instructions

To help operators there are instructions. These instructions include both text and pictures often in a step by step format. These are the primary tool and aid for knowledge distribution. The instructions are seldom up to date.

Email

Emails are an important tool for conveying information and knowledge at FLIR. Everyone that works at FLIR gets an email address and account. Logging in on their personal account gives them access to their email. Email is used primarily by the administrative part of the unit. Only the administrative staff has their own computer. Operators seldom check their email and some never do. If they are to check it they need to use a production computer. FLIRs email retention policy means that emails are erased after 3 months. There are ways to save emails but it is troublesome.

Placards, notes and scribbles

Placards are another method used primarily to convey information regarding best practices. These include warnings but also instructions on how to use machines etc. Other includes tables of which software goes in which camera, pictures of how assemblies should look like and placards telling operators what a bench should be used for, for example “detector assembly”.

Notes are also frequently used. This includes A4 with more text or post-it with notes. These often contain information that isn't contained by the ATR or progress card. Examples include descriptions of an error that has occurred, a list of parts exchanged during troubleshooting or other similar information. This is most often kept with the camera and is available to all.

An alternative that is used instead of notes is scribbles. It is common that additional information is written in margins of ATRs and progress cards. This also applies to instructions and other production documentation. Instead of updating instructions and similar a note is added in the margin of the paper copy.

Conversation

The most common way of distributing knowledge and information at FLIR is conversation. This is either as a group at meetings or unscheduled during the workday. Information regarding, among others, problems, priorities and progress is mainly conveyed this way. Teaching new tasks are carried out by a more experienced employee showing and explaining the procedures. There are no guidelines for how this or meetings are to be organized. Daily meetings with the production staff and administrative staff are held to convey information. Being the only forum they often result in detailed discussion between two people.

ERP

FLIR uses SAP for all their sites in the world. SAP is used for several tasks within the organization. Planning and purchasing use SAP the most. Material is ordered via SAP and all order placed for cameras manufactured by the unit are also managed using this ERP. Other tasks include BOM management and construction, keeping track of inventory, material transactions and requisitions. The production staff uses SAP for material transactions and similar. Administrative staff is generally very capable in terms of working with the ERP. Production staff generally know little about how to use the system and often struggle.

5.1.3. Information and knowledge sharing, problems and consequences

This section is based on interview results, see appendix C for summary. The interviewed employees were asked to describe how information and knowledge was shared. They were also asked to describe shortcomings and problems if any. Five problem areas were identified from the interview results: Information hoarding, lack of documentation, silo thinking, unwritten rules take precedence and lack of understanding.

Information hoarders where earlier described as one of the most common factors that hinder the free flow of information. Information hoarders were identified as a problem at FLIR also. Several employees mention a tendency of individuals to keep information to themselves. This leads to misunderstandings and mistakes. It is also described as a factor that prevents working proactively. Information surfaces too late when it is not possible to act on it.

Silo thinking is also described as a hindrance to the free flow of information. Silo thinking is caused by units not sharing information among each other. Several examples of these were present at FLIR: Employees described a lack of feedback. When information is conveyed it is not verified that information was received and understood. There is a reluctance to share problems with other parts of the unit. Sharing what is to be expected next is insufficient. Other parts of the unit do not act on the information provided by another unit. The silo thinking at FLIR leads to misunderstandings and unnecessary mistakes. It can also cause frustration and lack of will to cooperate.

All employees noticed that mistakes are regularly repeated due to the lack of documentation. This leads to waste in the production workflow as it takes a while, sometimes a few hours, to get the help required to solve the problem. Mistakes were often repeated and most of the time they would recognize a mistake but not be able to solve it since they had not documented the solution. There has been initiative to address this but they have to some degree stalled it. A reason is described as high workload and the feeling that there is no time to document. A risk that was described by employees is if someone with specialist knowledge is not available. Several instances where described where time was lost when this happened.

There were several mentions of new procedures and changes not being adhered to. This is more common in production as changes are more common there. This can be new software, parts, procedures or similar. This is problematic as it has prevented the work to establish best practices.

Several of the staff members also mentioned a lack of understanding between the different roles. Production uses a vocabulary and communication adapted to their environment. The administrative staff uses another. This causes misunderstandings and sometimes frustration. Also information that are important to one role is insignificant to another. This means that it is sometime difficult to understand the type of information that other staff members need.

5.1.4. Analysis of the pre-study

The result combined during the pre-study was analyzed to identify waste and solutions to reduce it. The focus is waste related to information and knowledge distribution. Discussed initially is the hierarchy, roles of employees and structure of the workflow. Also discussed are current information and knowledge regime, how information and knowledge is shared and how it can be improved. The result of the analysis is then used to formulate goals for and questions to evaluate prototype 1.

The current hierarchy of the production is clear and reasonably flat. A flat hierarchy has been shown as a prerequisite for efficient information flow. The tasks of different roles within the structure are also clear and logical. Thus it is possible to identify the information need of the different roles. Some individuals have expanded the tasks that they perform. However admirable this can cause confusion and that their original tasks are somewhat neglected. For information and knowledge to flow efficiently it is important that this is addressed. The reason for this is both uncertainty of the employees as to what they are hired to do but also because others within the team neglect their tasks.

The structure of the workflow is logical and clear. There is however some disagreement amongst the employees how the workflow looks. There is at the moment no documentation that clearly illustrates how the flow looks like thus allowing for different interpretations of the structure. This should be addressed as agreement on the structure is essential for proper information and knowledge flow. Agreement is necessary to provide a common reference during discussions regarding the workflow and the cameras that is flowing through production.

The primary tools for distributing information at the moment are the production overview, progress card and ATR. These three combined provides much of the relevant camera information. It is however cumbersome to look through all of them. This means that the information and knowledge within might not be utilized. The way information is presented should therefore be reformatted. The production overview should include the information that is most often needed presented in a clear manner. This will reduce the need to look in the ATR and progress card. The information presented in the ATR and progress card should also be easier to access. This would preferably be accomplished using a

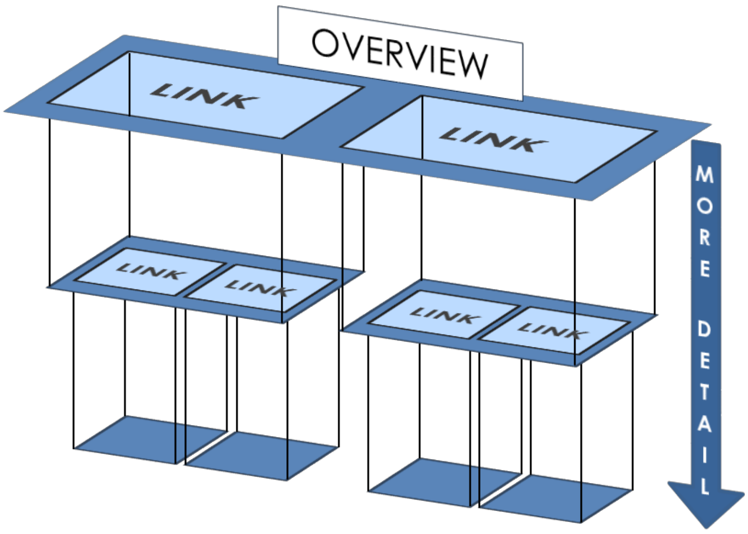


Figure 6: Multi-level information structure

multi leveled information structure. Overview is in the top level and more detailed levels are linked to the top level (see figure 6). A user can this way easily access the level that is required from the same place.

Other weaknesses of the production overview, progress card and ATR are that there might not be up to date. This was a common commentary during the interviews. A MIS should assist employees to make strategically and tactically correct decisions and priorities. For this to be possible it is important that information is up to date and credible. Since physical copies are used there is also a risk that they can disappear and the information lost. Digitizing this is a priority to avoid losing information. The digital version should also be designed to encourage or force the users to update the information. Keeping track of who is responsible for a camera should also be improved and handling problems with erroneous cameras. Responsibility is important so that one knows who to ask about a specific camera.

The primary tools and aids for distributing knowledge in the unit are: instructions, emails, placards, notes and scribbles. These together represent a sizeable amount of explicit knowledge. There are however several shortcomings in terms of knowledge distribution. Many of the instruction are outdated and little effort has been made to change this. The amount of explicit information is therefore misleading as this is no longer relevant to the organization. Knowledge regarding current procedures, processors and similar is thus implicit. Some of the current information has been made explicit using scribbles notes and similar. These means that in the best case scenario there is one document where current knowledge has been made explicit. Emails also contain important knowledge but retention policy and lack of access is a limitation.

We can conclude that there are two major shortcomings in terms of knowledge within the unit. Little or no of the current knowledge has been converted from implicit to explicit knowledge. The second shortcoming is availability. As knowledge is kept in emails or one updated hardcopy it is only available to those with direct access to the email or instruction. A proven method for knowledge distribution is wikis which is probably an appropriate solution for FLIR. This wiki should be made available on the intranet. It would contain instructions, proven solution and similar. Everyone should have privileges to add articles to the wiki. FLIR should also add adding knowledge articles part of the job description. If every staff member adds articles it maximizes the amount of knowledge being converted from implicit to explicit knowledge. It is important that all participate so that articles become as useful for all roles within the unit. Implementing the wiki and encouraging use would probably result in a large percentage of knowledge being made explicit. A wiki of this type will require an administrator. After consideration it was concluded that the most suitable are the production technicians. A fairly small percentage of knowledge is tacit. This can be explained by the structure and predictability of the production unit.

Other factors that limit information and knowledge flowing freely are: silo thinking, information, hoarding, lack of understanding. Solving these problems probably include creating a common system for sharing information and knowledge. Using a common platform will provide a common reference and way of working. This should increase understanding and decrease silo thinking. The goal should be high PU and PEOU. This will encourage increased communication and as a consequence increase understanding. Solving the problem of information hoarding is probably more problematic. The solution would probably be routines and process that address this problem directly. A combination of coercion and encouragement is probably the most effective solution.

The analysis proves that there is large potential for improvement if an MMIS were implemented and included a KM component. The continued work to examine how such an MMIS should be structured and designed were directed by the following goals:

- Create a knowledge database in order to reduce time loss and improve efficiency. This to turn implicit knowledge into explicit knowledge with the help of documentation.

- Provide the employees with the information it needs when it needs it. This is to be achieved with a software implementation that manage and encourages information flows within the unit.
- Adapting the current structures, processes and tools into software to achieve high levels of recognition and learnability.

5.1.5. Conclusion of the pre-study: The first prototype

Prototype 1 was created using the results and goals from the pre-study. The aim is to address the most significant shortcomings in the current information and knowledge regime. Initially the structure of the program is described together with differences depending on role. Detailed descriptions of the major functions are also presented. Lastly question for evaluating the iteration are presented. See appendix D for pictures of the prototype 1.

The software that were prototyped can be divided into two sections based on features. The first addresses problems with information flow and the other converting and making knowledge available. For an overview of the structure see figure 7. The figures represent the structure for a working and an erroneous camera. The functions which have been faded were not included in the prototype. The user was instead informed that they would be there in the final prototype and what their function was. This choice was motivated by it not being necessary to try this already to fulfil the goal of the iteration.

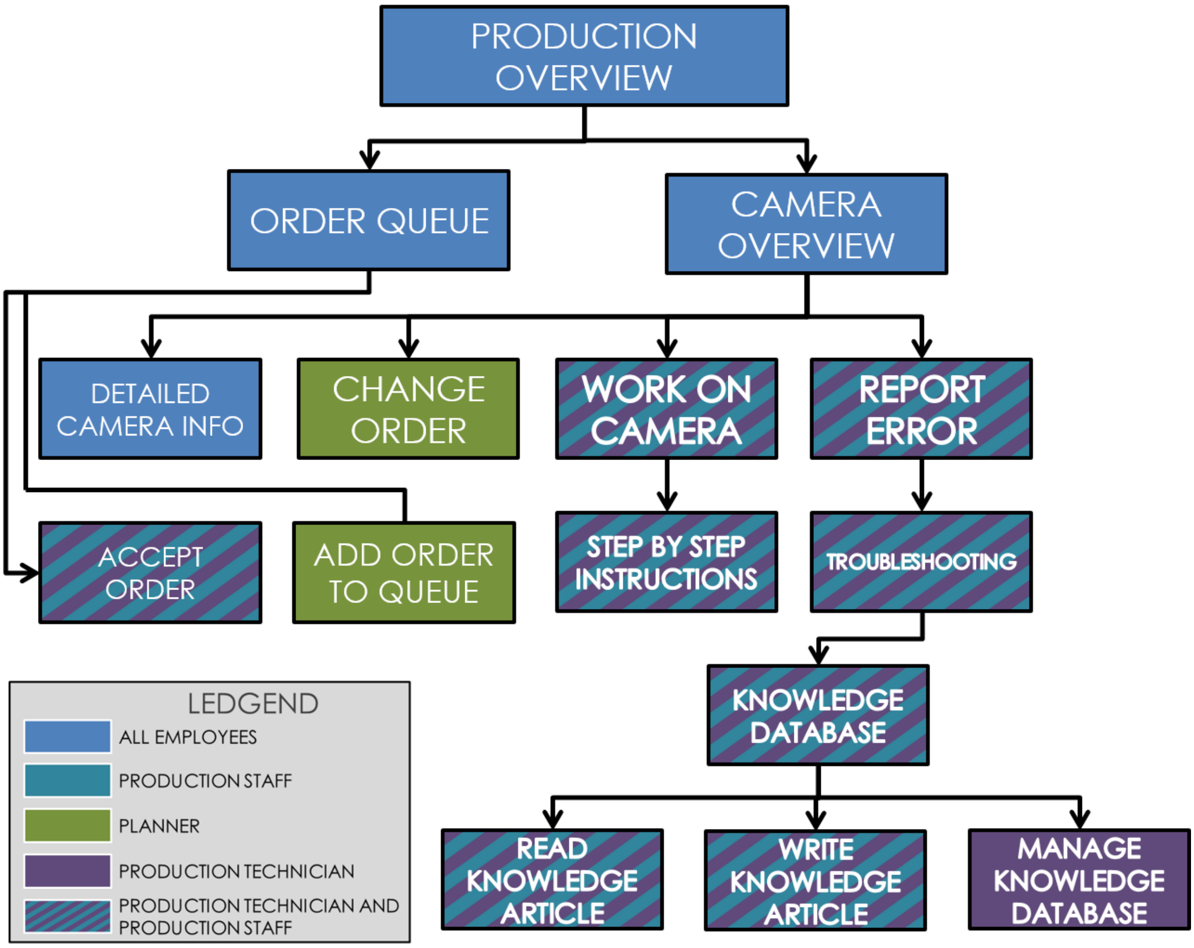


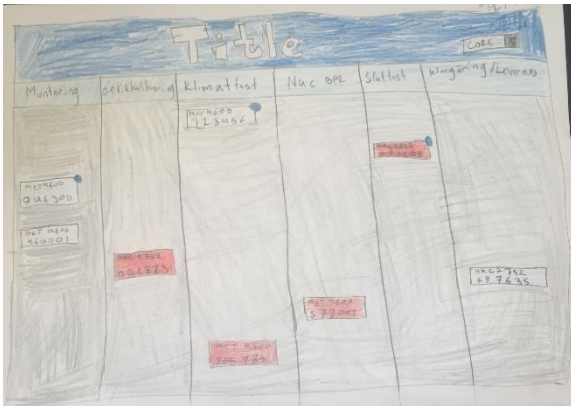
Figure 7: Structure and links of prototype 1

Production overview:

The production overview is the center of the software and looks very similar for all roles. The same basic design will provide a common reference. The production team and production technicians share the same view. They will access the production overview, click on a camera individual and check it out in order to work on it. This is used to gather data on mistakes and efficiency of employees. If a mistake is made or the camera malfunctions they will have to report and write error report and a notification will be sent out.

Planners use the same basic production overview. Added functions are adding and changing order information of cameras in the flow. They can also alter the priority of a camera. Removed functions include the possibility to work with the camera and troubleshoot. The camera overview is also different for planners as the information presented here are connected to the requirements of that role. The set of functions that they can access through camera overview also differs.

Since the goal is a design with high learnability two different designs of the production overview were tested.



