JOHANNA ISSAKAINEN
UPDATE OF A USER INTERFACE DESIGN PROCESS DIAGRAM
FOR A MACHINERY AUTOMATION COMPANY

Master of Science Thesis

ABSTRACT

JOHANNA ISSAKAINEN: Update of a user interface design process diagram
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The appreciation of good user interface have been increasing for a quite a while in many areas. People do not want to spend their time pondering what the user interface is all about. In user interfaces of machine automation companies, safety is one of the most important aspects. When big machines are handled, a mistake can lead to hazardous situations and unclear error messages can cause incorrect interpretations. That is why the meaning of good user interface is significant.

Sandvik's user interface design process diagram was out of date and it was supposed to be replaced with a new diagram. In this thesis the new diagram is created. The diagram defines what phases belong to user interface design. In addition the new diagram has a list of people who are part of user interface design and their tasks in it.

For the creation of the new diagram, existing user interface design methods were studied and they were utilized in suitable parts in the design of the new diagram. Additionally Sandvik's employees were interviewed. It was examined in the interviews, what would be good to have in the new diagram to make it as useful as possible. According to design methods, interviews, and the old diagrams the first version of the new diagram was created. It was verified by interviewing more people. The interviewees were able to freely express their views about the diagram and its possible flaws. The interviews made clear that the diagram includes all of the parts in user interface design fairly well. However, some suggestions for improvement were discovered in the interviews. According to the second round of interviews the diagram was edited to its final form.

The outcome of this thesis is user interface design diagram that is customized for Sandvik's needs. The diagram consists of the main diagram which includes the phases of making user interface design. The phases are research, concept design, design, implementation, support and updates. In addition, there is more information about different parts around the main diagram. There is argumentation about why user study would be useful to do, examples about design models that could help with design are given, it is listed where things should be documented, and tips for making the project are given. Additionally one of the most important aspects of the diagram, roles connected to user interface design and their tasks, are listed.

TIIVISTELMÄ

JOHANNA ISSAKAINEN: Käyttöliittymäsuunnittelun prosessikaavion
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Avainsanat: käyttöliittymäsuunnittelu, prosessikaavio, suunnittelumenetelmä

Hyvän käyttöliittymän arvostus on ollut kasvussa jo jonkin aikaa monilla aloilla. Ihmiset eivät halua käyttää aikaansa miettimällä, mitä käyttöliittymässä oikein yritetään hakea. Koneautomaatioyritysten käyttöliittymissä turvallisuus on yksi tärkeimmistä osa-alueista. Isoja koneita käsiteltäessä virhe saattaa johtaa vaaratilanteisiin ja epäselvät virheilmoitukset virheellisiin tulkintoihin. Siksi hyvän käyttöliittymän merkitys on merkittävä.

Sandvikin käyttöliittymäsuunnittelun prosessikaavio oli vanhentunut, minkä vuoksi sen tilalle haluttiin saada uusi kaavio. Tässä työssä uusi kaavio luodaan. Kaaviossa määritellään, mitä vaiheita käyttöliittymäsuunnitteluun kuuluu. Lisäksi uuteen kaavioon otettiin mukaan käyttöliittymäsuunnitteluun kuuluvat ihmiset ja heidän roolinsa sen teossa.

Uuden kaavion luomista varten käytiin läpi olemassa olevia käyttöliittymän suunnittelumenetelmiä ja niitä hyödynnettiin sopivilta osin uuden kaavion suunnittelussa. Lisäksi haastateltiin Sandvikin työntekijöitä. Haastatteluissa selvitettiin, mitä uudessa kaaviossa olisi hyvä olla, jotta siitä olisi mahdollisimman paljon hyötyä. Suunnittelumenetelmien, haastattelujen ja vanhojen kaavioiden perusteella luotiin ensimmäinen versio uudesta kaaviosta. Sitä verifioitiin haastattelemalla lisää ihmisiä. Haastateltavien annettiin kertoa vapaasti mielipiteensä kaaviosta ja sen mahdollisista puutteista. Haastatteluista kävi ilmi, että kaavio kattaa käyttöliittymäsuunnittelun osa-alueet melko hyvin. Parannusehdotuksia haastattelujen perusteella saatiin kuitenkin jonkin verran. Toisen kierroksen haastattelujen perusteella kaavio muokattiin lopulliseen muotoonsa.

Lopputuloksena on Sandvikin tarpeisiin räätälöity käyttöliittymäsuunnittelun prosessikaavio. Kaavio koostuu pääkaaviosta, jossa on selostettu, mitä missäkin käyttöliittymäsuunnittelun vaiheessa tehdään. Vaiheet ovat tutkimus, konseptisuunnittelu, suunnittelu, toteutus, tuki ja päivitykset. Sen lisäksi pääkaavion ympäriltä löytyy lisätietoa eri osista. Siitä löytyy perusteluja siitä, miksi käyttäjätutkimus olisi hyvä tehdä, annetaan esimerkkejä suunnittelumalleista, jotka voisivat auttaa suunnittelussa, kerrotaan minne mitäkin pitäisi dokumentoida ja annetaan vinkkejä projektin tekoon. Lisäksi on listattuna yksi kaavion tärkeimmistä asioista, käyttöliittymäsuunnitteluun liittyvät roolit ja rooleihin liittyvät tehtävät.

PREFACE

This thesis work was carried out between March 2016 and May 2017 for machinery automation company Sandvik. The goal was to make new user interface design process diagram that could be spread to a wide audience within the company.

I would like to thank my instructors at Sandvik, Eemeli Haverinen and Juha Hokka, for providing me all of the information that was needed for making the thesis. I also thank my examiner Kaisa Väänänen at TUT for guiding me about the writing process. Thanks for them all for putting up with all of the delays that came from my part.

Special thanks go to my fellow student and friend Elina Lukkarinen without whom I would probably still be stuck at the second programming course.

Tampere, on May 22nd, 2017

Johanna Issakainen

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ABBREVIATIONS

CD	Contextual design
CI	Contextual inquiry
GUI	Graphical user interface
HMI	Human-machine interface, physical user interface
ISO	International organization for standardization
UCD	User-centered design
UED	User environment design
UX	User experience

1. INTRODUCTION

Probably everyone uses some kind of user interface daily. Nowadays they are a central part of our life and they are expected to work without problems. Unclear and complex user interfaces are quickly dismissed and replaced with more intuitive user interfaces since there is a variety of user interfaces available. Therefore, good user interface gives competitive advantage. When the company's process for making user interfaces is well thought over, it is easier to prevent same mistakes from happening in several projects. It also speeds up the design process and time can be used more productively.

This thesis was made because Sandvik's employees thought that their user interface design diagram was out of date and therefore they did not want it to be shared for broad audience. The user interface designer was supposed to update the diagram but he has not had enough time to do it. That is why it was thought that updating user interface design diagram would be good subject for master's thesis. The outcome of this thesis is new user interface design diagram that is customized for Sandvik's needs. Study methods for making the new diagram were literature review and interviewing Sandvik's employees.

The objectives of the research made for this thesis were to find out how user interfaces have been designed in the past and how the employees have experienced the process. The best practices for user interface design were looked for and the worst identified so that they could be avoided. The roles of the people who are part of the design process were recognized and their tasks separated. Also ideas about the representation of the diagram were gathered. The more precise research questions were:

- What happens in Sandvik's user interface design process?
- Who are involved in it and what is each person's role?
- How the process could be portrayed?

The meaning of the new and improved process diagram is to portray the process in clearer and unambiguous way. It is supposed to be useful for as many people as possible, improve communication, share information about user interface design and what user interface designers do. It can be used as a tool for training employees about user interface design.

This thesis describes how the process of creating the new process diagram proceeded and how the new diagram looks like. In Chapter 2 are explained relevant aspects for user interface design process. In Chapter 3 are studied few relevant user interface design

methods that can be utilized in the new diagram. Chapter 4 explains how the empirical study was made and what the objectives were. Also a brief introduction of Sandvik is given. Chapter 5 includes the information about 14 interviews that were held to gain knowledge about Sandvik's way of doing user interface design. The chapter has information about the participants of the interviews, interview questions and what were the results. In Chapter 6 are shown the old process diagrams and what of them can be used in the new diagram. Then the first version of the new diagram that is made based on the interviews, old diagrams, and existing design methods is introduced. The first version of the new process diagram was evaluated with holding six more interviews. The participants and interview results are described in Chapter 7. The final version of the new diagram is presented and explained in Chapter 8. Chapter 9 concludes the thesis.

2. CENTRAL CONCEPTS

The user interface design process aims for making the user interface as good as possible. In this chapter are explained the most important concepts that are related to user interface design.

2.1 Usability

When product is usable it is easy to use. That is hard to measure but usable can be thought as the absence of frustration while using the product [1, p. 4]. The definition of usability in the ISO 9241 standard [2] is: *"The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use"*. Effectiveness is explained as: *"The accuracy and completeness with which users achieve specified goals"*. Efficiency is explained as *"The resources expended in relation to the accuracy and completeness with which users achieve goals"*. Satisfaction: *"Freedom from discomfort, and positive attitude to the use of the product"*. Context of use: *"Characteristics of the users, tasks and the organizational and physical environments"*. Handbook of usability testing defines usability in easily understandable form as follows: *"The user can do what he or she wants to do the way he or she expects to be able to do it, without hindrance, hesitation, or questions"*.