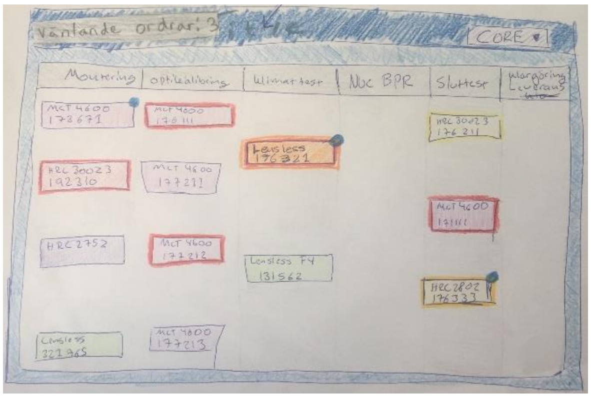


Figure 8: Design proposal 1. To the left the simpler design, to the right the more complex design

The first version lists the cameras vertically in the order of priority. All camera containers have the same color. The only other color used is red to signal that a camera has malfunctioned. This approach will easily give an overview of the cameras in production and which cameras should be prioritized. A marker is added to the container if someone is currently working with it. The downside of this approach is that the user will have to use a scroll function in order to see all the cameras. Another downside is the user will have to read the information in order to see what type of cameras is in the workflow.

The second approach is in terms of design more complex. Colors are used to convey several pieces of information. The color of the container is dependent on the camera model. This is supposed to make it easier for the user to find the camera he is looking for. Cameras are not listed in order of priority in this design. Priority is instead conveyed using the color of the containers. The three highest priorities were given different colors to signal priority. A second marker is used to show that the camera I currently being worked on. All cameras are fitted on one view to avoid scrolling. The main advantage of this approach is that it doesn't need scrolling functions in and it is easy to get a more detailed overview of the cameras in production. The downside is that using a color scheme for two different functions, both for prioritizing and for identifying the type of camera, might be make it a little too complex.

Knowledge database:

The knowledge database is used as support when troubleshooting. The knowledge database is an entire new view and occupies the entire screen. The user is asked to input a search phrase and relevant suggestions are returned. The order of the returns are based on which result that historically has been the most useful. The user is also given the option to add a knowledge article. A knowledge article consists of a title, some sort of media (picture, video, audio), a description of what is solved by reading the article and instructions on how to solve the problem. Other information given in the article is author, how many that found it useful and if the article has been vetted. Articles are vetted by the production technicians.

Order queue:

A new function has been added for planners and production staff. Planners can add orders to the order queue. The production staff then accesses the order queue and confirms the order. The camera is then added to the production overview.

Notifications:

The system will also have notification popups to inform of important actions. One of the popups tell the employees that an error report has been submitted. The second one will notify if when the error has been fixed. The last will notify the employees once a new order has been added. These popups exist to create an overview on what goes on in the different levels. The planners will see how many mistakes occur, which they haven't been able to do and the person who fix the mistakes will get credit.

Before testing a number of questions were decided on. These will be used to evaluate the first prototype in terms of the established goals. The questions to be answered are:

1. Knowledge management
    a. Are employees open to the idea of a knowledge database?
    b. Would the employees benefit from the knowledge database?
    c. Would this resolve the problem attributed to shortcomings related to knowledge management?
2. Information distribution
    a. Which of the two production overview designs does the user feels gives them the best informational overview?
    b. Do they get the information they need from the prototype?
    c. Are the functions needed present?
3. Learnability
    a. Is it easy to learn how to use the software?
4. Effectiveness
    a. Can something be improved to make the software easier to use?

5.2. The first prototype

5.2.1. Results

The answers to the questions in section 5.1.5 can be found in Appendix E. Comments on answers given are described more thoroughly in this section.

All employees showed enthusiasm when they saw the sketch of the virtual production overview. All of them preferred the rightmost sketch, see Figure 8, mainly due to the fact that they wouldn't have to scroll and they could easily see what type of cameras were in production.

A comment brought up, regarding the virtual production overview, was the complexity of color scheme showing the priority of cameras. It was perceived as confusing since color was already used to signal camera model. The employee thought that it would be better if numbers in the corners were used to show the priority instead.

The second main function, the database, received a positive response. It was pointed out that it would be hard in the beginning to write knowledge articles and error reports. This since it had never been done before. Regarding the database, it was also brought up that the employees might not have the knowledge of how to optimize search statements. As a solution a short seminar could be held to help the members of the production teams. It was also brought up that it must be ease of use must be a priority since people might not use it otherwise. Several of the employees also asked to include a function in the database that record errors that occur. Error history would then be created so that it could be checked.

One employee working in a production team stated that the notification sent out should only be sent to those working with the team and not to everybody within the production unit. The reason behind this was that the notification will probably disturb them if they are working and the goal should therefore be to minimize the number of notifications. Later on it was added that this comment could be applied to all three of the notification function in the prototype.

Lastly several employees asked for a function for supporting troubleshooting. This function should be designed to encourage established best practices for troubleshooting. Examples include only exchanging on part at the time and writing down all changes.

The goal of the iteration was to create a design with high learnability. When asked all participants agreed that the design made it easy to understand and learn how to use it. The elements reused from current tools aid was mentioned as a factor that contributed to high learnability. When asked if anything could be changed to enhance learnability and usability few suggested anything. Mentioned was improving troubleshooting and search somewhat and how to show priority.

5.2.2. Analysis

As mentioned above it might be difficult for employees to write error reports and knowledge articles when software is newly implemented. This might have the consequence that users refrain from using the system. To maximize the likelihood of use some measures need to be taken. A seminar on how to write these articles would be appropriate. Writing articles should also be made into a task of all the different roles. Initially it will probably be necessary to “force” users to write articles to create explicit knowledge. However, once the database has a number of articles, it is likely that use will increase. This since employees would gain from using it, which would motivate them to use the service and create more articles.

The results can overall be considered as a success due to the positive response and the concept was accepted by the employees. Since the concept was accepted with only a few comments a more advanced prototype can be created with the first prototype as a basis. The goals are:

- To create a more intuitive color scheme for the virtual production overview
- Make the knowledge database easier to use
- Create a prototype with high effectiveness

5.2.3. Conclusion from prototype 1: Second prototype design.

Prototype 2 was created using the results from testing of prototype 1 and the following analysis. The aim is primarily to increase the effectiveness of the design and address some of the shortcomings mentioned when testing prototype 1. Initially changes to the design due to user feedback will be addressed. After that details of the interaction and linking of views will be discussed. Lastly question for evaluating the iteration are presented. See appendix F for pictures of the prototype 2.

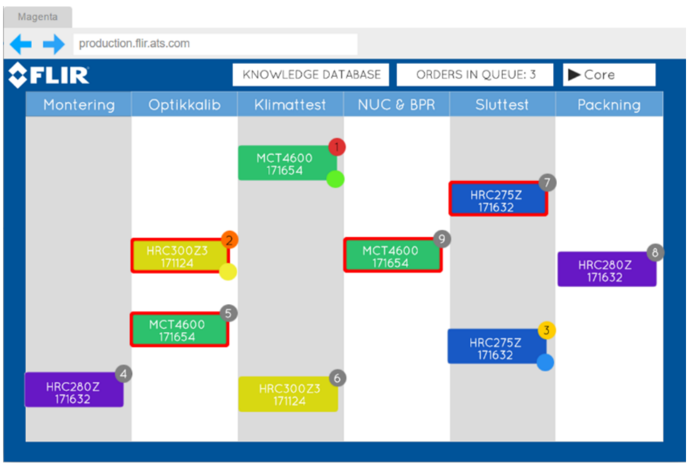


Figure 9: Production overview prototype 2

Due to the comment regarding the color scheme of the priority another alternative will be shown. A marker will be added to all camera containers. A number will be added to the marker signaling priority. The top 3 in priority will have differing colors while priority 4 or lower will all have the same color. In order to avoid too many mismatching colors, the circle that states if a camera is checked out will be closer to the color of the camera type. A red frame surrounds containers of malfunctioning cameras. See figure 9.

Another change is a button that takes you directly to the knowledge database from the production overview. This encourages the use of the knowledge database. See figure 10 for structure. Changes are marked in red.

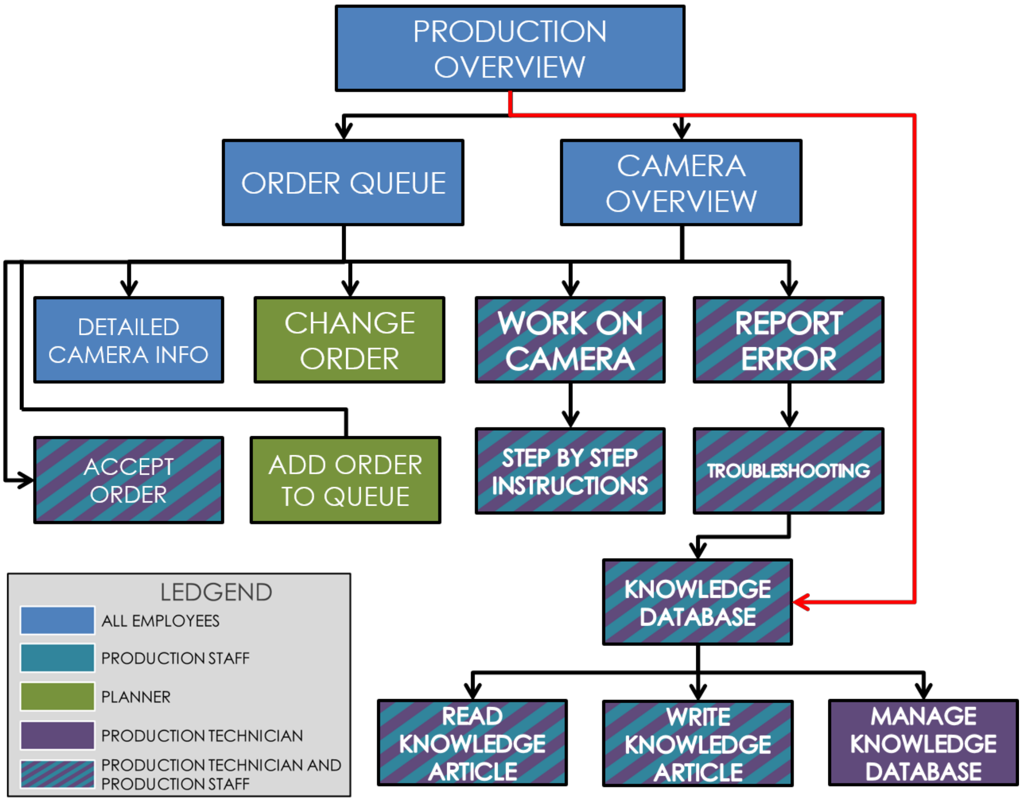


Figure 10: Structure and links of prototype 2

To increase the effectiveness decisions were made how the different views should be linked to on another. Production overview is the start page. The user can click the containers. A click results in a popup. The popup contains the camera overview. Using a popup keeps a connection with the production overview. The user can check a number of cameras but keep the sense of where in the flow they are at the moment. The pop ups are closed by clicking a close button or clicking outside its container. The order queue is also a popup. This so that the user can get a sense of how full the flow is already before beginning work on another one.

Other views such as; work on camera, ATR and the knowledge database open in separate windows. The production overview is not relevant to those tasks and should therefore not be visible. This limits the available information and makes the program easier to use.

Before testing a number of questions were decided on. These will be used to evaluate the second prototype in terms of the established goals. The questions to be answered are:

1. Is it easy to understand the color coding and the rest of the design?
2. Is the linking between the different views logical and understandable?
3. Are the buttons and other elements used for navigation easy to use and understand?
4. Is the system easy to use?

5.3. The second prototype

5.3.1. Results

Answers to the DECIDE questions in the previous section can be found in Appendix G. The answers with comments are described more thoroughly in this section.

Most people found the new colors schemes easy to understand. One comment regarding the colors were that there were too many on the virtual board. Later on the employee added that the colors are necessary since the information shown on the board need to be seen from a distance without having to read the details. Another comment from the employees were that they would save time since they wouldn't have to run between the office and production area asking about the cameras.

During user testing four new functions were requested:

1. A view of troubleshooting history for every camera.
2. Not checking in a camera overnight. Means that you don't need to check it in once you go home and still be sure that you get to work on it the next day.
3. The possibility for production staff to send a signal to request assistance from the production technicians. The request will be saved in a to do list they can access later. This was however contradicted by another employee who thought it would be better if the person asked for help in person.
4. Personal checkout colors or something similar so you could easily see who has checked out a camera

5.3.2. Analysis

When troubleshooting a malfunctioning camera, it is common to add exchange parts to identify the faulty one. To keep track of which parts has been exchanged there should be a log consisting of part added to the camera. The log will be added as a part of the troubleshooting page. There are two issues with troubleshooting today at FLIR. People exchange several parts at once making it impossible to identify what was actually faulty. Secondly since there are no record of what has already been tried it is likely that the same solution is tried again. This results in waste since the same measure is taken several times. It also prevents the creation of explicit knowledge regarding the solution. Since several parts are replaced every time it becomes impossible to know what actually solved the problem.

It has been decided against given the user the possibility to "save" a camera overnight. This is due to two different reasons. When a camera is checked out it is supposed to signal that progress is made on the camera at that moment. Allowing a camera to be checked in without progress being made will break this functionality. Also if the person who checked out the camera is absent no one else will be able to work on it.

During testing it was noted by the test supervisor that it might be appropriate to added new function to support decision making. To support strategical and tactical decision making is an important function of an MMIS. Testing revealed that the production gets enough support already but that it can be improved for planners and production technicians. Also needed is a tool to support the flow team manager.

The design for the flow team manager can be summarized by one word: efficiency. The goal of this view should be to measure efficiency. This is done by keeping track of statistics on the employees, errors and overall production. The software created is designed to documents all the things mentioned. To create a quick overview a dashboard with four components will be created. The components of the dashboard should show general information regarding the efficiency of employees, error statistics, production statistics and the virtual production overview. It is also possible to get a more detailed information regarding all components. The statistics for efficiency worked as a showcase for the flow team manager. How to actually measure efficiency needs to be discussed and evaluated before such a function can be added to an implemented version of the software.

5.3.3. Conclusion from prototype 2: Third prototype design.

The analysis of the results of prototype 2 testing were used to develop prototype 2 into prototype 3. Several new functions were added and existing ones improved. For structure of prototype 3 see figure 11. See appendix H for pictures of the prototype 3.

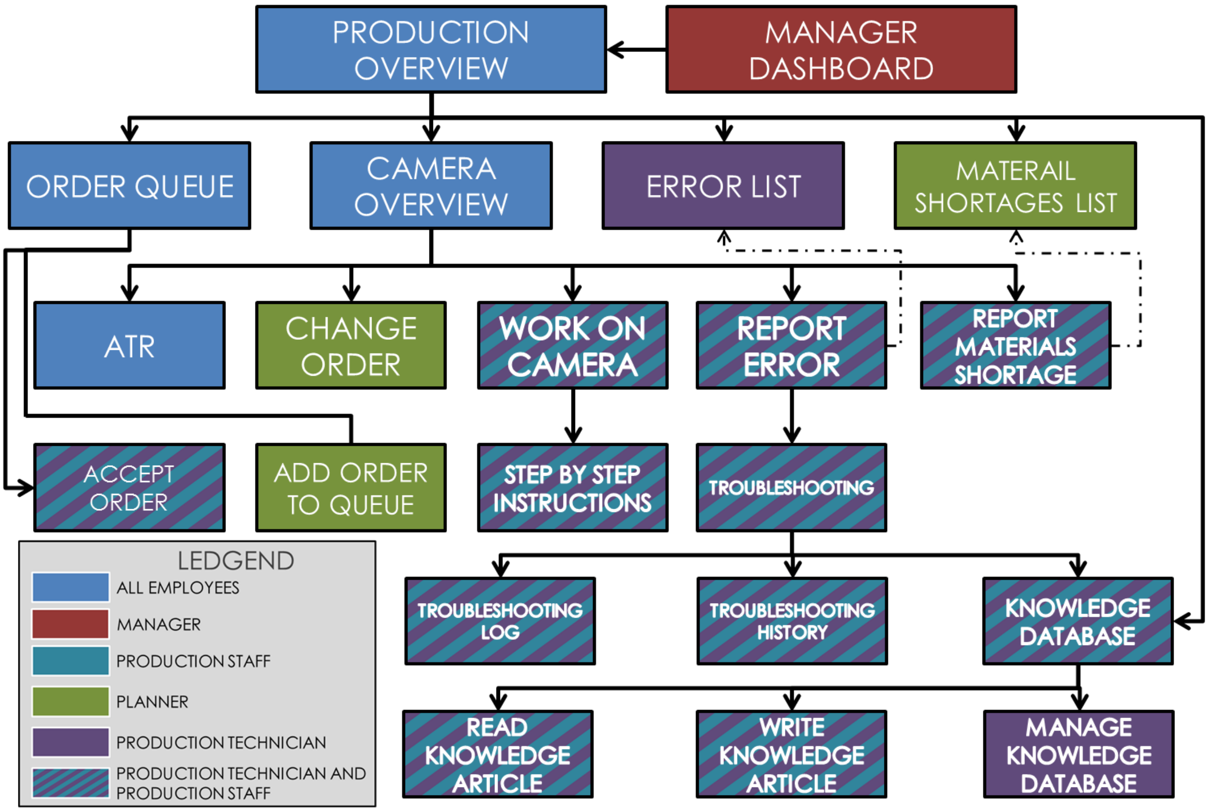


Figure 11 Structure and links of prototype 3

To resolve the shortcomings of the current troubleshooting regime several changes were made. The troubleshooting page now consists of 3 parts. Knowledge database search, troubleshooting log and troubleshooting history of the camera. The troubleshooting log where designed to promote best practices. This was achieved by having the employee working in the following way: Before he saves the log he is asked to answer two questions: Was this the solution and if he have changed back the part. The program gives feedback if the part has not been put back into place again to encourage best practices. By minimizing the number of repeated steps when solving an error efficiency will rise. This new function was combined with the knowledge database and troubleshooting to create a new concept for troubleshooting. See figure 12 for details.

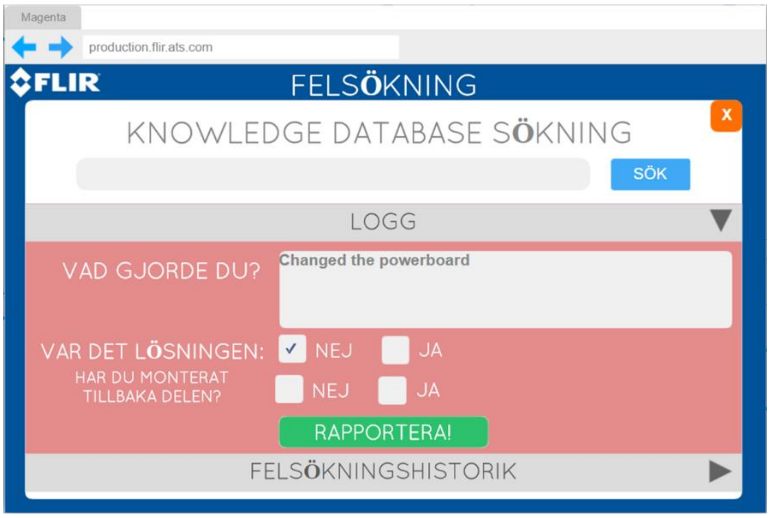


Figure 12: Troubleshooting view of prototype 3

Some of the button labels are updated to increase learnability. Check-out is relabeled work on camera. Camera details is relabeled to ATR.

Another function that was added was a list of current technical problems. This function is used by the production technicians. It was inspired by the production overview whiteboard currently in use. It has a section for technical issues where production staff can describe any problems they have for the production technicians to see. When an error is reported in production it is added to the production technicians list. The list is ordered according to the severity of the issues. This functions will not reduce the face-to-face interaction but rather alert that it is needed. Instead of having to try and find a production technician it is now possible to get help without leaving your work stations. It also helps the technicians prioritizes. This will hopefully increase strategically and tactical correct decision making related to troubleshooting.

A function was also added for planners. This was also inspired by a section off the current production overview. The function added is called material shortages. It lists all the current material shortages present in production. Material shortages are reported by the production staff. Thus reporting materials shortage was added to the production staff's views. The production staff reports on the severity of the shortage and the consequences. This information is gathered and sorted according to severity and presented to the planner. This will hopefully increase strategically and tactical correct decision making related to material shortages.

As mentioned above functions were also introduced to assist the flow team manager in decision making (see figure 13). The focus was efficiency monitoring. As mentioned above it consist of 4 components. They are each given their own section. Error is presented as a vertical bar chart showing the number of errors that are unresolved at the moment. There is one bar for every production line and one for materials shortage. Clicking a bar shows more detailed error statistics. Statistics about employees is also presented as a bar graph. A horizontal one is used to allow scrolling. The height of the bars is decided by the Total Efficiency Index (TEI) of the employees. Clicking the bars gives detailed information detailing how the TEI was calculated. Production statistics is also presented in table form. Real time production information is also displayed in the form of the production overview.

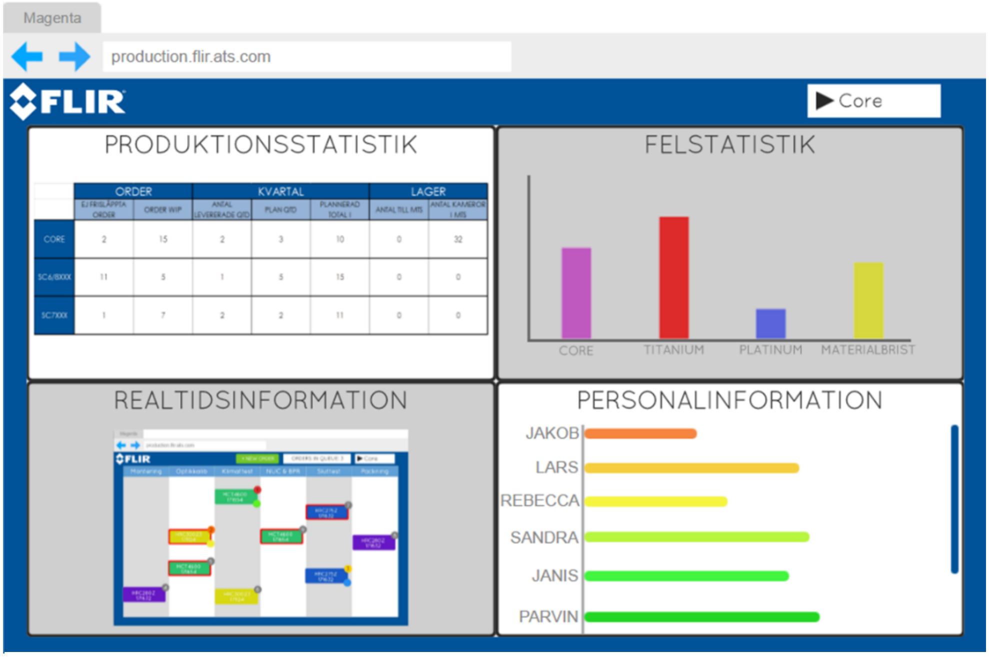


Figure 13: Flow team manager dashboard

If someone is working on a camera it should be easy to see who it is. A solution suggested by an employee was adding personal colors. This would however complicate the colors schemes even more and is therefore not optimal. In order to solve this problem, without complicating the production overview, the name of the employee working is displayed when the mouse hovers over the checked-out marker.

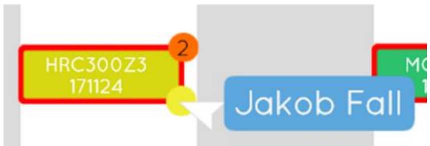


Figure 14: Name of employee shown when hovering

The final prototype was then tested together with employees and after this interviews were conducted. The tasks to be carried out varied for different employees. The employees that had not tested the prototype earlier were however given the same task. This was:

- Start working with the camera of the highest priority
- Troubleshoot the malfunctioning camera of highest priority and make a knowledge database search to find a possible solution.

5.4. Final test and evaluation

The results are first described and later on they are analyzed and generalized.

5.4.1. Results

Answers to the interview questions in Appendix B can be found in Appendix I. The answers with comments are described more thoroughly in this section.

The users could all complete their tasks without assistance, even the ones using the system for the first time. When asked about the different functions of the program all could describe them without making any mistakes.

When asked if the system was easy to use all employees answered yes. That the design used familiar colors, for example red for marking cameras with was given as an explanation. Others, such as usages of common designs such as popups and close button was also described as keys to high learnability. The virtual production overview was described as clear, logical and similar to their current work process. The new users said that they recognized their current production overview in the production overview of the system. This meant that the main function was easy use. Navigating between the cameras and performing different tasks were no problem.

All employees said that the system would be an asset for them. They all concluded that since it is an asset for them it would also be an asset for FLIR Systems AB. Problems will be easier to fix and the time it takes to fix them will be reduced. This is mainly attributed to the content and easy navigation of the knowledge database. The employees are aware that if the system was to be implemented it would take a while to fill the knowledge database with articles and solution. It was estimated that once up and running it would be a huge asset, especially for those working directly with production. All employees also agreed that the program positively affected information flow within the unit. Having a tool that ensured that up to date information flowed trouble free were deemed a great asset for the unit. Several employees also thought that the software would improve communication. This because all employees will use the same terminology and will have common references when talking about a camera individual or process. All employees concluded that they would save time and reduce waste if using the system. The time estimated to be saved varied, but overall all estimated that it would be a substantial time save.

When asked about using participatory design as a tool to develop a MMIS, the employees all said it was the desirable approach. The main reason according to them were that they know what is missing, what can be improved and how to improve it. A majority also mentioned that they would be more open and optimistic to use a software that they had helped to create.

5.4.2. Analysis

As mentioned earlier the purpose of the final evaluation and test was to answer the questions of the study: Will well-defined strategies and processes for information and knowledge management lead to higher efficiency within a manufacturing unit? Is a specialized software a useful tool and how should it be designed to facilitate efficient information and knowledge management? The results of the final test are analyzed below to answer these questions.

The software was designed to test the effects when information and knowledge management strategies were implemented in a real world manufacturing unit. Information management strategies will aid in strategically and tactically correct decision making. By minimizing incorrect decision or decisions made too late or due to misunderstandings operations run smoother and more efficient. When asked, all employees agreed that the new system would allow them to more effectively carry out their tasks. They would be able to prioritizes and react quicker and more decisively since they have updated and correct information. Since the system formalizes communication it is also estimated that instructions will be carried out correctly. In essence all employees agree that working consciously with information management is an asset to FLIR and increases efficiency.

The knowledge tools were also seen as a source of greater efficiency. When using well-defined strategies and processes (the knowledge database) it will help turn implicit knowledge into explicit. This will improve efficiency since the knowledge can be better utilized. By making more information explicit the five problem areas, described in section 5.1.3, are countered. Employees mentioned that it would minimize the times that the same solution must be invented. It would create a standardized way of working establishing best practices. This would reduce mistakes and increase efficiency. The 5 problem areas of FLIR can be found at any company and are usually the result of personality or lack of documented procedures. By creating software, where the user has to keep documentation their personality won’t allow them to hoard information and their work process will be automatically documented.

Since all users completed their tasks without any mistakes or problems it can be concluded that the user testing was a success. All employee answered that the software is easy to use and it takes little time to learn how to use it. They also unanimously agreed that it is easy, even for someone new, to navigate the system. It can be concluded high learnability has been achieved. By creating software reminding of the current work process and knowledge regimes etc. the user will have an easier time to use the system and they will also be more likely to use it.

Also it is clear that a system created by one's peers or yourself is more fun to use. By using participatory designed software that is beneficial for all roles within the flow team could be developed. When asked all employees agree that the software will improve information distribution and increase the usage of knowledge within the unit. Using software has been received very positively since much of the work is already used on computers. Software also makes it easier to predict how it will be used. This makes it easier to design to promote a certain way of working.

It can be concluded that by using a specialized software tool it will be easier to facilitate efficient information and knowledge management within the production unit. By using a specialized software tool best practices are encouraged and the flow of information is not based on the individuals within a team, but by the software used.

It can be concluded that well-defined strategies and processes for information and knowledge management resulted in higher efficiency within the studied manufacturing unit. Using specialized software to facilitate this is also a useful tool. Since the research has been limited to one manufacturing unit it is hard comment on the effects that it would have generally. The results are however so conclusive that it is reasonable to assume that implementing the ideas used herein would probably lead to higher efficiency within other manufacturing units.

6. Discussion

This chapter discusses the benefits of using a specialized software tool. Also discussed are the advantages of using participatory design and sources of errors in this study.

6.1. Organizational benefits

When a company has a high production cost, it is the easiest variable to change in order to raise the profit. High-tech companies in Sweden usually have a high production cost and could gain from streamlining their production. With the help of our software the employees said that they would save a significant amount of time, this time could instead be used to produce even more and reducing the lead time. The reduced lead time results in more flexibility when handling large orders and last minute orders.

By turning implicit into explicit knowledge, procedures are documented and improved. By documenting the work processes, a new and standardized way of working will be established. By having standardized work processes any employee can continue where someone left of since they know what step is next. Since all steps would be standardized if would be much easier for new employees to learn how to work with the high-tech cameras. By regularly updating and creating new knowledge articles the quality will be more consistent and might even improve. It also allows for a more flexible working force. Both in terms of moving employees from one unit to the next and that you can fire and rehire with less loss. This can be a major competitive advantage if the number of orders fluctuate. It also allows for making informed decisions about relevant sustaining actions and the like.

Several of the employees stated that the software would improve the communication by creating a common terminology for all employees. If all employees use the same terminology the number of misunderstandings will be reduced and especially communication between the different levels of the hierarchy will be improved. When misunderstandings are reduced, the efficiency increases.

Lastly since information flows more freely it is also possible to react more quickly to changing market conditions. This has been identified as an important factor for success and the competitive advantage is predicted to increase as markets are predicted the change even quicker in the future.

6.2. Participatory design

While working on this study participatory design was used to create the software. By using participatory design, we were able to create a software fulfilling the needs of all employees. During this process we noticed other positive effects that are outside the scope of this study, but still relevant to discuss.

Since all the employees are included in the process, not just managers, they feel more like equals which had a very positive effects on attitudes towards the program. This positive attitude makes them more willing to use the system as well as to change their current work process. They felt that all changes in their current work process were the result of their own reflections, which they partly were, and therefor they were all positive to establishing a new way of working. The employees also gain knowledge about the MMIS and they understand the reasoning behind all the functions and the need for them to be used and followed.

When no MMIS is currently in use developers generally have a hard time. This is due to the magnitude of different solution when creating a MMIS for all employees within the production unit. More commonly a specification of requirements is formulated at the managerial level rather than involving all employees. These systems might be more difficult to use for employees since it might not resemble previously known work procedures and the functions in the system might be an inconvenience and disrupt the workflow. When developing a MMIS from scratch it is better to work with the actual users so it can fit into their work process and solve their actual problems and not the problems perceived by managers.

By using participatory designed the time and cost for implementing the software are reduced, this is mainly due to the fact that most employees already understand the software and they work well with current work processes. In our case, 10 out of 15 employees working in the flow team already understands the software and know how to use it. If problems using the software would arise for new users during the implementation a majority of the employees could help them.

6.3. Sources of error

While doing the interviews we noticed that there was a bit of inconsistency with the employees. During the first interview they could say: "*I don't lose any time"* and during the next interview they could state that they would save lots of hours by using the software. Since many of our questions might have regarded subject that they hadn't thought about their estimations could have been done on the spot giving an unclear view of how much time is wasted. During our process they might have thought about the actual time they lose by having to wait for specific information, therefore changing their view. A way to avoid this kind of inconsistency would be to send an information sheet to the interviews, a week before the interview, with instructions where they are told what to reflect over certain aspects.

In the section above we wrote about the positive effects of using participatory designs. However, this method of working can lead to a source of error. Some people have a hard time thinking in abstracts terms and because of that they don't know what to ask for when testing a prototype. They also had a hard time using the first prototype and didn't automatically see how the different functions were linked. This was also the reason for getting more functionality feedback on the second prototype than the first, the first prototype was probably too abstract for them and therefor they could not picture how it would actually work. We think that if the exact same study was conducted with the same employees you would get a software with other features due to their newfound knowledge about both MMIS and prototypes.

Since there is no current software for this function the employees/users were really excited. This is mostly positive due to the fact they were very cooperative, but the main drawback was that they might have missed a few details regarding functionality and visual design. They were all eager to say that they would gain extremely much from this system, and this eagerness might have overshadowed their constructive criticism.

7. Conclusion

The purpose of the study was to answer two scientific questions:

- Will well-defined strategies and processes for information and knowledge management lead to higher efficiency within a manufacturing unit?
- Is a specialized software a useful tool and how should it be designed to facilitate efficient information and knowledge management?

This study has shown that well-defined strategies and processes for information and knowledge management lead to higher efficiency within a manufacturing unit. In the case described in this study the goal of the strategies and processes can be divided into two parts. The first is to turn implicit into explicit knowledge. The second is to only have updated information available, thus reducing misunderstanding and making sure that all employees have the same information.