To be usable, a product or service should be useful, efficient, effective, learnable, and satisfying. Usefulness means that the user is able to achieve his goals with the product and is an assessment of the user's willingness to use the product at all. Efficiency is usually measured as time that the completion of the task takes. Effectiveness is usually measured as the number of mistakes the user makes. Effectiveness is affected by the fact that the product behaves as the user expects and the ease that the user can use the product to do what he wants. Learnability measures the time that it takes for the user to learn to use the product. Also the time that it takes to relearn the use of the product after not using it for a while can be measured. Satisfaction is the subjective feeling and opinion that the user gets from using the product. [1, p. 4]

Usability is practically invisible. When everything goes smoothly nobody notices it but if there is something faulty in the product many people notice. The only way to find out if the product is usable is to test it on the users. Even in that case testing is practically about how unusable the product is. Testing tells how many problems users have while using the product, what the problems are and what is causing them. Using evaluation methods throughout an iterative design process enables making usable products. [1, p. 6]

2.2 User experience (UX)

User experience is often incorrectly used for a synonym for usability [3]. Where usability is understood as ease of use and ability to carry out a certain task user experience has broader meaning. User experience looks at the entire interaction with something, the thoughts, feelings, and perceptions that arise from it [4, p. 5]. From other point of view it can be said that UX is subjective, context-dependent and dynamic [5]. Therefore, usability is part of user experience [6].

User experience is harder to measure than usability since it is not only about measuring time or the amount of mistakes [7]. Those measurements are objective but UX is subjective. UX should be measured before, between and after using the studied system [6]. Usually one method is not enough for measuring UX [8]. According to one case study, made in metals and engineering industry, companies are using UX as possible competitive advantage and value creation for the customer [9]. Therefore, it is useful to invest in user experience.

2.3 User-Centered Design (UCD)

The discipline of making things usable is called user-centered design (UCD). As a design process, UCD seeks to support how target users actually work, rather than forcing users to change what they do to use something [1, p. 12]. The main part of UCD is that the user participates the project's design process.

Basic principles of user-centered design [1, p.13]:

- Early focus on users and their tasks
- Evaluation and measurement of product usage
- Iterated design

Early focus on user does not only mean identifying and categorizing user but direct contact between users and the design team. User information collection requires systematic and structured approach. Evaluation and measurement includes testing of prototypes with actual users and measuring ease of learning and using the product. Iterated design is not only fine tuning the design in the end but it allows making even big changes through the design process.

2.4 Usability testing

Usability testing is one phase of user-centered design that aims to confirm that the user interface will be usable. In usability tests the user interface or its plans are tested on users who will use the actual product. The users are given one or several tasks and they

are asked to perform those without interaction from the tester. Users are often asked to think aloud so that the conductor of the test knows why the user does what he does. After test user is often asked to share his experience about using the product.

Basic Elements of Usability Testing [1, p.25]

- Development of research questions or test objectives rather than hypotheses.
- Use of a representative sample of end users which may or may not be randomly chosen.
- Representation of the actual work environment.
- Observation of end users who either use or review a representation of the product.
- Controlled and sometimes extensive interviewing and probing of the participants by the test moderator.
- Collection of quantitative and qualitative performance and preference measures.
- Recommendation of improvements to the design of the product.

Usability testing has some challenges. The users that are chosen for the tests do not represent all of the users so their opinions do not mean that everyone thinks the same. Testing is an artificial situation and the presence of the tester can affect the results. [1, p. 26]

2.5   User study

User study is the most useful when it is made as early in the design process as possible. If there is an existing version of the product that is designed it can be studied. Users can be observed and asked questions while they use the product. There is not usually any predefined task that the user is expected to solve, they can use the product as they normally do. User study is all about collecting background information about the product and familiarizing the designers with the product. [10]

There has to be some kind of focus in user study, otherwise it will not be as useful. The data from user study can be used for creating personas which are fictional representations about the users. Persona is a document that tells how certain type of people will use the system, and it is used to show the goals that the users are trying to achieve [11, p. 10]. Personas help to bring the users to more personal level so that they are easier to identify with. Personas can be used later as the support of design and they can be presented for example to stakeholders.

3. USER INTERFACE DESIGN METHODS

There are many processes and methods for designing user interfaces. The processes are designed for different purposes. In this chapter different methods are studied and the parts of them that can be utilized in Sandvik's user interface design process diagram are pointed out.

3.1 ISO 9241-210

The most known standard for user interface design is ISO 9241-210 "Human-centered design for interactive systems". It defines principles and activities of human-centered design. The principles are [12]:

- The design is based upon an explicit understanding of users, tasks and environments.
- Users are involved throughout design and development.
- The design is driven and refined by user-centered evaluation.
- The process is iterative.
- The design addresses the whole user experience.
- The design team includes multidisciplinary skills and perspectives.

The first principle means understanding users' context of use. It is important to know what users really need to use their tool as efficiently as possible. Sandvik's machines are often used in noisy and dirty environment. Some machines are used underground where it is dark or on the surface where sun can cause problems with seeing the screen. There are still chances in the context of use so it has to be defined separately for every machine. That is why user studies are made. Active user involvement makes it easy to get feedback from the design at an early point. That is not possible at Sandvik since the users are far away and hard to reach. Alternatively it is possible to use internal experts who know the most about users to get feedback. There has not been much if any usability tests made at Sandvik so user-centered evaluation has not been driven and refined the design. That is definitely one part that could be improved. The process being iterative is rather obvious. It has been a goal to make the design to address the whole user experience but the term user experience has been rarely used. The design team usually has at least usability designer, software engineer and software architect so the team is multidisciplinary. Still there could be more stakeholders involved.

Activities that are the center part of the standard [13]:

- Understanding and specifying the context of use
- Specifying the user requirements
- Producing design solutions
- Evaluating the design

Activities are also shown as a picture that represents their relations, which form a process. This can be seen in figure 3.1. The process does not define how every step should be made but it gives a frame for the process. This will be used as a starting point of the new diagram.
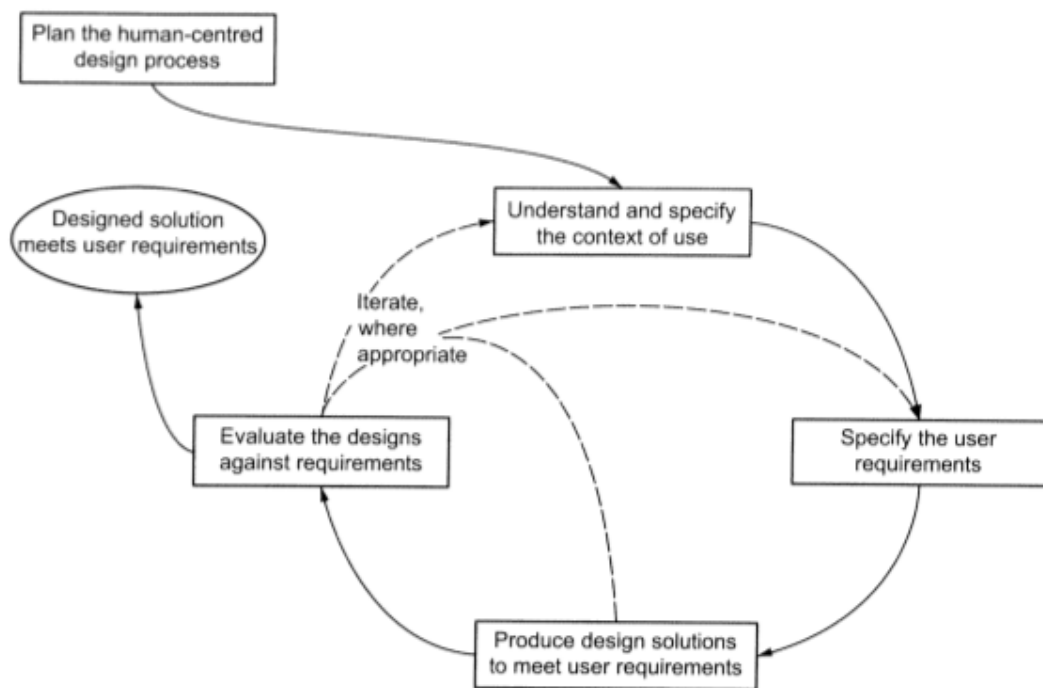
Figure 3.1: *ISO 9241-210 [13]*

3.2   Goal-directed design

Goal-directed design is a combination of different techniques. The process is divided into six phases that can be seen in the figure 3.2.
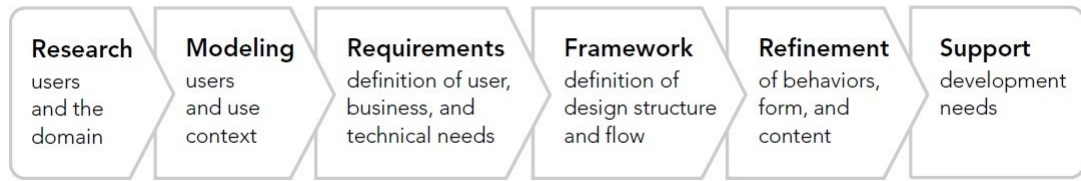
Figure 3.2: *The Goal-Directed Design process [14, p. 20]*

The first phase is research in which field study techniques are used to provide qualitative data about the users and stakeholders. Also many related aspects are studied. One of the main results is behavior patterns. Modeling phase includes creating personas and workflow models based on the results of research phase. Requirements definition phase gathers together all of the information about users and other models so that it can be seen what is really important. In framework definition phase the overall product concept is created. At refinement phase the focus is on details and implementation. The last phase is development support, during it is essential to be available if developers have questions. [14, p. 20-24]

Goal directed design is a rather challenging method to use at Sandvik since it includes much interaction with stakeholders and users who are hard to reach. Some of the method's steps could still be used. Making research is always important even though it could not be done as extensively as the method requires. Personas have not been used at Sandvik since many of the machines are used in similar conditions. Perhaps it might be good to do few general personas to remind designers for example that not all of the users are literate. Those personas could be then modified for each project's needs. Making workflow models could also help to understand how users tend to use the machines. Concept design has been used at Sandvik already and that will be continued. It is good to notice that designers work does not end when the design goes to implementation but support is needed and developers probably need answers quickly.