By using the specialized software tool it will be easier to facilitate efficient information and knowledge management. It can be concluded that it is a useful tool to use. Even though this software was developed especially for FLIR Systems AB, some generalized principles could be established when designing this kind of software:

- Use current tools, aid and processes when designing the software. Try to emulate or reuse them to increase recognition and learnability.
- Colors are a good tool for showing information, but the usage of them should be appropriate to avoid cluttered interfaces.
- Try to standardize the software as much as possible. This minimizes developmental effort and creates a common context for employees.
- The software should establish and encourage best practice of work procedures
- The perception of transparency on all levels so that people feel included
- The software should be developed in way that all actions can be documented
- Limit the amount of information available to that which is necessary for the users to perform their tasks and no more.

It should be noted that in order to implement a new process or procedure the employees need to be on terms with it. It has been shown in this study that using participatory design has had that effect. All employees showed great enthusiasm for the idea that the software were to be implemented and used on a larger scale.

7.1. Recommendation

Today there are many opportunities on how to streamline the production at FLIR Systems AB. Our results are beneficial to FLIR but the software needs to be implemented for maximum benefit. It can be concluded is that they need a MMIS. We recommend that FLIR does a pilot study implementing and testing the complete software in one production unit. They would evaluate the time and cost to create the backend of the software and how to implement it into the production unit today. Since a majority of the flow team already knows how to use our software it would be beneficial for FLIR to use the software designed by us, rather than designing a new one.

Lastly for the sake of limiting the workload this study was limited to a single production unit and some roles there within. For maximum utility it is probably appropriate to include more roles and unit in the network created by the software.

Bibliography

Al-Mamary, Yaser Hasan, Alina Shamsuddin & Nor Aziati, *The Impact of Management Information Systems Adoption in Managerial Decision Making*, 2013, Management information systems volume 8.

Artit Kornkaew, *Management Information System Implementation Challenges, Success Key Issues, Effects and Consequences*, 2012, Jönköpings universitet.

Astrid von Euler-Chelpin, *Information modelling for the manufacturing system life cycle*, 2008, Kungliga tekniska högskolan.

Boaz Ronen & Shimeon Pass, *Manufacturing Management information systems require simplification*, 1992, Industrial engineering 53.

Conference board, *Hourly compensation costs in manufacturing, US Dollars, 2010 and 2013*, 2013.

Dahai Liu, Wei-Song Tan & Ram Bishu, *Web evaluation: Heuristic evaluation vs user testing,* 2009, International Journal of Industrial Ergonomics.

David Benyon, *Designing Interactive Systems: A comprehensive guide to HCI and interaction design,* vol 2, 2010, Pearson Education.

Elizabeth Kremp & Jacques Mairesse, *Knowledge management in the manufacturing industry*, 2002, Ministère de l'Economie, des Finances et de l'Industrie.

Helen Sharp, Jenny Preece & Yvonne Rogers, *Interaction Design: Beyound human-computer interaction,* 3rd edition, 2011, John Wiley & Sons Inc.

Jakob Nielsen, *10 Usability Heuristics for User Interface Design,* 1995a, Nielsen Norman Group.

Jakob Nielsen, *How to Conduct a Heuristic Evaluation,* 1995b, Nielsen Norman Group.

Jakob Nielsen & Victoria L. Phillips, *Estimating the relative usability of two interfaces: heuristic, formal, and empirical methods compared,* 1993, CHI '93 Conference.

Ji Jong Park, *Interactive user experience design: creating an effective online experience,* 2007, Swinburne University of Technology.

John Maleyeff, *Exploration of internal service systems using lean principles,* 2006, Rensselaer Polytechnic Institute.

Michel Beaudouin-Lafon & Wendy Mackay, *Prototyping tools and techniques*, 2002, The human-computer interaction handbook, pages 1006-103.

Michael E. D. Koenig, *What is KM? Knowledge management explained*, 2012, KMworld.

The Economist Inteligence Unit (TIU), *Knowledge management in manufacturing*, 2007.

Thomas H Davenport, Saving IT's Soul: Human Centered Information Management ,1994, Harvard Business Review

Appendix A: Pre-study interview questions

Current situation: Here the goal is to identify how the work environment and above all the flow of information is today.

1. What information do you have regarding a camera individual in production?
2. How are new working methods and procedures handled?
3. Is there a template to introduce new procedures?
4. How good is the flow team at sharing information flow within
    a. Your own positions?
    b. The ones working on your level (production or administration)?
    c. The other level?

Weaknesses: What information and knowledge do you think is missing at present.

5. What information do you ask for? (Information you need)
6. What information do you feel is missing? (Information you want)
7. Does the same mistake occur more than once?
8. When you lack information, or do not know what to do, how much time will it take before it problem is solved?
9. How much time do you lose due to lack of information?
10. Can you describe one or more situations where, because of a lack of information, something went wrong?

Production Environment:

11. If you were to describe the "production flow" how would it look? (Drawing on paper)
12. Are there any parts in the production flow where bottleneck occur?
    a. Why?
13. Do you think it is easy to see and understand how the production flow is structured?
    a. Why / why not

Information flow:

14. Can you draw up the information flow works appear in the company?
15. How should the information flow change/improve? *
    a. Why?
16. What information do you think the other positions need?
    a. Why?

Appendix B: Final evaluation interview questions

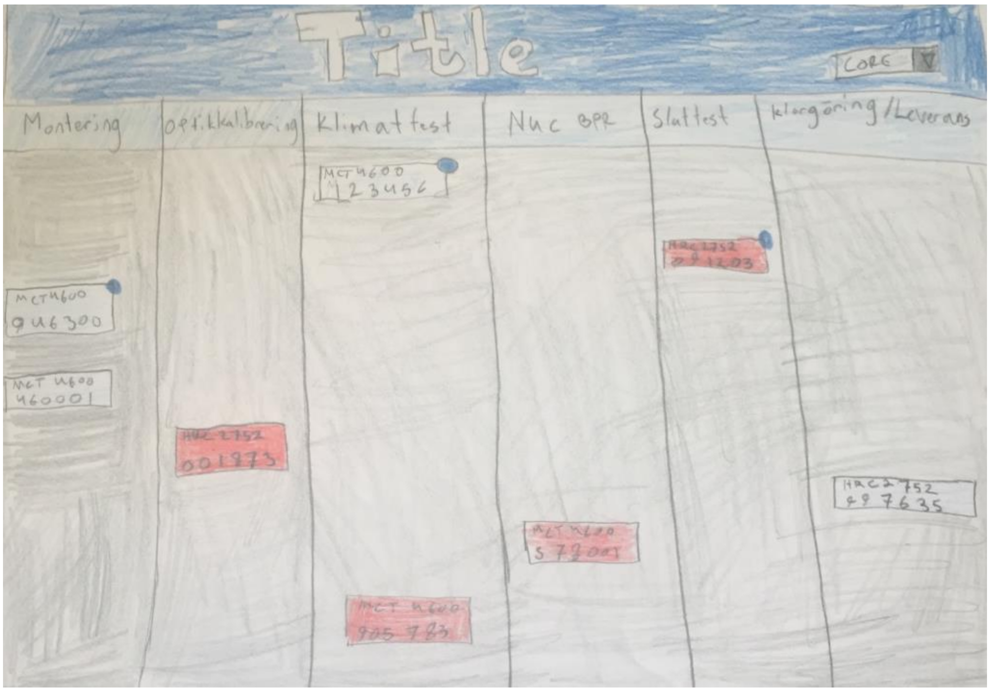
1. How much time would this system save?
2. Would the system be an asset?
    a. For you?
    b. For FLIR?
3. Do you get the information you need?
    a. If no, what do you need?
4. Is the system easy to use?
5. Would problems get fixed faster?
    a. Why?
6. How would the system affect the communication?
7. Which function is your favorite?
    a. Why?
8. Which function isn't necessary?
9. Would this system and work procedure establish how to work?

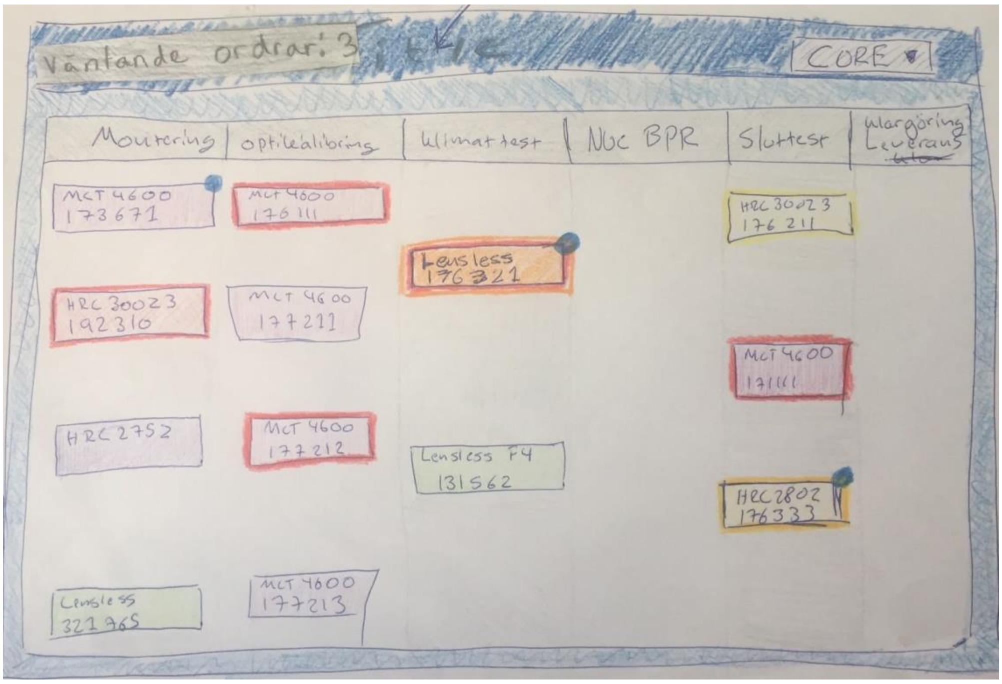
Appendix C: Interview answers

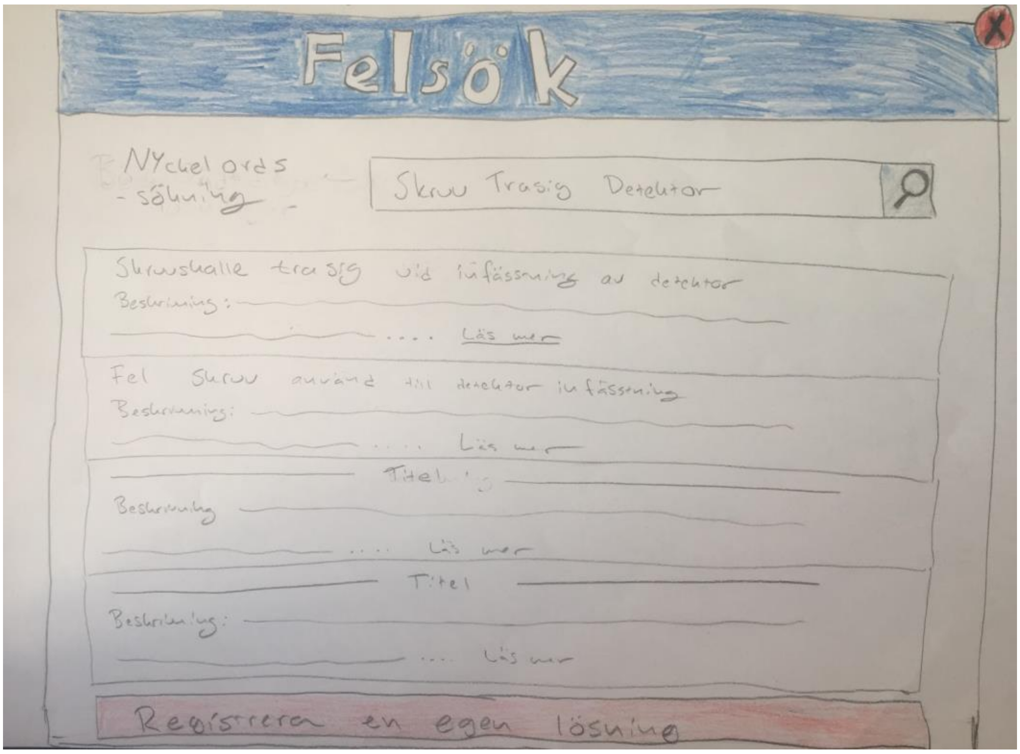
	Person 1	Person 2	Person 3	Person 4	Person 5
Is there a template to introduce new procedures?	Yes, but it isn't followed.	No	Yes, but it isn't followed.	No	No
What information do you need		An overview of the cameras in production and detailed information on cameras in production.	An overview of the cameras in production and available resources.	Dates regarding expected worktime time and status on cameras	Type och camera and detailed information
What information do you want	Information regarding stops in productions and efficiency of employees		Mistakes in production	Technical problems	Priority and computerising orders
Estimated time loss due to lack of communication	Loss of efficiency when changing task, but can not estimate any time loss.	1h/day	Can take time to get answers, but no real time is "lost"	None, the employee changes task.	No real time loss
Does the same misstake occur more than once?	Yes	Yes	Yes	Yes	Yes
Communication		No systematic errors in communication, but problems exist at with certain individuals.	Can sometimes get useless information.	Information hoarder exists	
Other	New procedures does not reach the production team.	Details of the production is only the employees mind (no documentation)	Sometimes they do nothing within the production team because they can not be bothered to look for info		It feels like the planners/chief keep information to themselves.

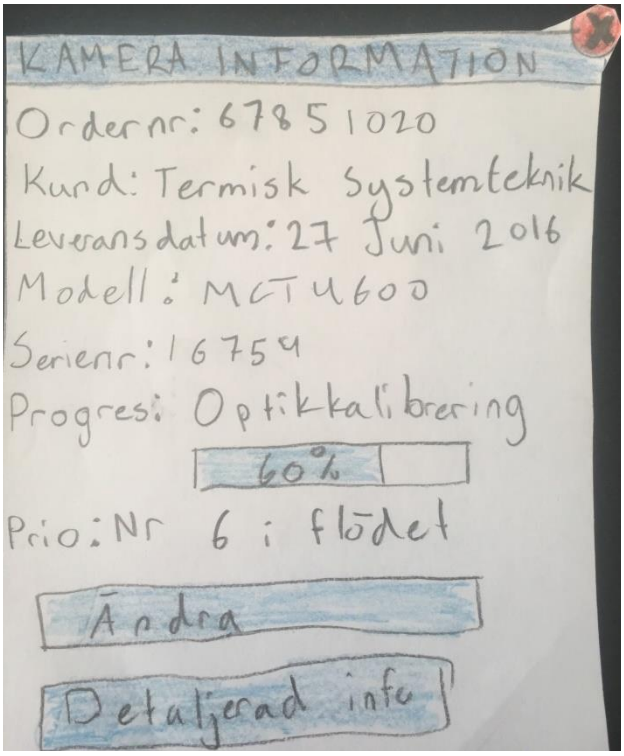
	Person 6	Person 7	Person 8	Person 9	Person 10
Is there a template to introduce new procedures?	No	No	Not really, it's shared orally and by email.	No	No
What information do you need		Priority, status of cameras and how to fix camera when certain errors occur.	Logs containing camera and priority of cameras.	Status on camera	Priority and parts for the camera.
What information do you want	Customer and sales order	When material is in storage	Are the cameras pre-payments	Priority and shipping date	Overview
Estimated time loss due to lack of communication	10-30min/day or 1 camera/week		2-3h/week	At least 1h/week	A few minutes per week
Does the same misstake occur more than once?	Yes	Yes	Yes	Yes	Yes
Communication	Do not know what happens with the communication after they ask for help. No error	No systematic errors in communication, but problems exist at with certain individuals.	Communication works generally good (though lacking documentation), think that everyone should		Have to chase people in development. Within production it takes a while before they change the
Other		As long as it works, everything is fine, but once problems occurs, they wonder how they will proceed.	A searchable errorlog would be good		