The method has five changes compared to the traditional way of software development. Those are [15]:

1. Design first; program second
2. Separate responsibility for design from responsibility for programming.
3. Hold designers responsible for product quality and user satisfaction.
4. Define one specific user for your product; then invent a persona—give that user a name and an environment and derive his or her goals.
5. Work in teams of two: designer and design communicator

The idea of the first point is that implementation does not begin as soon as possible but when the design is ready. That is the way that is used at Sandvik. Sometimes

implementation has to be started before wireframes are ready but then user interface designer gives at least verbal instructions of what needs to be done. Also the second and third point about responsibilities realizes at Sandvik. User interface designer is the one responsible for the appearance of the design, not programmer. Programmers make sure that the look is like designed and that everything works properly. That is why many reviews are held so that the designer can check that all looks as planned. Personas have not been used at Sandvik as stated before but those could be used in the future also to make users more alive to the stakeholders. The fifth point encourages working in a team of two in design. That is hard to fulfill since there is not enough user interface designers to put two for every project. But since software architect and software engineer are also so closely involved of the design process user interface designer is not in charge of every decision alone.

3.3   Contextual design

Contextual design is a method that consists of seven phases and covers the whole design process. The first phase is contextual inquiry (CI) that means observing and interviewing the user in a real context at his workplace. One or two team members should participate this phase. [16]

The second phase is interpretation session which all team members should participate. The interpretation session consists of analyzing the CI session, writing affinity notes and short user description and making different models based on the CI. Models are sequence, artifact, physical, cultural and flow. Sequence model represents observed tasks step-by-step. Artifact model is a representation of something physical or electronic that is created or used by the user during the CI. Physical model represents the physical environment. [16] Flow model shows communication, movement of artifacts between the user and other persons or the system parts and the user. Cultural model represents the culture, attitudes and values that affect how the work is done. Affinity notes are all kinds of notifications that arise at the CIs. They describe information that will not show in the models. [17]

The next phase is consolidation, in which models made CI sessions are consolidated. Consolidating models means making one combined model from all of the models created for each CI. As a result there will be five consolidated models that can be used as a starting point for the new design. Also affinity diagram and personas are made during this phase. Affinity diagram is a hierarchical representation of the issues labeled to reflect user needs. The affinity diagram is built from the bottom up, grouping individual affinity notes that reveal key themes in your data [16]. Affinity note groups are given headings and sub headings to make them to form a hierarchical tree structure. When the affinity wall is ready it helps with getting design ideas. Persona is a fictional description of typical user based on the real users. Personas are given a name, picture and textual

description of who they are, what they do and what are their goals. The point of personas is that they help stakeholders to understand users on a personal level. [17]

The fourth phase is work (re)design. In this phase designing the new system begins with creating abstract ideas and more concrete ways like storyboards and user stories. Storyboards are guided by the sequence models and affinity data [16] and they are like comics of how some task proceeds.

User environment design (UED) model is the next phase. UED model defines main parts and views of the designed system. It means concretizing earlier abstract ideas. The notation consists of boxes that have arrows between them as links to other boxes. Each box has a name, purpose, a list of functionalities, links to other parts and objects. UED helps to ensure that the system will support all the main cases and design goals. After UED it is time to make wireframes. [17]

The sixth phase includes making a low fidelity prototype and iterating it. It can be for example paper prototype. Prototype should be tested with end users. The last phase is implementation that does not have much input from user interface designer. [17]

At Sandvik it would be very hard to use contextual design in its entirety since it takes so much time and requires many participants. However, when user study is made at least some parts of CD could be useful. If user study is made, it usually means going to the end users and observing and interviewing them. That is like making contextual inquiry. The end users are normally very far away so it is not possible to go there with a big team. Therefore it is challenging to keep comprehensive analyzing sessions. It would be also hard to get the end users to these sessions. There is usually only one user interface designer in a project so it would be hard to get several opinions from user interface designers. It might not be useful to make as detailed analysis as the CD method requires if there are only one or two people present. Because of limited time and personnel better way could be that the user interface designer makes a conclusion about all the arisen matters and presents that to rest of the project team.

Some of the models that are created in CD process could be very useful at Sandvik. Physical model does not change much. The machines are always used outside so the weather conditions have an effect. It can be dark when underground or very light at direct sunlight. For that Sandvik has different color themes for light and dark. The physical surroundings are dirty and noisy. Safety is also very important. Cultural model could help to understand the users better since their culture is often different from developers. Flow model might not give any relevant information about the usage of screen. Artifact model would be interesting at least in a case where remote control is used. Sequence model is one of the most interesting models since it would show whether or not the screen is used as the designers have planned or not.

There are other possible ways to conduct user study and there is no need to limit doing it only one way. However, contextual inquiry is one noteworthy way of doing it and it should be noted in the design process diagram.

3.4 Paper prototyping

Paper prototyping is a technique in which the design can be tested without any coding. It is most useful when it is used in an early design and concept phase. All of the different screens of the user interface are drawn on a paper and users are asked to perform typical use cases with the sketches. [18]

The sketches do not have to be perfectly drawn since the point is not to test perfectly looking prototypes but to evaluate the idea behind the user interface. Wireframes do not work as paper prototypes since wireframes' layout is too detailed. Users might focus too much for example on fonts and alignment. Wireframes are also meant for later phase of the design than paper prototypes. Paper prototypes are meant for testing aspects like navigation, workflow, terminology and functionality. [19] When the paper prototype is tested someone of the design team acts as a computer and changes things on the screen according to the users actions. One person has a role of facilitator and he documents the issues that arise during testing. Others are observers who observe and interpret how the users interact with the prototype. [18]

Paper prototyping has many benefits compared to digital prototyping. It is fast since drawing views on a paper is quick. It is also cheap because using pen and paper does not require much investment. There are some ready stencils and tools that can be used for paper prototyping that has to be paid for. But even buying those would not make paper prototyping especially expensive compared to software development. Drawing on paper gives more freedom to be creative than using a software. It can be a lot of fun to do paper prototyping in a team and that can be good for team building. Paper prototyping does not require any technical skills so everyone can do it. For example different stakeholders can be involved. Documentation comes automatically with paper prototypes. Notes can be written on them and any possible modifications made during testing can be seen from prototypes. [20] Paper prototypes do not look ready so it might be easier for the users to tell if they would like to change something.

There are also downsides in paper prototyping. It is not possible to replicate the use of software on a paper and therefore user cannot get the same experience as they would by using the software. Paper prototypes require a lot if imagination of how the ready software will look like and if user's thought of it does not match designers view feedback will be somewhat wrong. Making paper prototyping means extra steps in design but it rarely goes to waste. [20]

Paper prototyping is a method that requires contact with the users. That is hard to achieve but instead of users inner experts could be used as users. Paper prototyping could be very useful method for Sandvik's needs since it is cheap and quick. Even one of the interviewees mentioned that when the design was showed to inner experts in an early stage in a form of wireframes it might have been better to use paper and post-its since it is more concrete. When it is explained that some popup comes after certain situation it is not as clear as if the user concretely presses something and then gets the popup.

3.5 Heuristic evaluation

"Heuristic evaluation involves having a small set of evaluators examine the interface and judge its compliance with recognized usability principles (the "heuristics")." [21] There are different opinions of how many evaluators would be the optimum amount. Nielsen [21] says that there should be three to five evaluators whereas UsabilityNet [22] recommends two to three evaluators. One person does not find all of the usability problems and different people find different problems [21] so it is useful to have at least more than one person doing the evaluation. Evaluators are usually usability experts but others can be taught to do heuristic evaluation too.

Heuristic evaluation is conducted by each evaluator individually and after that all of the results are gathered together and evaluators are able to share their findings with each other. The results can be reviewed by evaluators in written form or verbally telling their comments to an observer while going through the interface. Verbal may me better if evaluators are very busy and they do not have much time for the evaluation. Observer can help the evaluator if he has problems and answer possible questions unlike in traditional user testing when the observer cannot interfere.

One heuristic evaluation session lasts typically one to two hours. During the evaluation user interface is gone through several times and it is checked according to the heuristics. Evaluators can also use any other usability principles and write down other things that come to mind. The outcome of the heuristic evaluation is a list of problems in the interface and information of which usability principle the problem violates. The way how to do the evaluation is rather free. [21] Heuristics are general principles that are broad rules but not specific usability guidelines. Jakob Nielsen created 10 heuristics in collaboration with Rolf Molich in 1990 and those were refined in 1994 to their current form. [23] Nielsen's heuristics are probably the most used heuristics. Those are [23]:

- Visibility of system status
  - User should always be aware of what is going on and get feedback.
- Match between system and the real world
  - The system should use language and terms that are familiar to users.
- User control and freedom

- - o If user makes a mistake, it needs to be able to be canceled without going back to the start.
- Consistency and standards
  - o It should be clear which words, situations, or actions mean the same thing.
- Error prevention
  - o Problems should be prevented from happening by eliminating error-prone conditions or asking confirmations from the users.
- Recognition rather than recall
  - o Objects, actions, and options should be visible so that the user does not have to memorize anything.
- Flexibility and efficiency of use
  - o There should be some personalization available and shortcuts for experienced users.
- Aesthetic and minimalist design
  - o There should not be anything irrelevant or rarely needed information shown in the system.
- Help users recognize, diagnose, and recover from errors
  - o Error messages should be clear and expressed with words not codes.
- Help and documentation
  - o The system should be easy to use without documentation, but some documentation should be offered. Documentation should be easy to find and search and be easy to understand.

In addition to Nielsen's heuristics there are also other heuristics that can be used at heuristic evaluation but most of them are rather similar to Nielsen's. If heuristic evaluation is used at Sandvik it might be the best to select the most suitable ones for Sandvik's needs and maybe add some own checklist too.

The users are not involved in heuristic evaluation. Therefore it can be done rather quickly and cheaply. Drawbacks are that heuristic evaluation does not reveal all of the problems and it does not automatically generate solutions to the found problems. Heuristic evaluation can be done as soon as there is something to test. It is possible to do the heuristic evaluation when the plans are only on paper since during the heuristic evaluation no real tasks are performed. [21]

Heuristic evaluation could be very useful method to use at Sandvik. It is a great benefit that the users are not needed for the method since they are always hard to reach. Heuristic evaluation could be executed by the two usability experts and maybe one or few other people could be trained to do it. For example tester, software architect or system engineer who are already involved with user interface. Since all of the evaluators would come from inside the company they are familiar with the functions of user interface and there would not be need for an observer who explains what the system is for. Documen-

tation could be done a bit lighter than the method suggests to save some time. Evaluators could do the evaluation and mark down all their findings but there is no need for formal documentation. After each individual evaluation evaluators could have a meeting where they share their findings and think about solutions to the problems. One common document should be written so that also others know what have been found and how problems are fixed. If there is not enough time during the meeting to write the documentation one person could take responsibility of it and finish it after the meeting.

3.6   Summary of the chapter

The basis for the new diagram will be ISO-9241-210. It gives a starting point of how user interface design proceeds generally. Goal directed design brings in many useful aspects that can be used in the new diagram. Those are making research, personas, workflow models, and concept design. It also determines that implementation comes after design is ready and that support is given in implementation phase by user interface designer. According to contextual design the new diagram will have mention of using contextual inquiry as a user study method and that different models, like physical model, cultural model, artifact model and sequence model, could be beneficial to do during the design. In addition of these methods paper prototyping and heuristic evaluation are added to the new diagram as a useful ways to evaluate the state of the design.

4. DEVELOPMENT OF THE PROCESS DIAGRAM

In this chapter are presented the phases, objectives and methods of the empirical study. Also a short description of Sandvik is provided.

4.1   Objectives

The main goal of the thesis was to produce new and improved user interface design diagram that is customized for Sandvik's needs. Sandvik is a machinery automation company that is briefly introduced in chapter 4.4.

The first part of the study, the first interview round, focused on finding out what happens in the user interface design process at Sandvik. It was examined, who are involved in the user interface design, what their responsibilities are, and what ensures that the end product will have good user experience. Also aspects that went well and that should be improved in the process were studied. The interviewees represented different roles so the process was viewed from different angles. The information gained from the first round interviews was used to create the first version of the new process diagram.

When the second interview round was held the first version of the design process diagram existed and it was analyzed. The aim of the second interview round was to verify the correctness, understandability and usefulness of the diagram. Weak spots, missing aspects and things that differed from the style of the rest of the diagram were identified and corrected.

The objective of the new process diagram is to offer information about what happens in the user interface process, how the process proceeds, and who does what. The process diagram can be used when new employees are hired or old employees are trained about user interface design.

4.2   Process and timeline

The whole process of making this thesis took about 14 months. The client did not have any specific timeline for when the thesis should be ready. Therefore no hurry was kept while doing the thesis and in the end it took twice as much time as the initial plan. The beginning of the thesis was fast-paced. The first interviews were planned within a few first weeks of making the thesis. In retrospect, it might have been a good idea to study theory before the interviews were held since it would have been easier to identify the most important aspects of the process. After the interviews were held the thesis jammed

in place for the summer and the beginning of the autumn since it was somehow unclear how to proceed. The original plan was to finalize the thesis at fall of 2016 but in the end it was ready at late spring of 2017. There was an expectation that the new diagram should be something completely different than the previous one which made it hard to start designing the new diagram.

Towards the end of the thesis process, the pace was sped up so that the thesis would be completed before summer. More time could have been used for modifying the process diagram and testing different representations. However, the diagram seems to fulfill the requirements that were set to it. Making of the thesis was independent since it was not dependent on anyone else's work or the other way around.

The first interview round

Interview process started with inventing interview questions. At the same time I also contacted employees who were chosen for the interviews. First I gave them advance notice that I will arrange interviews in near future and asked if they are willing to participate. Everyone agreed to participate the interview. After that interview questions were iterated two times. When the final question list was ready I started to reserve interview times. Interview questions can be found at the end of the thesis as appendix A.

The plan was to interview people one project at a time starting from the project manager. That plan kept fairly well apart from the people who had participated several projects. At the beginning of the interview project managers were asked to tell what the project was about. I also asked project managers to send me some information about the project beforehand so that I had some kind of understanding of what kind of projects were in question. Due to that I was able to able to discuss the projects in more detailed level. All of the interviewees filled a form of personal details at the beginning of the interview. The form included questions about age, job description, how long the person has worked at Sandvik and if he has worked at similar job earlier and how long.

The interviews of the first round were hold during six weeks in April and May of 2016. Each interview took about an hour. The first interview served also as a pilot interview. All of the interviews were recorded with the permission of interviewee. Based on the recordings the interviews were transcribed after each interview within 24 hours. 12 of the interviews were held face to face at Sandvik premises and two were held via computer. Those two interviews were not possible to arrange face to face since one of the interviewees was in other city and one in other country. 13 interviews were held in Finnish and one in English. Most of the interviews were conducted as semi-structured. However, two of them were less formal since the interviewees had not been part of any of the chosen projects.

The second interview round

The interviews were held during two weeks in April 2017. There were only few days between the invitations and the actual interviews since the time that was planned to be used for the thesis was coming to an end. Fortunately all of the suggested interviewees had time for the interview. One hour was reserved for each interview and most of them took about 50 minutes. Every interview was held at Sandvik's premises and all of them were held in Finnish. All of the interviews were recorded with the permission of the interviewee. After the interviews recordings were listened and the main points were written down as soon as possible after the interview. At the beginning of the interview the participant was asked to fill out the same form of personal details as at the earlier interview round. The first interviewee was the one that had been interviewed also in the first round of interviews. The first interview served also as a pilot interview.

There was no specific order in which the interviewees were planned to interview. The order was dependent only about it when interviewees had free slot in their calendar. At most two interviews were held in one day since it took time to go through the recording of the interview and it was preferred to go through the recording before new interview started.

4.3   Methods

The study was conducted by making interviews for the employees. An interview is a situation where the interviewer asks questions from the interviewee who answers them. The interview revolves around some specific topic and produces qualitative data. [24, p. 28-32] Interviews were chosen as the method since it the most logical way to find out what had actually happened in the previous projects.

In the first round semi-structured interview was used. In semi-structured interview there is a beforehand designed question topics but also questions outside the topics can be asked and discussed [25, p. 24]. This was chosen because that way same parts of the projects are asked which makes it easier to do comparison between the projects. There is also a chance to ask more defined questions and discuss matters outside the question list.

In the first interview of the first round my instructor was present but all the following interviews were held only by me. All of the interviews were recorded since there was not a chance to write down everything that the interviewee said during the interview.

When the first version of the diagram was made it was given to my instructor for feedback. According to his expertise some terms were corrected to resemble the terms that are used in the company to avoid confusion. Also few important matters were added,

one thing that was not related to user interface was left out and some texts were clarified.

After correcting the obvious faults from the diagram six persons were interviewed about the new diagram. In addition one meeting was held about showing the diagram to people who are part of a project that is at an early phase. Present in the meeting were me, my instructor, and two other employees. They were given a brief about how user interface design should proceed and they gave a few good ideas of improving the diagram. The meeting took place between the first and second interview.

In the second round unstructured interview was used. In unstructured interview there are no predetermined questions but a free interview format is followed [26]. It was chosen for the interview method because the point of the interviews was to go through the whole process diagram. The least leading way to do that was to let the participants study and comment the diagram on their own and then ask about the parts that the participant did not comment.