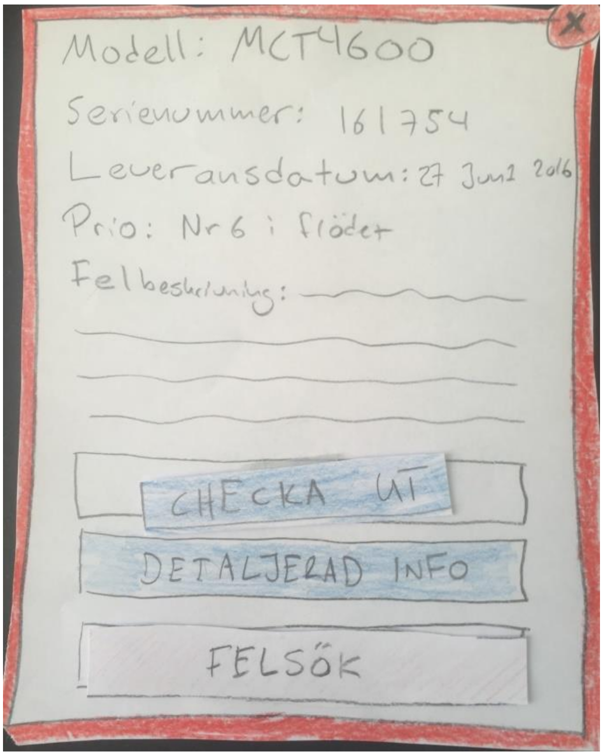
Appendix D: The first prototype

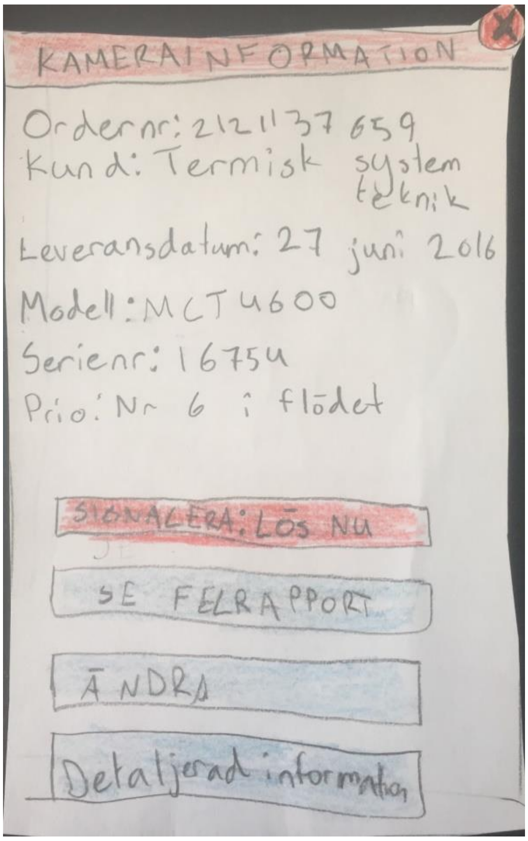


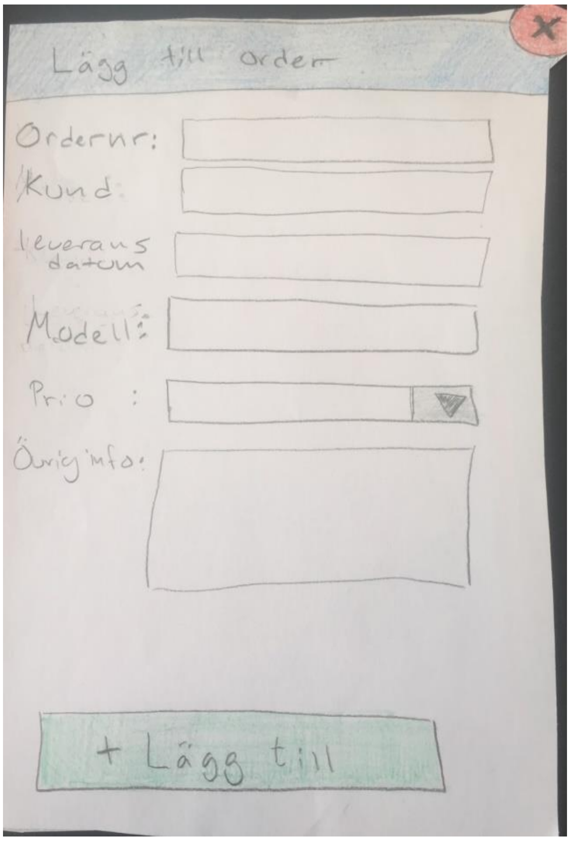


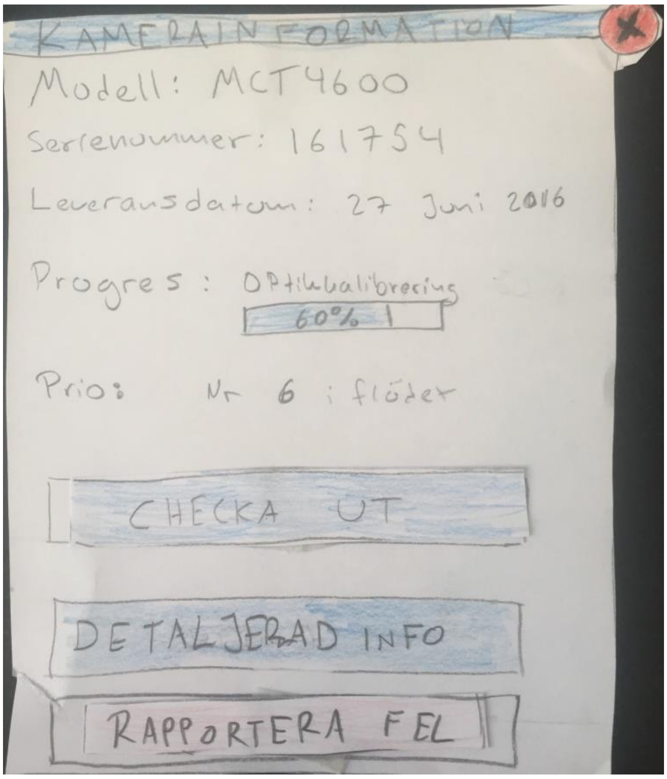

Felsök
Nyckelords-sökning
Skruv Trasig Detektor
Skruvskalle trasig vid infästning av detektor
Beskrivning:
.... Läs mer
Fel skruv använd till detektor infästning
Beskrivning:
.... Läs mer
Titel
Beskrivning
.... Läs mer
Titel
Beskrivning:
.... Läs mer
Registrera en egen lösning


KAMERA INFORMATION
Ordernr: 67851020
Kund: Termisk Systemteknik
Leveransdatum: 27 Juni 2016
Modell: MCT4600
Serienr: 16754
Progres: Optikkalibrering
60%
Prio: Nr 6 i flödet
Ändra
Detaljerad info


Modell: MCT4600
Serienummer: 161754
Leveransdatum: 27 Juni 2016
Prio: Nr 6 i flödet
Felbeskrivning:
CHECKA UT
DETALJERAD INFO
FELSÖK


KAMERAINFORMATION
Ordernr: 2121137659
Kund: Termisk system teknik
Leveransdatum: 27 juni 2016
Modell: MCT4600
Serienr: 16754
Prio: Nr 6 i flödet
SIGNALERA: LÖS NU
SE FELRAPPORT
ÄNDRA
Detaljerad information

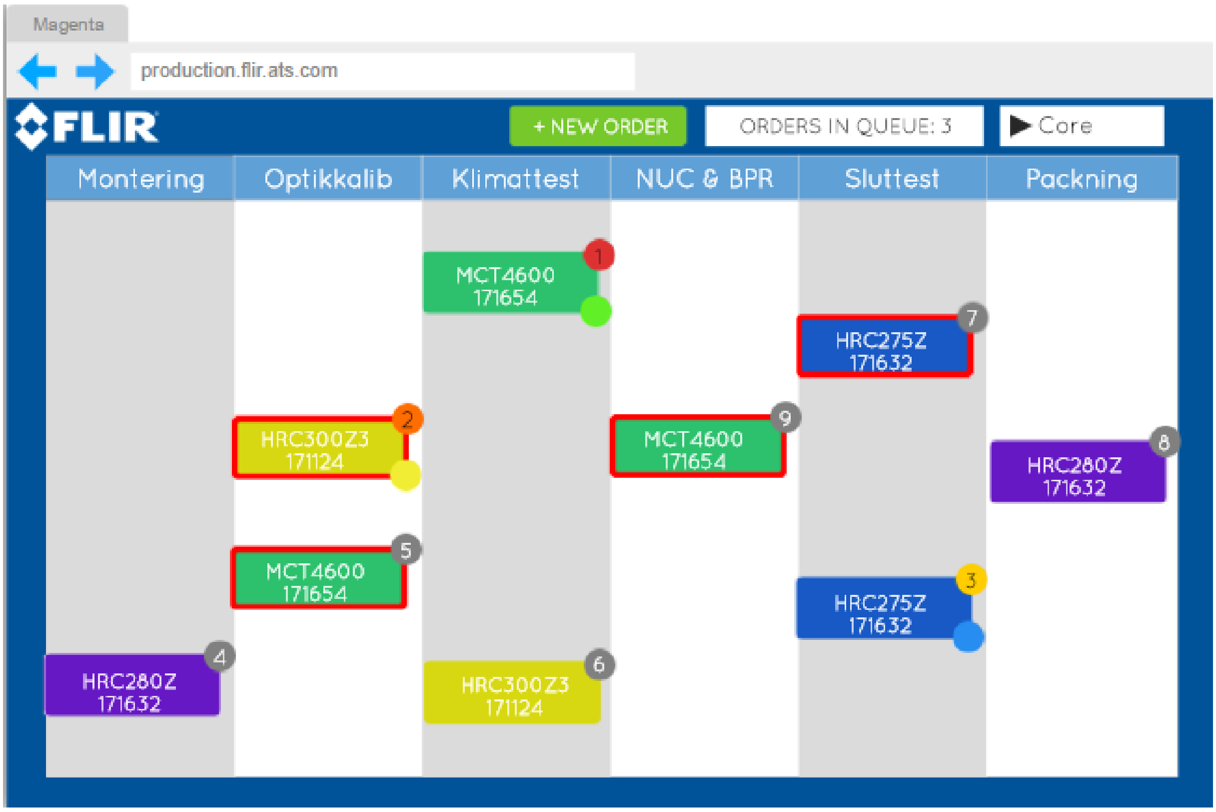

Lägg till order
Ordernr:
Kund:
Leverans datum
Modell:
Prio :
Övrig info:
+ Lägg till


KAMERAINFORMATION
Modell: MCT4600
Serienummer: 161754
Leveransdatum: 27 Juni 2016
Progres: Optikkalibrering
60%
Prio: Nr 6 i flödet
CHECKA UT
DETALJERAD INFO
RAPPORTERA FEL

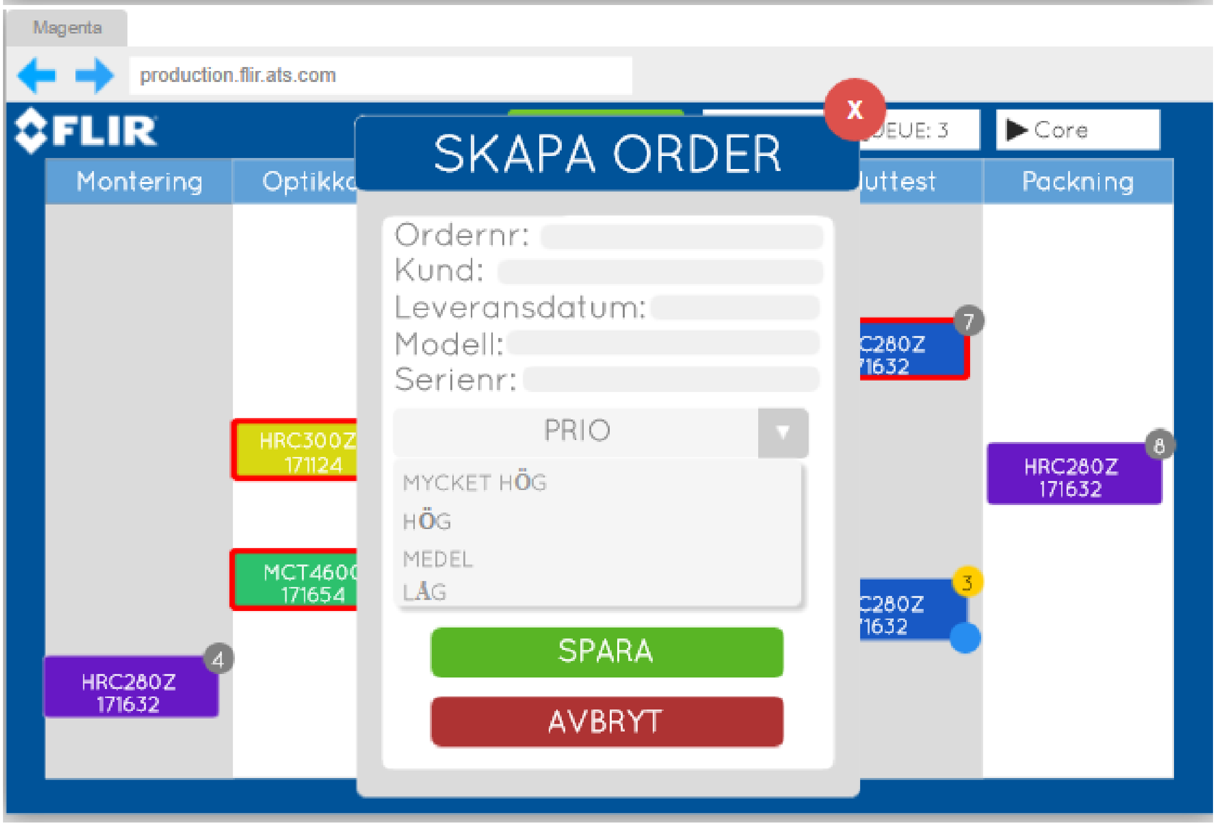
Appendix E: Answer to DECIDE questions in section 5.1.5

	Person 1	Person 2	Person 3	Person 4	Person 5	Person 6	Person 7
Are employees open to the idea of a knowledge database?	N/A	N/A	YES	YES	Yes, but it would probably be hard to write articels from the start	YES	Yes, concerned that people might not use the database.
Would the employees benefit from the knowledge database?	N/A	N/A	Yes, described by employee as somehting very useful to have.	Yes, would be very good so that all knowledge doesn't dissappear	Yes, useful to check amongst prevouis solutions to problems.	Yes, it would be very useful	Yes it would granted that the search function is effective.
Would this resolve the problem attributed to shortcomings related to knowledge management?	N/A	N/A	This would solve the problem with having to find the solution every time a problem occurs. It will not help to log how often errors occurs.	It would be helpful	Yes, repeatedly having to find a solution to the same problem is common. Well be very good and save time.	It will definitly be an improvement, it should however also be possible to log and see how often problems occur.	Yes it has the potential to do this. However search must be exact, it must be easy to use and quick if people are to use it.
Which of the two production overview designs does the user feels gives them the best informational overview?	The more complex design using color to provide inforamtion	The more complex design using color to provide inforamtion	The more complex design using color to provide inforamtion	The more complex design using color to provide inforamtion	The more complex design using color to provide inforamtion	The more complex design using color to provide inforamtion	The more complex design using color to provide inforamtion
Do they get the information they need from the prototype?	YES	Mostly, esspecially useful that it is current info. Would be good with responsibility for every camera.	YES	YES	YES, the information usually needed is there	Partly, would like to see more statistics off errors occuring in production	YES
Are the functions needed present?	YES, Can not imagine any more that is needed	Mostly, would be good to be able to send messages to production.	Mostly, a function to registrer diffrent fault and solutions would be good.	YES	YES	Mostly, function to encourage best practies during troubleshooting would be good. Also history on trobuleshooting	YES, but they can be refined. For example making search easier.
Is it easy to learn how to use the software?	YES	YES	YES	YES	YES	YES	YES
Can something be improved to make the software easier to use?	-	Could change how priortiy is displayed	NO	NO	NO	Improve troubleshooting and search	Improve troubleshooting and search