The process diagram was drawn using Microsoft Visio because that is the basic tool for drawing at Sandvik. I also had some experience of using the tool so it was an obvious option.

4.4 Sandvik

Sandvik is a company that was founded in Sweden in 1862. It has approximately 43 000 employees worldwide. At Tampere Sandvik has about 1000 employees. There are both design and construction of machines at Tampere. Overall the company has activity in over 150 countries. [27]

Nowadays Sandvik consists of three business areas: Sandvik Mining and Construction, Sandvik Tooling and Sandvik Material Technology. This thesis is made for Sandvik Mining and Construction area of the company which includes rock drilling, rock cutting, crushing and screening, loading and hauling, tunneling, quarrying and breaking and demolition. [27] Two examples of machines that Sandvik has made can be seen in figure 4.1.

Figure 4.1: *Examples of machines made by Sandvik [28], [29]*

According to Sandvik's homepage [30], Sandvik has achieved world-leading positions in the following areas:

- Tools and tooling systems for industrial metal cutting
- Equipment and tools, service and technical solutions for the mining and construction industries
- Advanced stainless steels and special alloys as well as products for industrial heating

5. THE FIRST INTERVIEW ROUND

This chapter represents the participants, interview questions and interview results of the first interview round. Also a short summary of the results is provided.

5.1 Participants

Altogether 14 people were interviewed in the first round. Two of them were female and 12 male. Interviewees' age ranged from 30 to 50 years, the average being 38 years. Their work experience at Sandvik varied between 0.75 and 22 years while the average was 8.4 years. Interviewees had earlier work experience at other companies from zero to 21 years, on average 4.8 years. One of the interviewees was external employee who did not work for Sandvik anymore and the rest of them were internal employees. All but one of those 13 interviewees worked at Sandvik's location at Tampere and one of them in Australia. More precise information about the interviewees can be found from table 5.1.

Table 5.1: Interviewees' information

Interviewee	Age	Gender	Job description	Work experience at Sandvik (years)	Previous work experience from similar jobs (years)
I1	35	Male	Project manager	9	4
I2	35	Male	System engineer	8	0
I3	35	Male	Software architect	10	0
I4	50	Male	System engineer	22	0
I5	42	Male	Project manager	10	0
I6	30	Male	System engineer	5	0
I7	37	Female	User interface designer	5,5	2
I8	41	Male	Project manager	8,5	10
I9	40	Male	Software designer	7	21
I10	36	Male	System engineer	8	1
I11	40	Male	Project manager	9	4
I12	31	Male	User interface designer	1,5	5
I13	41	Female	User interface designer	0,75	18
I14	37	Male	User interface designer	13	2

The participants had taken part of one or several of four projects that were chosen for the interviews. Four projects were chosen since it is easier for the interviewees to think of some concrete case rather than how user interface design has proceeded in general. The chosen four projects represented different projects by size and duration. The projects included one small, one medium and two big projects. In some of the projects something completely new was created and some included only making new visual look. The idea was to interview four people from each project but since two people had participated three of the projects they were only interviewed once. Four of the interviewees were user interface designers, four system engineers, four project managers, one software designer, and one software architect.

Two of the interviewees had not participated any of the chosen projects but they were interviewed because they are user interface designers and therefore they have good insight about the subject. They were not interviewed using the same interview questions since those had specific questions about a project. Instead they were interviewed with an open interview that had only a few questions prepared beforehand. The main focus of those two interviews was to find out what user interface designer really does.

5.2 Interview questions

The interview questions were divided into seven categories. Those were schedule, communication, roles, user interface designer, problems/successes, process, and user study. At the end of the interview participants had also a chance to say anything that they thought of.

Under schedule were questions about the duration, phases, and changes of the project. Some basic questions about the duration of the project were not asked from every interviewee since everyone would answer the same concerning one project.

The second category, communication, included questions of how it worked between team members, what kinds of communication methods were used and how it could have been improved. Communication is very important part of project's success but it is hard to write down how it should work.

Roles category had questions about the interviewee's role, how clear the boundaries of different roles were, and how prioritizing was handled. The point was to find out if everyone has the same idea of what the job description of each role includes.

The next category, user interface designer, included questions about how useful it was to have a user interface designer in the project and if he was along till the end of the project. Problems/successes category was for finding out it everything went as planned, what caused the most problems, and what was the biggest success.

Process section contained questions about the existing user interface design diagrams and what kind of process description would be useful in practice. The last category, user study, had questions about what kind of user study was made and if it was useful. If user study was not made the question was if it would have been useful to do.

When all of the interviews were held the categories were gone through one at a time in every interview and results were compiled based on those. Even though two of the interviews were not held with the same interview questions as the rest, results from those two interviews are put under suitable category.

5.3 Interview results

Interview results are categorized under the topics used in the interviews.

Schedule

Schedule kept fairly well in most of the projects regarding user interface design and software development. The active duration of control system development was about one to three years in the projects. One of them is still ongoing. Timetable is usually dependent on the timetable of the machine being built. Most of the projects had plans about how user interface design would proceed in monthly level. User interface did not have many changes made to it in the projects. If there were changes, it was probably result from showing the design to inner experts who said that some essential functionality was missing or something irrelevant was shown. That usually happened at the early phase of the design. Other phase where problems were noticed was testing. Most of the problems found with testing were correctable with fine-tuning.

 In few projects changes were caused by the lack of domain understanding at the beginning of the project or because some design did not work in all of the machines. "When we wanted to keep congruence between the machines, sometimes we noticed that the plan does not work in some machine and the plan was changed to all machines." (I7) Sometimes user interface designer did not have enough time to do proper design before implementation but then instructions were given with pen and paper in a meeting and wireframes were made afterwards. Some interviewees did not have information about the planned schedule if they came to the project in the middle of it.

Communication

Communication was experienced as rather good overall, but there were still some hopes for improvement. Used communication methods were meetings, project management tool, e-mail, chat, conversations at a hallway and calling each other. Interviewees thought that e-mail conversations were a poor way to communicate, since not all could see them and the discussions are not saved anywhere. Some kind of tool for common discussion was hoped. That way everyone could see what has been discussed. "Com-

mon discussion platform would have been good. Now communication was rather static. Dynamics was missing." (I12) Also more internal demonstrations were desired so that it would be easier to understand what has been done and what has to be done in the future.

Many interviewees emphasized that it is very useful to physically sit in a same room because it makes communication a lot easier. If someone has a quick question it will be answered on the spot. There will also be a constant information flow during work. In practice it is hard to get everyone to a same place since people have also other projects going on. Their work stations can also be in different buildings.

It was not always clear how much information about functionality should be shown in wireframes and how much in the project management tool. Some people thought that everything that can be found from wireframes should also be in the project management tool, but some information was only in wireframes.

Roles

In some of the projects it had been a bit unclear where the border of user interface designer, system engineer and software architect work tasks goes. There was a wish for some clarification. It is very important that all know what their job description includes to make working as smooth as possible. Some projects on the other hand had very clear roles. Those were the smaller projects. It appeared that project manager had his part in maintaining clear roles in the project. "Project manager was genuinely interested of his work tasks and coordinated work well. Every division had its own clear responsibilities and it was taken care of that the communication worked." (I6) The project manager had named one person for each team who was responsible of sharing all the information that he got from the project manager to his team.

The role of user interface designer varies between projects based on designer's skills, abilities and amount of time that can be used for the project. Job description extends when user interface designer has more experience. In addition of drawing wireframes, user interface designer's job can include instructing graphic designer, ordering HMI-stickers from industrial designer, subcontracting, instructing developers about appearance of the user interface and iteration. It was hoped that the new process diagram would help others to understand what user interface designer's job includes. One of the interviewees found out that there is a user interface design department in the company after working for half a year. The new diagram should increase awareness of user interface design.

Few interviewees mentioned that the people who take part of the project have big influence of how smoothly the project goes. It would be useful to be able to have the same project team in several projects. Unfortunately it is not possible on behalf of the company.

When the projects started it was usually clear where user interface design aimed for but it was unclear how to get there and what kind of details will be done. In many projects all team members had more tasks than they were able to do. Tasks are impossible to divide equally since all have their own roles and work tasks based on that.

The big picture prioritization was usually made by project manager or together with the whole project team. Additionally everyone prioritized their own tasks alone or in a small team based on what is most crucial for the project. If someone asked after some task, it got more attention than others.

User interface designer

All of the interviewees said that user interface would look very different if there were no user interface designer in the project. User interface would look more "engineer-like" which means that every measurement can be seen at the screen. That makes user interface very complicated and unclear. When user interface designer is involved screen only shows what is necessary and it is placed reasonably. "It is a great benefit to have a user interface designer and good user interfaces bring competitive advantage." (I11) Using user interface designer also means using more time to the design since it means more phases to the design process. User interface design is still a rather new part of the design at Sandvik. Sometimes user interface designers have to justify their opinions very strictly since many of the older employees do not want to adopt any new way to do things. They want to do everything as it has always been made.

User interface designers are usually very busy and it may take a few weeks for them to be able to deliver what is needed for the project. That causes delay. In some projects user interface designer is taken along in a too late phase. Some plans have already been made and it would be too late to do user study even if it would be useful. Few interviewees thought that it is not necessary to consult user interface designer about everything. The most important thing is that all the main views are designed by user interface designer but some smaller priority views could be made without user interface designer. Those views could be checked afterwards by user interface designer. That would speed up the whole process.

Problems/successes

The interviewees felt that there were not many big problems in the software development part of the projects. If there were problems they were usually caused by some other sector than software design, for example hydraulics or electricity design. It should be noted that the interviewees were all part of the software development. In one of the projects the scope ended up to be bigger than what was anticipated beforehand. That caused delay. In the end user interface turned out to be very good. "Field feedback was very positive. Even older employees who think that everything should be done the old way have said that it is okay which means that it is good for real." (I1) The same project in-

cluded also harmonization of user interface in different machines that was a success. The project left very good basis for further development.

It was problematic that the user interface designer was not working for the projects full time since more time would have been needed. Interviewee number three described the problem like this: "The hours that the user interface designer had for the project were used quickly and then it was not possible to do anything for two weeks. That caused delay for the whole project. The lack of domain-understanding made it hard to design user interface. When designers did not have a clear image of how the machine is used, and what the machine is used for, it was challenging to design it. It took about half a year to be able to fully understand the machine. Especially when there are new employees in the project it takes time to get in it. One user interface designer mentioned the lack of usability testing as the biggest challenge in the project. There have been done very little if at all usability testing at Sandvik but it might be one part that could be improved. Most of the employees do not probably even know what usability testing means.

The project management tool caused negative feedback. It was thought that the amount of information in the project management tool was too much. It was not possible to reasonably follow the work flow via the project management tool since there were too many tasks and features. Meetings were required to see what is actually being made. Some kind of management tool is necessary but it needs to be used reasonably.

Process

The current version of the process diagram has not been in any general sharing so everyone had not seen it before. Three of the interviewees remembered seeing it before, five of them did not remember if they had seen it and six of them had not seen it earlier. Some said that their vison of what the diagram could contain was quite accurate. People, who had not seen the diagram, said that it might have been useful to read it through before starting the project. "The most important thing is to share as much information as possible to everyone so that everyone knows the goal." (I4) Interviewees who were not closely involved with user interface design did not know how the process proceeds. They could only see the outcome.

In the machines the screen is only supportive feature of the usage. The user does not stare at it the whole time so everything important has to been seen at a glance. It differs between projects how much user interface design is needed. In some projects everything is made from scratch and some projects only need updating user interface for new style or changing screen size.

User study

User study was made in one of the projects. User interface designer and project manager traveled to Australia for two weeks. The earlier version of the machine was in Australia

and Australian workers helped design the new machine. For the first week they circled at the drill machines that were currently used and observed their usage. On the second week they interviewed Australian experts. 90% of the input they got came from the people inside the company. Time used for the user study was not enough to see all of the work phases but it probably would have not been worth the money to spend more time to the user study.

Making the user study helped a lot with gaining domain understanding of the machine. Domain understanding is knowledge of how the machine is really used. If they had not seen the machine it would have left many aspects for guessing. If no user study had been made it would have been a lot harder to start and all the information would have based on the phone conversations with the Australians. "Making user study was very essential for the project. The project would not have succeeded half as well without the trip to Australia. 75% of the questions cleared because of the user study, rest of them got solved along the way." (I9) Prioritizing was easier when they had seen the real machine. They were also able to speak with the Australians with common terms. Without user study the project would have taken more time and there would have been more missteps. The greatest benefit was it that they could get to know the machine personally.

User studies are pretty rare at Sandvik since making them requires traveling very far which is expensive and time consuming. Deadlines do often come from upper level and they are so tight that it is not possible to do user study. Some interviewees said that user study would be useful if the machine or user interface designer is new. Someone thought that it is not useful to do user study if user interface designer is new since nothing new would be learned because of inexperience of user interface designer. People, who participated projects that did not have user study, evaluated that some small things might have had benefit from user study but not any basic use cases. They would have liked to know how client uses the machine.

5.4   Summary of the results

Based on the interviews the following important aspects of usability work were recognized. The new process diagram will include these findings in some form.

There were three points that were raised about improving communication. There is a need for **mutual platform for discussion** so that everyone can see what have been discussed and past conversations can be found later. Some guidance could be offered about **keeping internal demonstrations** to allow everyone to see where the project is going. It would also be good for communication, if the **project team could sit in the same room**.

It would clear things up to **list different project roles**, and the tasks that belong to each role, especially what user interface designer's role includes. It would also be beneficial to take the user interface designer along to the project from the very beginning, because possible user study must be started early on, and it would be useful for user interface designer to be part of the project when the first concepts are thought over.

During the work process **some views can be designed without user interface designer** when main views have been designed by user interface designer. User interface designer is often busy so it would speed up the process. Even though the usability tests and doing them at various point through the project are mentioned in the old diagram, not much usability testing has been done at Sandvik. It would be very useful to do it, so it will be mentioned in the new diagram, and some additional measures should be taken to promote it.

Some lines should be drawn of **what information would be good to show in wireframes and what in project manager tool** to avoid redundant information. Every project team can follow the line they wish but it should be consistent through the project. When designing the new diagram, different types of project will be taken into account. Some projects are only about updating user interface to a new style or platform and in some the entire user interface is new which effects what needs to be done, so the needs are different.

6. CREATION OF THE NEW PROCESS DIAGRAM

Based on the studied user interface design methods and the interviews, the first version of the new process diagram was created. Also some aspects of the old diagram were used to create the new diagram. Those are presented in this chapter.

6.1 The old diagrams

The old diagram consists of two separate diagrams. The other contains the whole process whereas the other one contains details about some parts of the other diagram. The two parts of the old diagram can be seen in figures 6.1 and 6.2.

The old process diagram is based on the general gate model. The gates can be seen at the top of the diagram. Since user interface and software are not the only parts of the whole project, but one huge part of it is the actual building of the machine, it is not possible to have different schedule from the machine building. Certain parts have to be ready when the machine needs them. That is why also the new diagram has to be based on the gate model.

The old diagram has three different usability levels from which one has to be chosen when the project begins. It depends on the decision which parts of the project will be done or if the diagram is followed at all. That was considered unnecessary complicated and many of the interviewees said that the box located down at the left, which explains usability levels, is not tempting to read since it has so much text. Therefore usability levels were left out from the new diagram.

There is input and output in every phase of the diagram which is unnecessary repetition since earlier phase's output is always input in the next phase. The new diagram does not have such a notation.

User Interface Design Process

Before project start:

Decide user experience level for the project:
- UX-focused
- UX-conscious
- UX-exclusive (project will not follow this process)

G0

Initiating and planning

G1

All projects

Input
- Product concept

Activities
- Get to know current products
- Interview in-house product experts
- Document use cases

Output
- Use cases documentation

Usability-focused projects

Activities
- Plan user study

Output
- User study plan

Concept design

G2

All projects

Input
- Use cases

Activities
- Define HMI control types and functionality
- Select GUI hardware
- Decide content and interaction of the most important GUI views

Output
- HMI concept
- GUI wireframe model

Usability-focused projects

Input
- User study plan

Activities
- Conduct user study with real end-users
- Run usability tests for concept designs

Output
- User study findings
- Usability test findings

All projects
Usability tests for design as necessary

Design and implementation

G3

All projects

Input
- HMI concept
- GUI wireframe model

Activities
HMI (before G3):
- Design detailed layout
- Carry out industrial design
- Design decals and symbols
GUI:
- Finalize wireframe model
- Design visual appearance and icons
- Implement software

Output
- HMI layout
- HMI decals and symbols
- GUI wireframe model
- GUI visualizations
- Icons

All projects
Usability tests for design as necessary

G4

Hand-over

All projects

Input
- Feedback from field tests

Activities
- Investigate feedback, make changes where needed

Output
- Updated design and implementation

G5

Notes

User study is a very time-critical step in the process: the design work usually cannot (or should not) start before the user study is completed. Thus any delays in arranging the user study typically postpone everything that lies ahead. According to past experience, practical arrangements for the site visits often take several weeks, so you should start preparations early.

Usability tests can be done in various phases of a project to find usability problems in the design. The test user interface can be at any stage of development: a paper sketch, an interactive prototype or a working product, depending on the functions that need testing and the maturity of design work.

Usability level of a project

Each project assigns itself a usability level before G0. The usability level is based on the importance of usability in the final product and it determines the usability-related actions that will be taken during the project.

Usability-focused projects recognize usability as one of the key factors for the project success. They are typically large-scale projects such as significant new products or major redesigns of current products. The project conducts a user study in field conditions with real users, which gives confidence in design decisions so that the product will meet end-user needs. Usability of the most important system parts is verified with user tests at several points during the design work.

Usability-conscious projects are usually small or medium size projects and often based on an existing product. No user studies are conducted: design decisions rely on usability specialists and in-house product experts. User tests may be conducted for selected areas if needed.

Usability-excluding projects utilize an existing user interface with no changes at all or deal with products without any user interface. No usability-related actions are included in the project.

Things to consider when deciding the usability level of a project:
- how user interface centered the project is
- how often and how much the product is used
- does the product have different user roles
- how important usability is for product success
- how large is the product market financially
- may mistakes in use put people or environment in danger

SANDVIK

Figure 6.1: The whole process according to the old diagram

The second diagram shows details about projects where user study is made. It takes a while to understand which parts of the other diagram it represents since one of the headlines are the same as in the other diagram, one is smaller part under a headline, and one headline is separated into two different headlines. It is good that the diagram explains what has to be done for the Graphical user interface (GUI) and Human-machine interface (HMI) parts since they need a bit different approach. That is also taken into account in the new diagram.