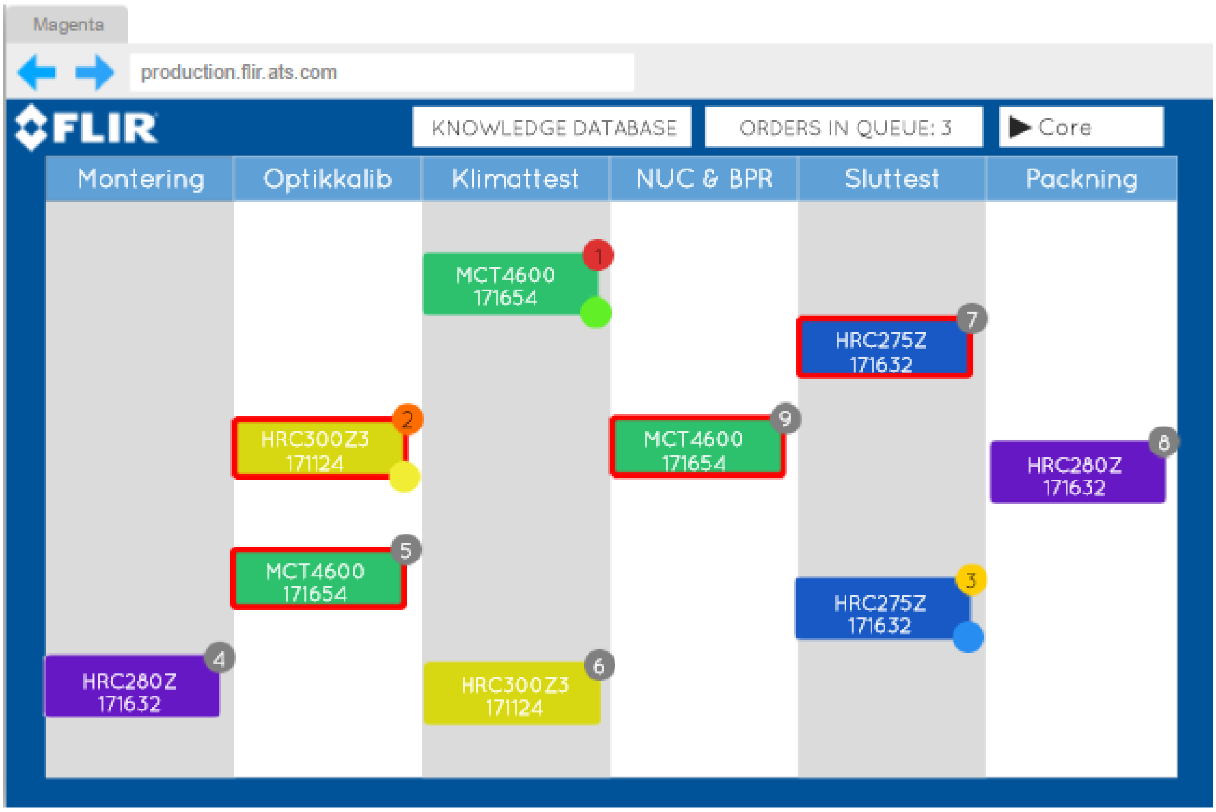
Appendix F: Second prototype

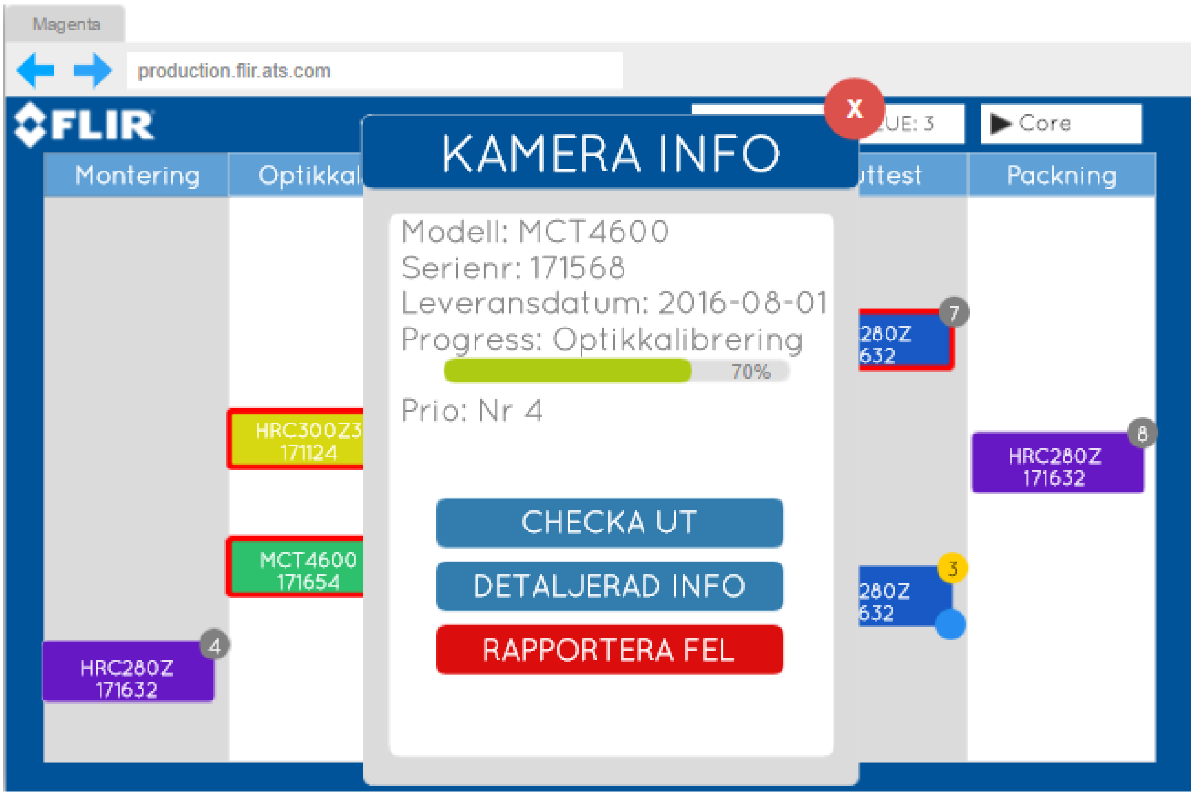


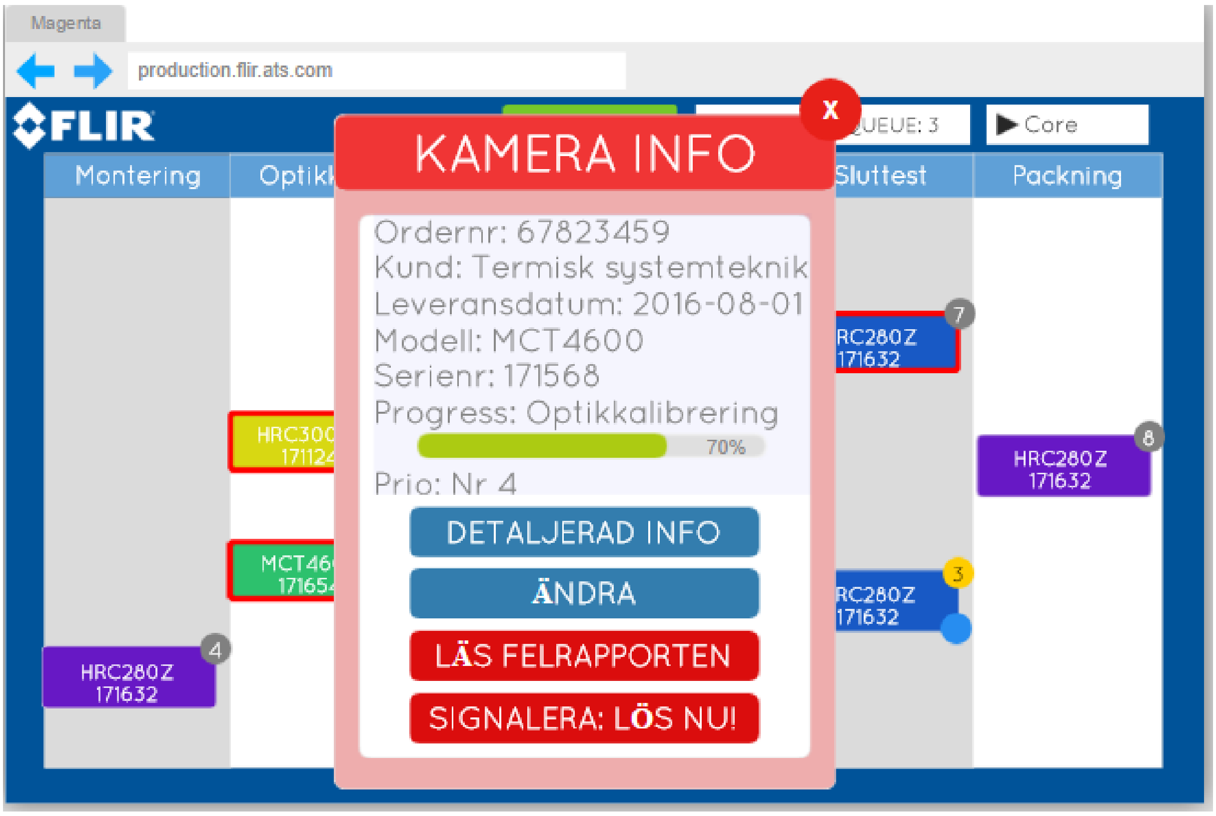

Magenta
production.flir.ats.com
FLIR
Montering
Sluttest
Packning
Core
KAMERA INFO
Ordernr: 67823459
Kund: Termisk systemteknik
Leveransdatum: 2016-08-01
Modell: MCT4600
Serienr: 171568
Progress: Optikkalibrering
70%
Prio: Nr 4
DETALJERAD INFO
ÄNDRA
LÄS FELRAPPORTEN
SIGNALERA: LÖS NU!
HRC280Z
171632


Magenta
production.flir.ats.com
FLIR
Montering
Packning
Core
SKAPA ORDER
Ordernr:
Kund:
Leveransdatum:
Modell:
Serienr:
PRIO
MYCKET HÖG
HÖG
MEDEL
LÅG
SPARA
AVBRYT
HRC300Z
171124
HRC280Z
171632


Magenta
production.flir.ats.com
FLIR
Core
Montering
Optikkal
ttest
Packning
ÄNDRA ORDER
Ordernr: 171859654
Kund: 171859654
Leveransdatum: 171859654
Modell: MCT4600
Serienr: 171458
PRIO
MYCKET HÖG
HÖG
MEDEL
LÅG
SPARA
AVBRYT
HRC300Z3
171124
MCT4600
171654
HRC280Z
171632
HRC280Z
171632

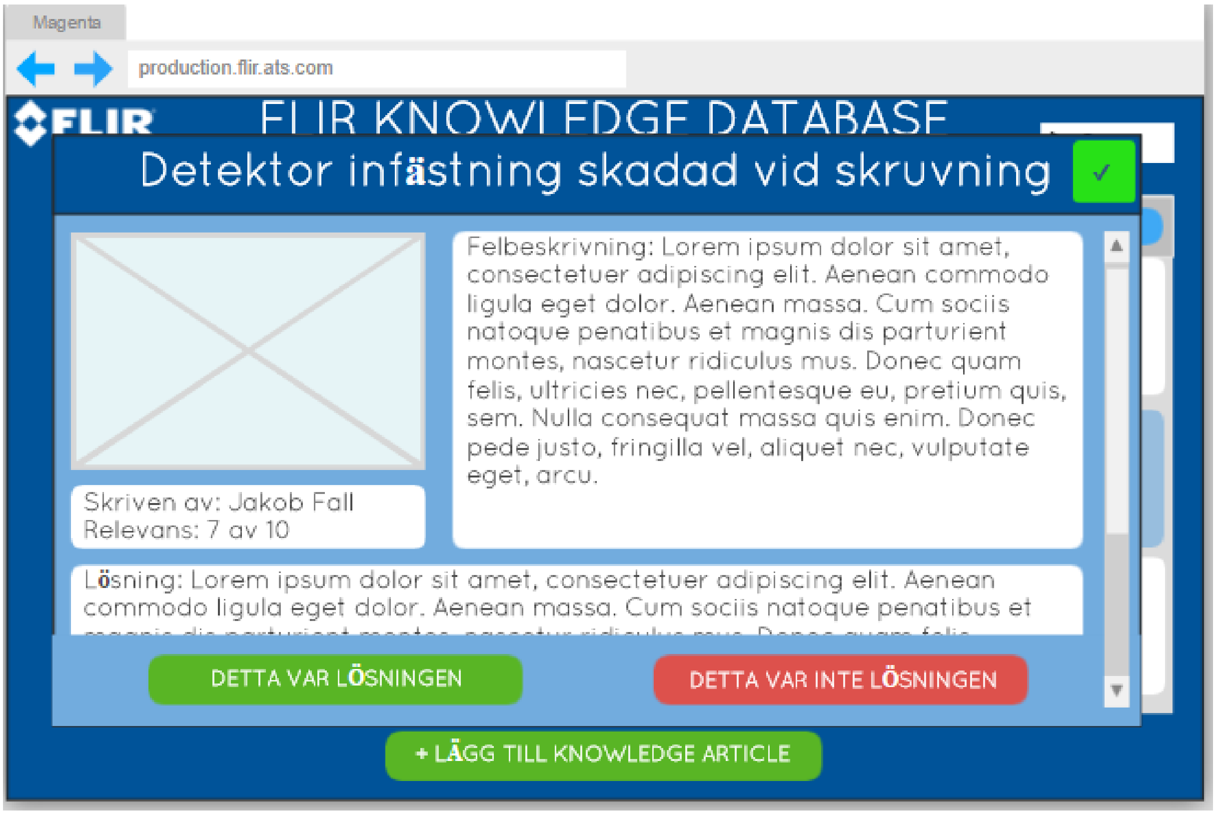

Magenta
production.flir.ats.com
FLIR
KNOWLEDGE DATABASE
ORDERS IN QUEUE: 3
Core
Montering
Optikkalib
Klimattest
NUC & BPR
Sluttest
Packning
MCT4600
171654
HRC275Z
171632
HRC300Z3
171124
MCT4600
171654
HRC280Z
171632
MCT4600
171654
HRC275Z
171632
HRC280Z
171632
HRC300Z3
171124


Magenta
production.flir.ats.com
FLIR
Core
Montering
Optikkal
ttest
Packning
KAMERA INFO
Modell: MCT4600
Serienr: 171568
Leveransdatum: 2016-08-01
Progress: Optikkalibrering
70%
Prio: Nr 4
CHECKA UT
DETALJERAD INFO
RAPPORTERA FEL
HRC300Z3
171124
MCT4600
171654
HRC280Z
171632
HRC280Z
171632


Magenta
production.flir.ats.com
FLIR
QUEUE: 3
Core
Montering
Sluttest
Packning
KAMERA INFO
Ordernr: 67823459
Kund: Termisk systemteknik
Leveransdatum: 2016-08-01
Modell: MCT4600
Serienr: 171568
Progress: Optikkalibrering
70%
Prio: Nr 4
DETALJERAD INFO
ÄNDRA
LÄS FELRAPPORTEN
SIGNALERA: LÖS NU!
HRC280Z
171632
HRC280Z
171632

Magenta
production.flir.ats.com
FLIR
ORDERS IN QUEUE: 3
Core
Montering
Optikkalib
Klimattest
NUC & BPR
est
Packning
X
NYA ORDRAR
Ordernr: 674293459
Modell: MCT4600
Leveransdatum: 2016-08-01
GENERERA SERIENR
Ordernr: 674293745
Modell: MCT4600
Leveransdatum: 2016-08-22
GENERERA SERIENR
Ordernr: 674293745
Modell: MCT4600
Leveransdatum: 2016-08-22
GENERERA SERIENR
HRC300Z3
171124
MCT4600
171654
HRC280Z
171632
HRC280Z
171632