Down at every box are marked what has to be documented in each phase. That is good since people are interested in concrete matters. However, the notation is easy to miss, since the font color is lighter than other text and the location is not central. There is an arrow at the bottom of most of the boxes and in the middle of that there is a text that says user tests. It represents the need to make user tests to verify that the design is actually usable. User tests and usability tests are not clear terms to all of the workers apart from user interface designers. That is why some more descriptive terms would be better.

Figure 6.2: Details about some parts of the old diagram

6.2   The first version of the new diagram

According to the points illustrated earlier the first version of the new diagram was made. It can be seen in figure 6.3.

User Interface Design Process

Check also general project model

User interface designer along the project

G0 — G1 — G2 — G3 — G4 — G5

Research
- Understand and specify the context of use
- Find out what the user really needs
- Use cases
- Make user study plan
- Contextual inquiry one useful method

Tip: If project produces something to patent, it has to be done before the machine goes to the client.

Tip: Use mutual platform for discussion to keep track of conversations.

User study
- Time consuming but rewarding
- Most useful when the machine or user interface designer is new
- Helps to gain domain understanding
- Speeds up the design process later
- Makes design better since there is more knowledge of the actual use of the machine

Concept design
- Conduct user study
- Personas
- Site map
- Different models to help the design:
  - Workflow model
  - Physical model
  - Culture model
  - Artifact model
  - Sequence model
- HMI: Define control types and functionality
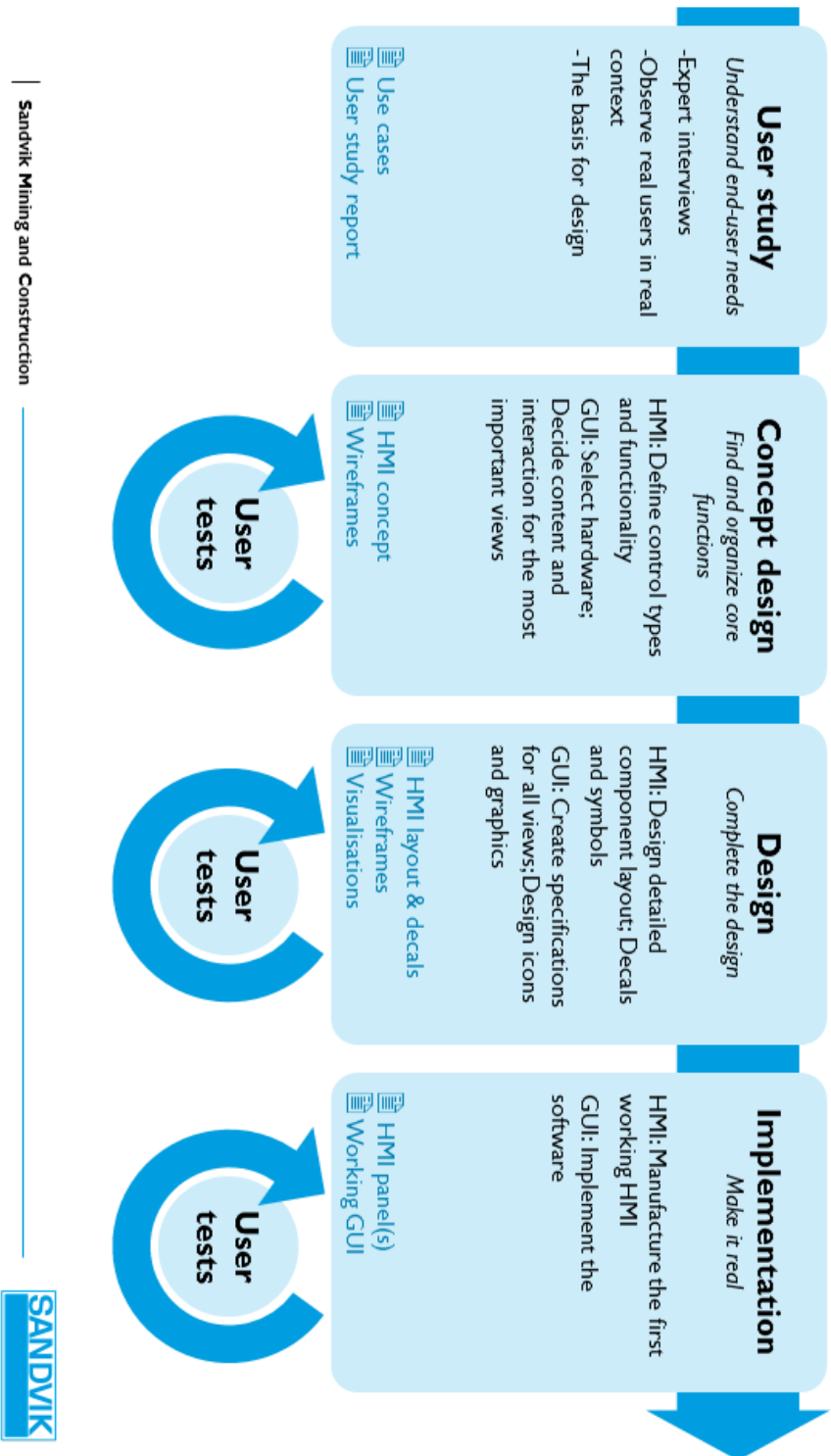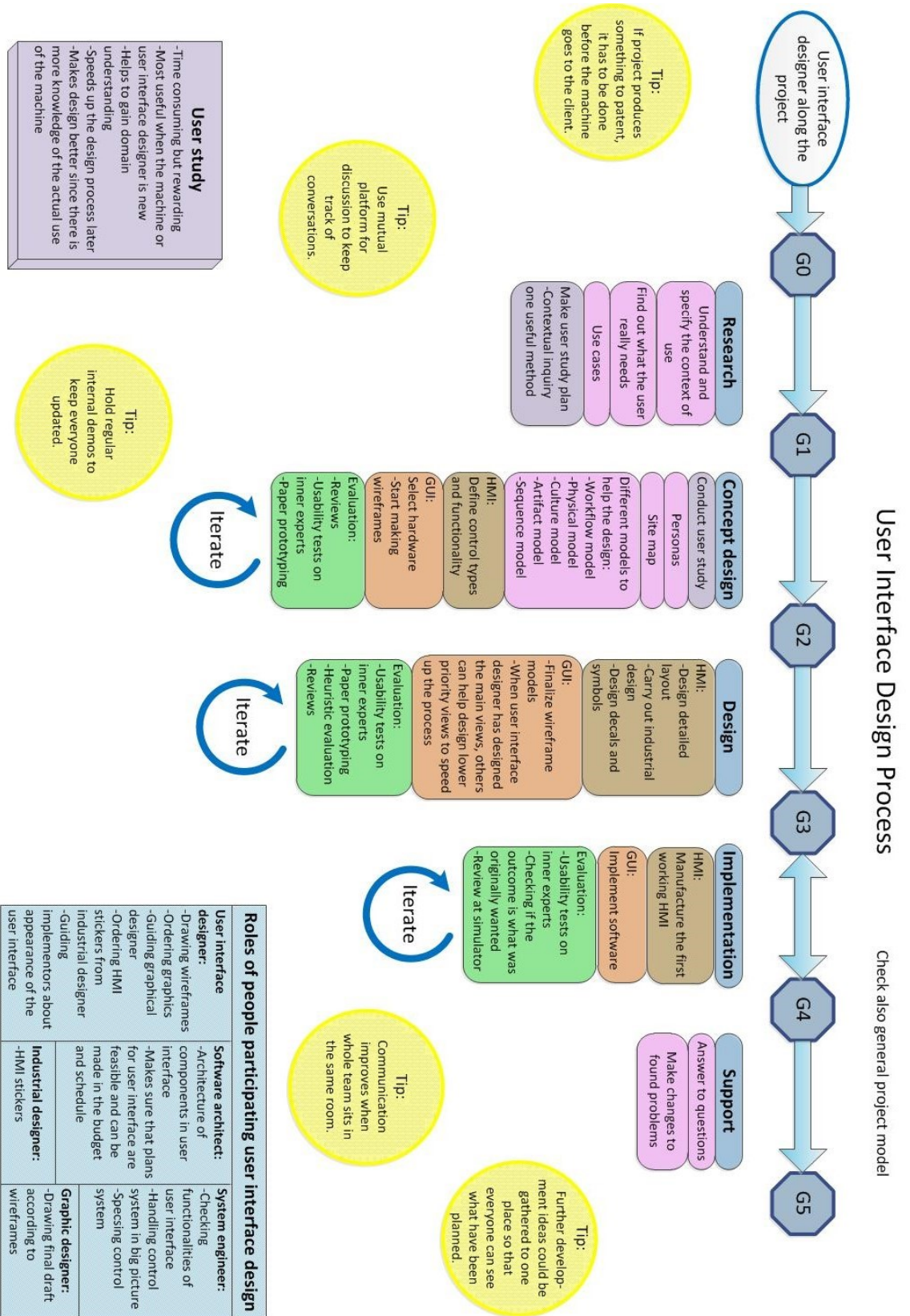- GUI: Select hardware, Start making wireframes
- Evaluation:
  - Reviews
  - Usability tests on inner experts
  - Paper prototyping

Iterate

Tip: Hold regular internal demos to keep everyone updated.