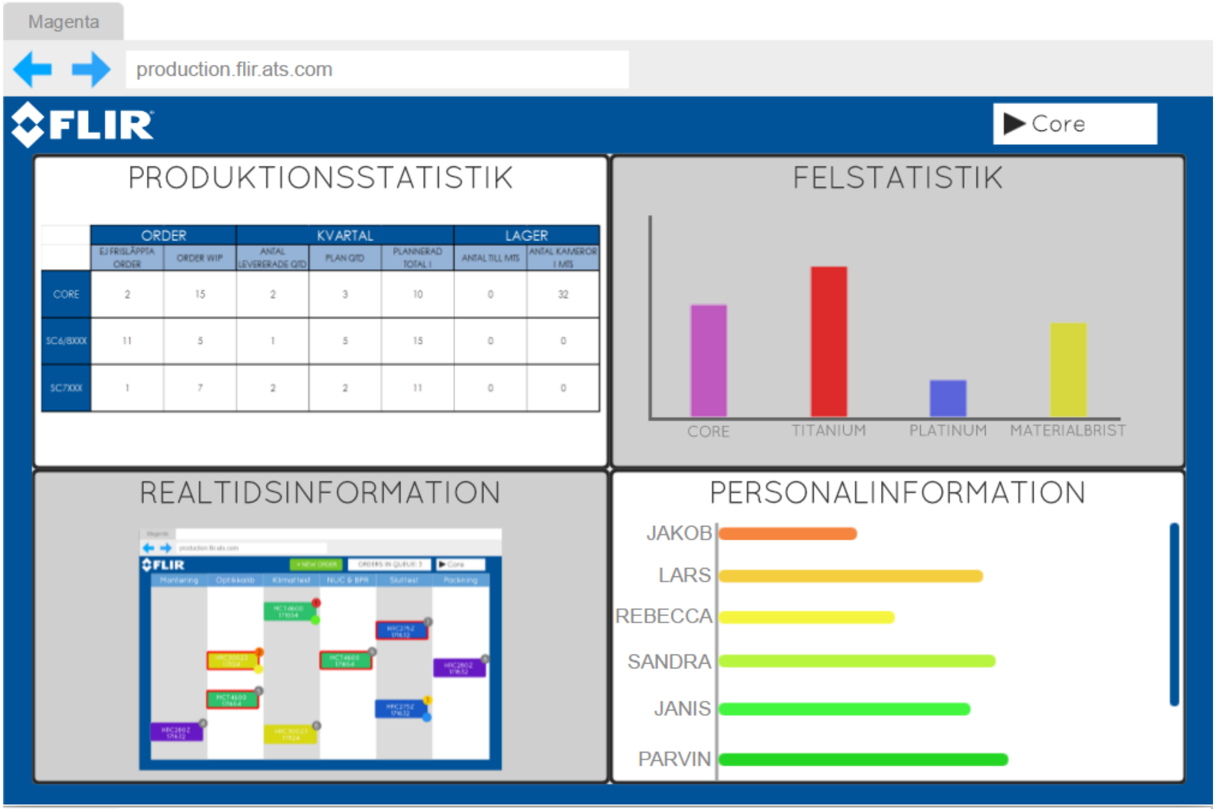
Magenta
production.flir.ats.com
FLIR
FLIR KNOWLEDGE DATABASE
Knowledge article search
Core
Skruv detektor trasig
SEARCH
Detektor infästning skadad vid skruvning
Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Aenean commodo ligula eget dolor. Aenean massa. Cum sociis natoque penatibus....
DETALJER
Detektor infästning skadad vid skruvning
Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Aenean commodo ligula eget dolor. Aenean massa. Cum sociis natoque penatibus....
DETALJER
Detektor infästning skadad vid skruvning
Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Aenean commodo ligula eget dolor. Aenean massa. Cum sociis natoque penatibus....
DETALJER
+ LÄGG TILL KNOWLEDGE ARTICLE
ADMINISTRERA

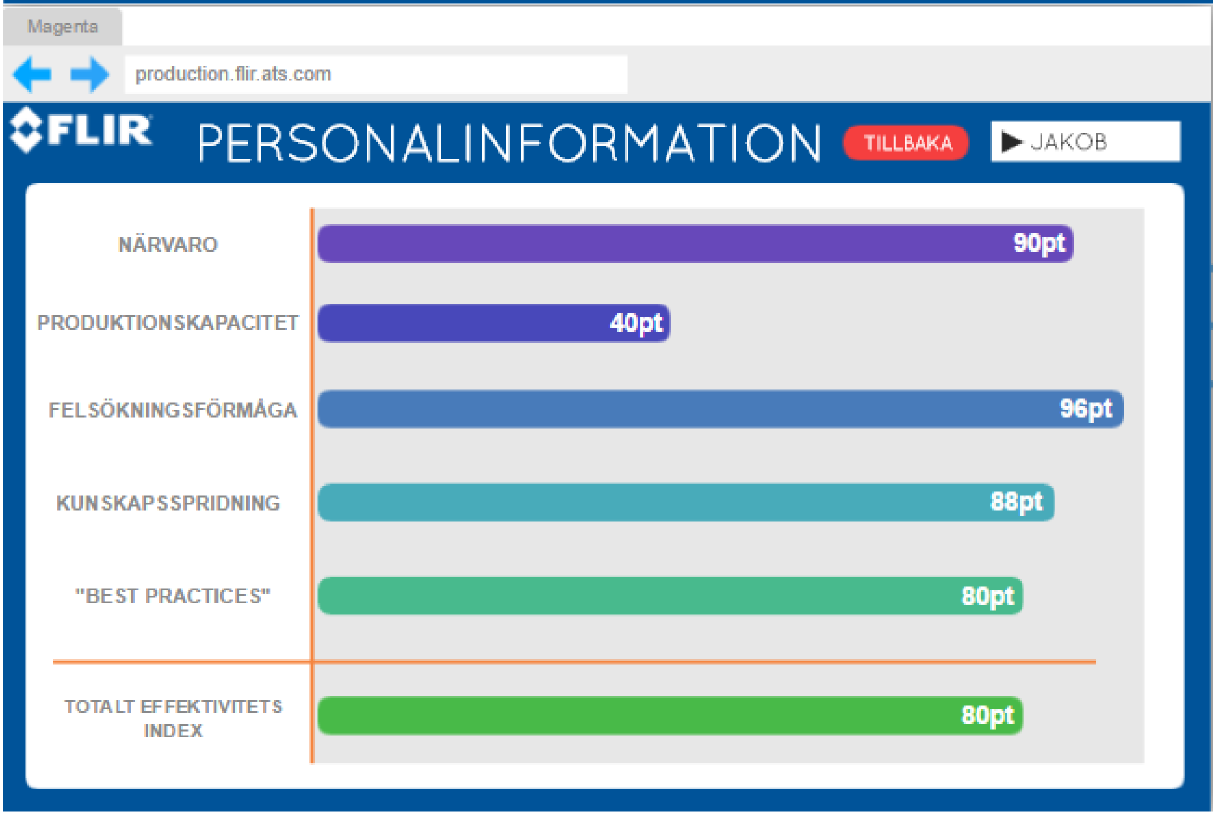

Magenta
production.flir.ats.com
FLIR
FLIR KNOWLEDGE DATABASE
Detektor infästning skadad vid skruvning
Felbeskrivning: Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Aenean commodo ligula eget dolor. Aenean massa. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Donec quam felis, ultricies nec, pellentesque eu, pretium quis, sem. Nulla consequat massa quis enim. Donec pede justo, fringilla vel, aliquet nec, vulputate eget, arcu.
Skriven av: Jakob Fall
Relevans: 7 av 10
Lösning: Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Aenean commodo ligula eget dolor. Aenean massa. Cum sociis natoque penatibus et
DETTA VAR LÖSNINGEN
DETTA VAR INTE LÖSNINGEN
+ LÄGG TILL KNOWLEDGE ARTICLE

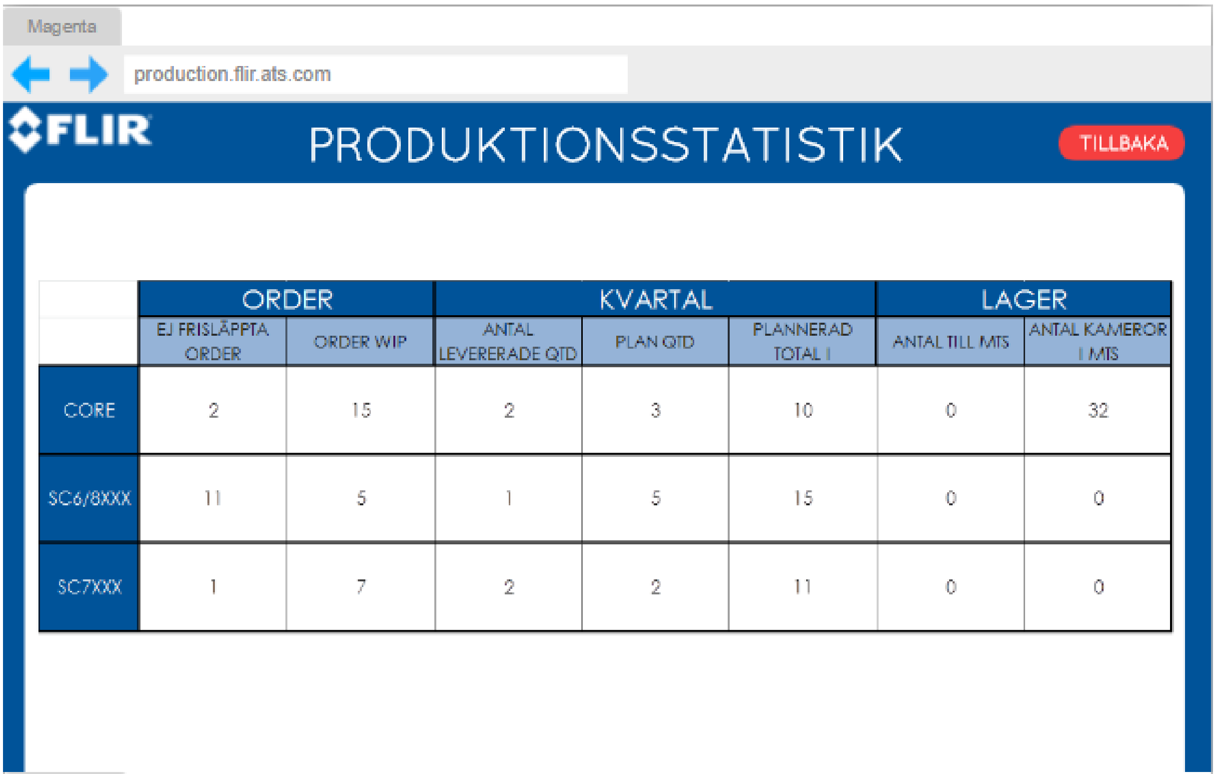
Appendix G: Answers to DECIDE questions in section 5.2.3

	Person 1	Person 2	Person 3	Person 4	Person 5	Person 6
Is it easy to understand the color coding and the rest of the design?	Yes	Yes	Yes	Yes, but might be too many different colors	Yes	Yes
Is the linking between the different views logical and understandable?	Yes	Yes	Yes	Yes	Yes	Yes
Are the buttons and other elements used for navigation easy to use and understand?	Yes	Yes	Yes	Yes	Yes	Yes
Is the system easy to use?	Yes	Yes	Yes	Yes	Yes	Yes

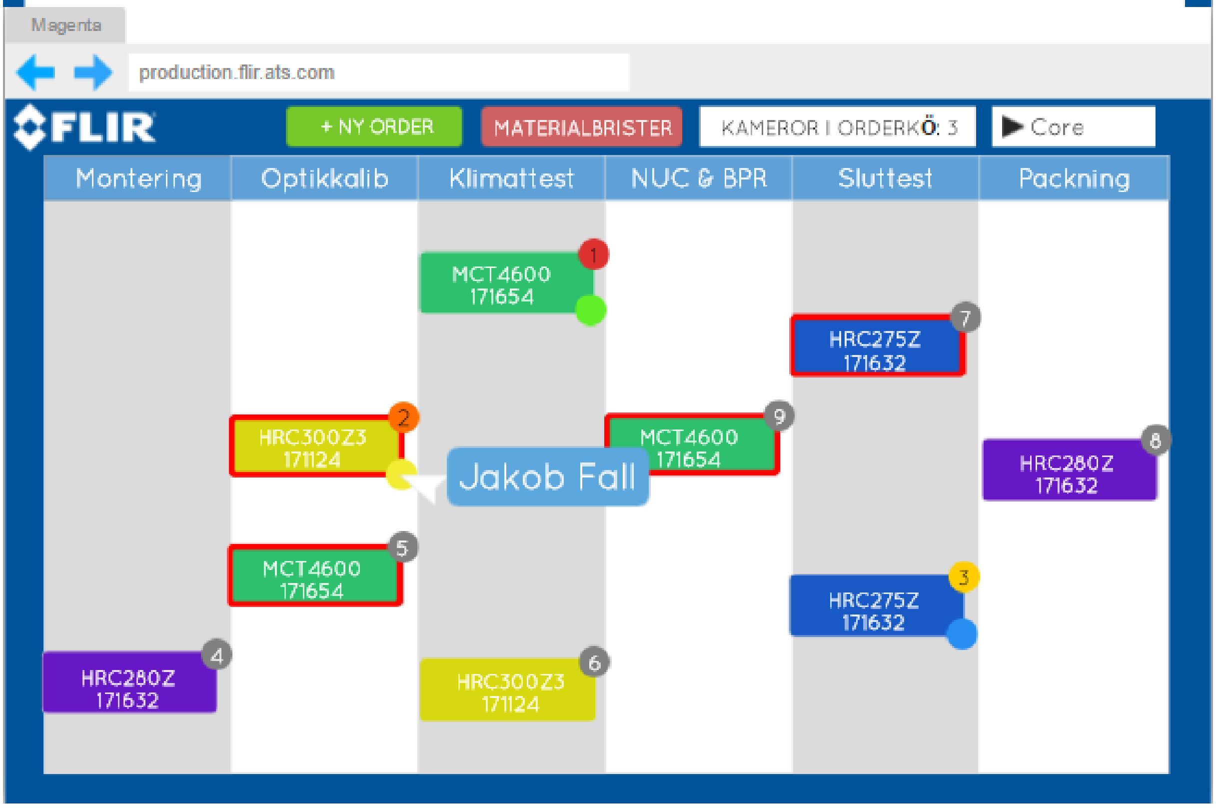
Appendix H: Third prototype

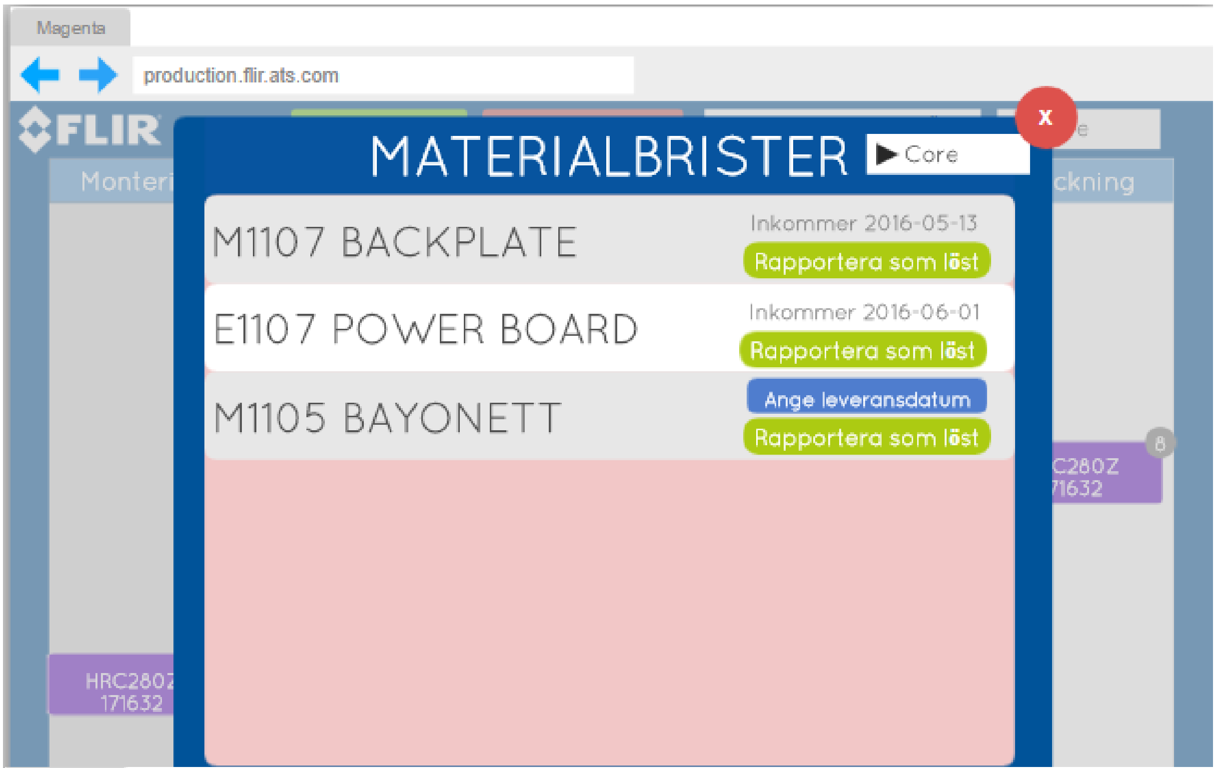


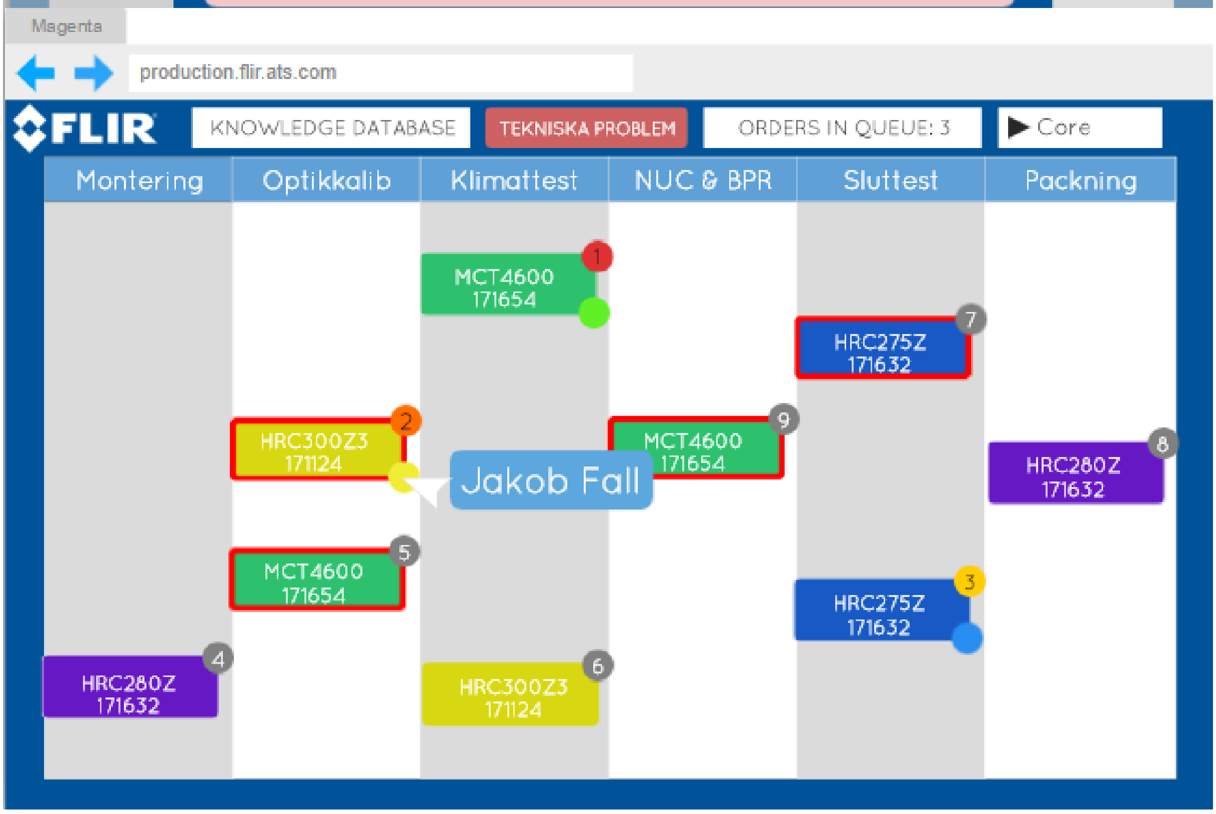


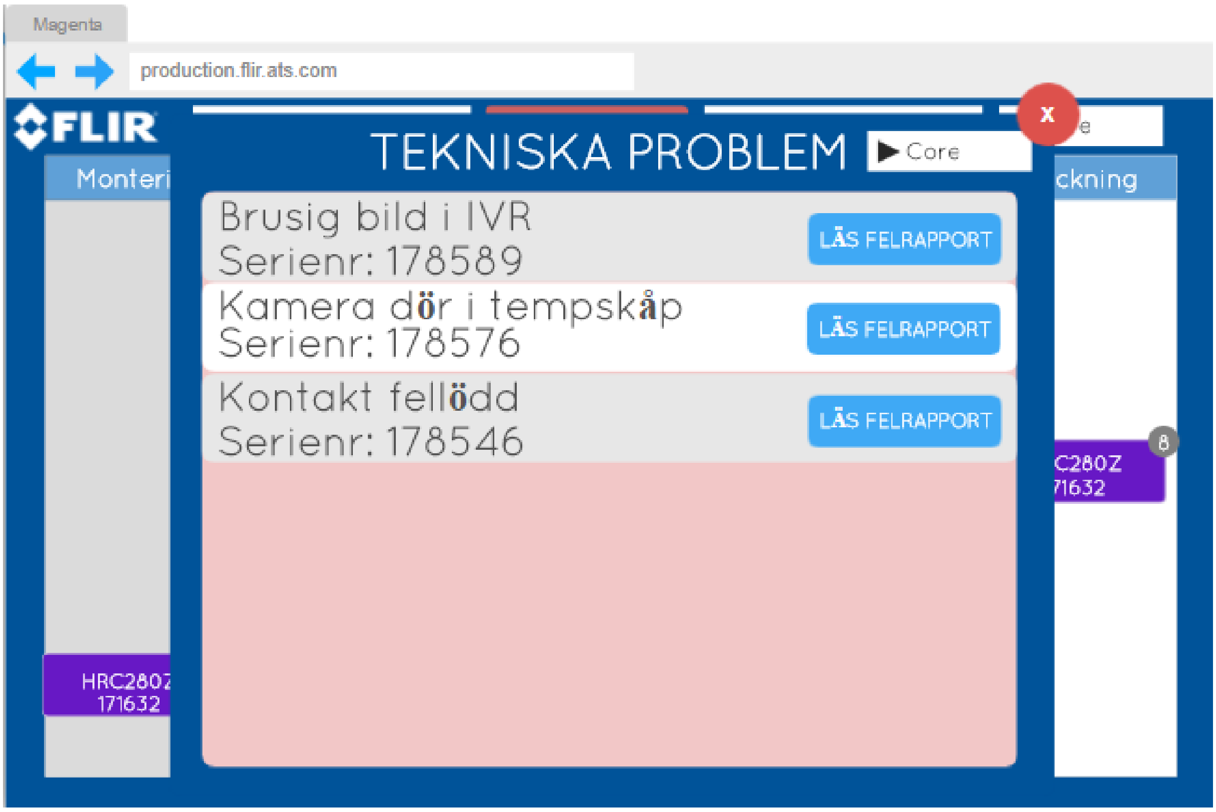


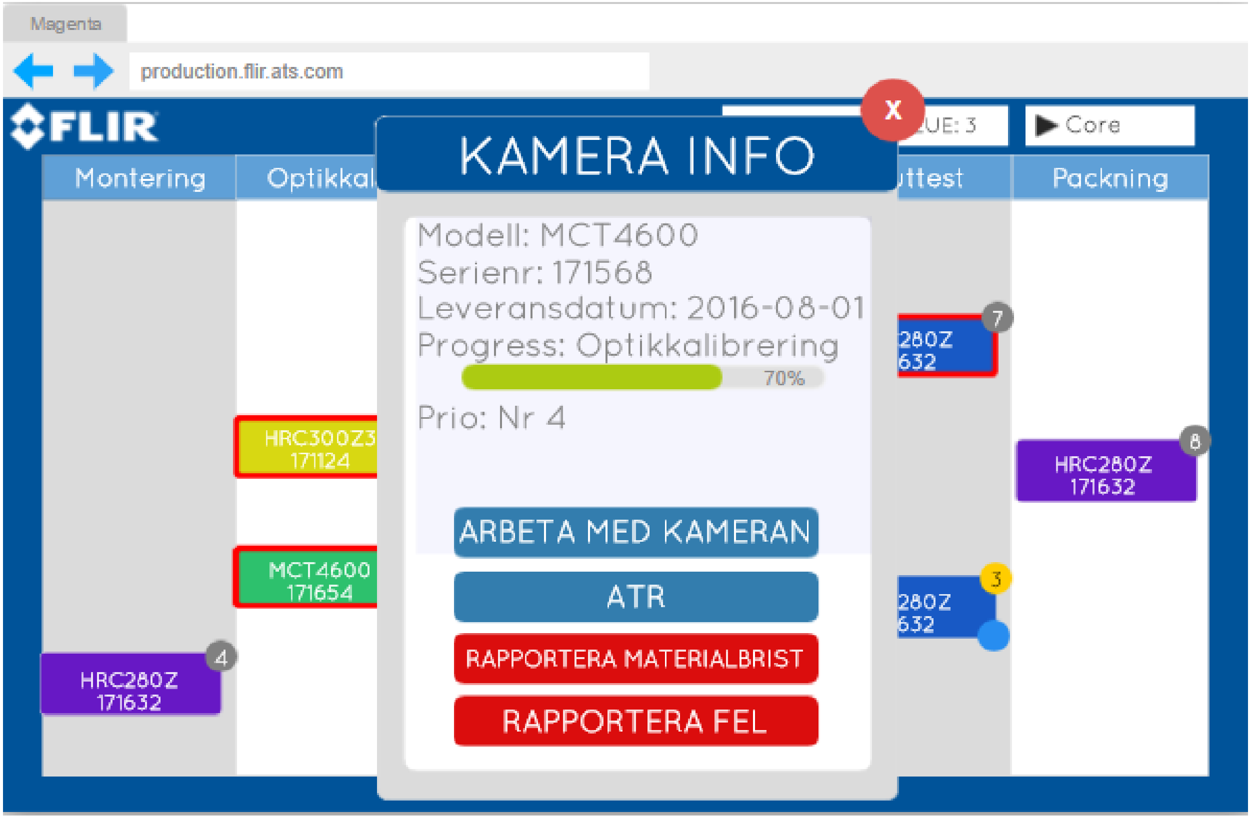
	ORDER		KVARTAL			LAGER	
	EJ FRISLÄPPTA ORDER	ORDER WIP	ANTAL LEVERERADE QTD	PLAN QTD	PLANNERAD TOTAL I	ANTAL TILL MTS	ANTAL KAMEROR I MTS
CORE	2	15	2	3	10	0	32
SC6/8XXX	11	5	1	5	15	0	0
SC7XXX	1	7	2	2	11	0	0

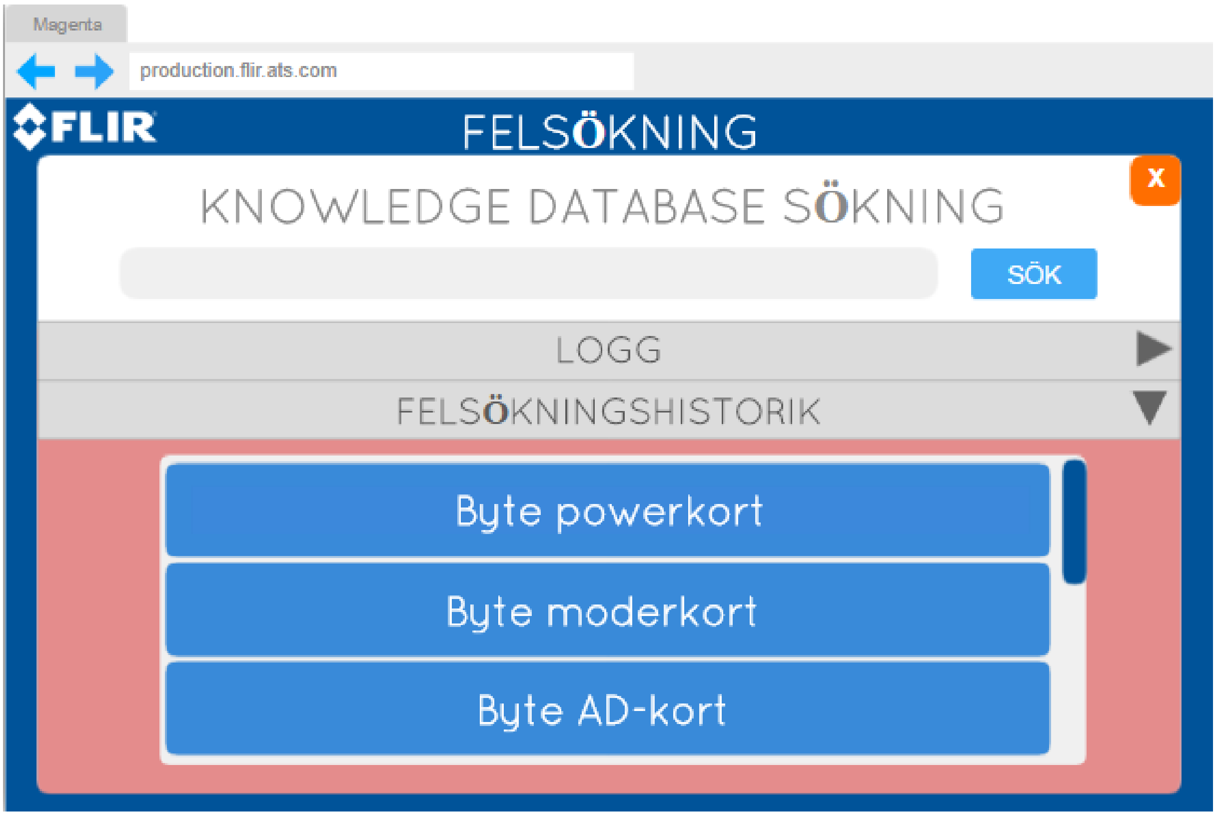



Magenta
production.flir.ats.com
FLIR
MATERIALBRISTER
▶ Core
x
M1107 BACKPLATE
Inkommer 2016-05-13
Rapportera som löst
E1107 POWER BOARD
Inkommer 2016-06-01
Rapportera som löst
M1105 BAYONETT
Ange leveransdatum
Rapportera som löst


Magenta
production.flir.ats.com
FLIR
KNOWLEDGE DATABASE
TEKNISKA PROBLEM
ORDERS IN QUEUE: 3
▶ Core
Montering
Optikkalib
Klimattest
NUC & BPR
Sluttest
Packning
MCT4600 171654
HRC275Z 171632
HRC300Z3 171124
MCT4600 171654
Jakob Fall
HRC280Z 171632
MCT4600 171654
HRC275Z 171632
HRC280Z 171632
HRC300Z3 171124


Magenta
production.flir.ats.com
FLIR
TEKNISKA PROBLEM
▶ Core
Brusig bild i IVR
Serienr: 178589
LÄS FELRAPPORT
Kamera dör i tempskåp
Serienr: 178576
LÄS FELRAPPORT
Kontakt fellödd
Serienr: 178546
LÄS FELRAPPORT


Magenta
production.flir.ats.com
FLIR
KAMERA INFO
▶ Core
Montering
Optikkal
Packning
Modell: MCT4600
Serienr: 171568
Leveransdatum: 2016-08-01
Progress: Optikkalibrering
70%
Prio: Nr 4
ARBETA MED KAMERAN
ATR
RAPPORTERA MATERIALBRIST
RAPPORTERA FEL
HRC280Z
171632
HRC280Z
171632


Magenta
production.flir.ats.com
FLIR
FELSÖKNING
KNOWLEDGE DATABASE SÖKNING
X
SÖK
LOGG
FELSÖKNINGSHISTORIK
Byte powerkort
Byte moderkort
Byte AD-kort


Magenta
production.flir.ats.com
FLIR
FELSÖKNING
KNOWLEDGE DATABASE SÖKNING
X
SÖK
LOGG
VAD GJORDE DU?
Changed the powerboard
VAR DET LÖSNINGEN:
NEJ
JA
HAR DU MONTERAT TILLBAKA DELEN?
NEJ
JA
RAPPORTERA!
FELSÖKNINGSHISTORIK


Magenta
production.flir.ats.com
FLIR
STÄNG
ORDERS IN QUEUE: 3
Core
STEG 11. LINJERING
ATT GÖRA: Koppla in kameran och ställ den mot kolimatorn, välj korrekt mål och zomma in. Använd växelvis stativ och justeringskruvar. Avsluta med att mäta.
DETALJERAD BESKRIVNING
VERTICAL ALIGNMENT (mrad)
1,73
mrad
HORIZONTAL ALIGNMENT (mrad)
mrad
Back
Next

Appendix I: Answers to final interview questions

	Person 1	Person 2	Person 3	Person 4	Person 5
How much time would this system save?	Doesn't know	Very much time	A significant amount.	1h/day	Much time
Do you get the information needed?	Yes	Yes	Yes	Yes	Yes
Is the system easy to use?	It was easy to learn.	Yes	Yes, it is logical	Yes	Yes, it is logical.
Will less time be needed to solve errors?		Yes	Yes	Yes	Simpler common misstakes: Yes
Would this work procedure establish how to work?	Yes	Yes	Yes, more focuse on lean	Yes	Yes
Would you gain anything from using this system?	Yes	Yes	Yes	Yes	Yes
Would FLIR gain anything from using this system?	Yes	Yes	Yes	Yes	Yes

	Person 6	Person 7	Person 8	Person 9	
How much time would this system save?	Very much time	Not much, just a little bit of time.	Very much time	Much time	
Do you get the information needed?	Yes	Yes	Yes	Yes	
Is the system easy to use?	Yes	Yes	Yes	Yes	
Will less time be needed to solve errors?	Yes	Yes	Yes	Yes	
Would this work procedure establish how to work?	Yes	Yes	Yes, to some extent.	Yes	
Would you gain anything from using this system?	Yes	Yes	Yes	Yes	
Would FLIR gain anything from using this system?	Yes	Yes	Yes	Yes	