Design
- HMI:
  - Design detailed layout
  - Carry out industrial design
  - Design decals and symbols
- GUI:
  - Finalize wireframe models
  - When user interface designer has designed the main views, others can help design lower priority views to speed up the process
- Evaluation:
  - Usability tests on inner experts
  - Paper prototyping
  - Heuristic evaluation
  - Reviews

Iterate

Implementation
- HMI: Manufacture the first working HMI
- GUI: Implement software
- Evaluation:
  - Usability tests on inner experts
  - Checking if the outcome is what was originally wanted
  - Review at simulator

Iterate

Tip: Communication improves when whole team sits in the same room.

Tip: Further development ideas could be gathered to one place so that everyone can see what have been planned.

Support
- Answer to questions
- Make changes to found problems

Roles of people participating user interface design

User interface designer:	Software architect:	System engineer:
-Drawing wireframes	-Architecture of components in user interface	-Checking functionalities of user interface
-Ordering graphics	-Makes sure that plans for user interface are feasible and can be made in the budget and schedule	-Handling control system in big picture
-Guiding graphical designer		-Specing control system
-Ordering HMI stickers from industrial designer	**Industrial designer:**	**Graphic designer:**
-Guiding implementors about appearance of the user interface	-HMI stickers	-Drawing final draft according to wireframes

Figure 6.3: *The first version of the new diagram*

The basic form of the diagram is quite similar to the old diagram since the gate model cannot be waived. The most obvious difference is that whereas the old version had two

diagrams the new one has only one. The new diagram was chosen to have only one page so that there is no need to switch between diagrams in order to see all of the information. If there are several diagrams there is a chance that only one of the diagrams is paid attention to and the other is ignored.

Different colors were added to make the diagram more appealing and to group similar matters. Everything that is related to user study is marked with light purple background color, HMI matters are brown, GUI matters orange, evaluation matters green, and boxes that cannot be sorted to any specific category are pink. Outside the gate model there are yellow tips and light blue roles box. There is not any deeper meaning in most of the colors. Evaluation is green since that is the part which gives the green light to the project for continuing if users like the design. Tips are yellow since it is positive color, and gates and roles box blue because it is neutral color.

In the old diagram the third gate was marked in the middle of the line between the second and fourth gates. That is because the third gate is not concrete in the software development process. Design and implementation occur simultaneously. Everything is not designed first and then implemented but when something is designed it goes to implementation and next screen is designed after that. Because design and implementation do have different phases they were separated to separate components. Evaluation is also different when there is only a design to be used and when an actual implementation. The new diagram has an arrow back from the fourth gate to the third to mark that there is a transition backwards.

GUI and HMI matters are separated in the old diagram which is good way to present their differences. GUI and HMI parts are also separated in the new diagram but it is marked even clearer with different color boxes. Most of the HMI matters are taken from the old diagrams. GUI matters are from the interviews and some from the old diagrams.

My instructors at Sandvik had a few wishes about matters that they wanted to have in the new diagram. They wanted to have rationale for making user study, hence the box about user study. They wanted to have a link to the general project model which is at the moment under some changes in the intranet and therefore a direct link cannot be provided. That is way the new diagram has only a reminder to check the general project model. It can be changed later when the model has found its new place. Description about roles of the people who are part of the user interface design process was asked for. It also came clear in the interviews that there is a need for such a clarification. The interviewees were asked about their tasks in a role they represent and role descriptions were created based on those apart from graphic designer and industrial designer who were not interviewed. One of the tips says: 'If project produces something to patent, it has to be done before the machine goes to the client' that was added on request from the instructor.

ISO 9241-210 standard is the base for the design. It can be seen as iteration and in different phases of the diagram. The first box under research-phase is 'understand and specify the context of use' which is taken directly from one phase of the standard's diagram. That sentence describes the main point of research well and that is why it is used in the new diagram. One phase of the standard says: 'Evaluate the designs against requirements' which is taken to the new diagram as evaluation box in concept design, design and implementation.

Goal-directed design shows in the new diagram as the names of two phases, research and support. Concept design has personas and different models added to it which come from both goal-directed design and contextual design.

Paper prototyping is mentioned in evaluation box of concept design and design. Heuristic evaluation can be seen in evaluation box under design.

The yellow round tips are mostly matters that arose in the interviews and have an effect during the whole project. They do not belong to any specific point of the diagram which is why they were put outside the main diagram as tips.

At the beginning of gates there is an ellipse that reminds to take the user interface designer along the project. That was added because during the interviews especially user interface designers said that they are often taken to the project too late. Some concepts may have already been made before the user interface designer has had a chance to get to know the project which is not ideal since user interface could be a great benefit during concept design. In practice it is not possible to take user interface designer to the project before there is even a project but the point of the ellipse is to remind that user interface has to be informed about the project as soon as it is possible.

7. THE SECOND INTERVIEW ROUND

In this chapter are introduced the participants of the second interview round. Interview question and interview results that led to the final version of the process diagram are explained.

7.1 Participants

For the second interview round six persons were interviewed. One of them was also interviewed in the earlier phase of interviews and five of them were not interviewed before. One of the interviewees was female and five of them male. Their age ranged from 36 years to 46 years, the average being 41 years. They had worked for Sandvik between 1.75 and 16 years the average being 8.2 years. Interviewees had previous work experience from similar jobs from two to 18 years, averagely 9.3 years. All of the interviewees work at Sandvik's location at Tampere. One of the interviewees was user interface designer, one software architect, three system engineers and one software designer. The interviewees were chosen by the recommendation from my instructor. Exact information from the participants can be seen in table 7.1. The interviewees from the second round are called participants for separating them from the interviewees of the first round.

Table 7.1: Participants' information

Participant	Age	Gender	Job description	Work experience at Sandvik (years)	Previous work experience from similar jobs (years)
P1	42	Female	User interface designer	1,75	18
P2	46	Male	System engineer	11	10
P3	41	Male	System engineer	16	2
P4	40	Male	System engineer	12	11
P5	43	Male	Software architect	4,5	10
P6	36	Male	Software designer	4	5

7.2 Interview questions

Some interview questions were prepared beforehand but not much time was used for creating them. As expected the questions were not specifically useful since many of them were quite similar. Many of the questions were also based on the differences be-

tween the old and new diagram which was not particularly useful since many of the interviewees had not seen the old diagrams or at least did not remember them well. The pilot interview made clear that there is no need to develop the interview questions further since almost unstructured interview was more suitable for this kind of investigation.

The best way to start the interview turned out to be asking the interviewee to study the new process diagram and tell how he understood it. That way most parts of the diagram were discussed without pointing them out separately. Some changes were made between interviews according to the earlier interviews so that other participants could also say their opinion about the changes. That way the change was not only one person's opinion. All of the changes were not made between interviews since there was not enough time and all of the successions were not feasible. Some of the ideas that the participants had were not related to user interface design or they were a lot smaller matters than the ones marked to the diagram. If there had not been time to make the relevant changes to the diagram, they were still discussed in the upcoming interviews.

7.3   Interview results

The interviews made clear that all of the participants had something to say about the content of the diagram. Therefore it could be possible to continue making changes to the diagram almost endlessly but the line had to be drawn somewhere. Six participants for the interviews seemed to be enough to verify that the diagram was close to what people want from it. People also had contradictory opinions about what the diagram should have so everyone's opinion cannot be followed. All of the participants thought that the diagram did not have any major problems as it was during the interviews but all kinds of minor changes were suggested. The results are grouped under relevant headlines.

Color coding

The participants had hard time understanding what the different colors mean. HMI, GUI and evaluation were easiest to understand since those have continuous headers. On the other hand pink color was the most problematic because there is no common term in the boxes which have pink background color. Pink color does not group any specific matters but it is meant for boxes that do not belong to any other. The pink background color could have been left out and the boxes could have no background color at all. However, it would have not been in line with the rest of the diagram so the pink boxes stayed. When color coding was explained to participants, most of them thought that it does not need explaining in the diagram. Only one of them clearly said that the colors need to be explained. Since the colors clearly caused confusion, explanations for the colors were added to the diagram.

Gates

Gates were understood well since they are used also elsewhere. That was initially the reason to use them. Participants did not notice the arrow back from gate four to gate three which is the only arrow from right to left. The point of that arrow is to describe that the process does not proceed as waterfall model but the design and implementation happen side by side. When one screen is designed it goes to implementation and the next screen is designed and so on. During the meeting with people in an ongoing project, the idea about making gate three less concrete was arisen. It was suggested that gate three could be presented as 'ghost-gate', making it more transparent. After that was made it still was not clear enough. Participants did not notice it or and when they looked at the printed version they thought that the lighter color was just a glitch from the printer. Therefore also text 'Not a concrete gate' was added above the gate.

Iteration

Before the interviews iteration was marked as a blue arrow and text 'iteration' under concept design, design, and implementation. The meeting with the people in an ongoing project produced an idea about making one shared iteration arrow for design and implementation to emphasize that they are closely connected. In later interviews it became clear that it was a right decision. One participant suggested adding even more arrows and chancing the text from iteration to 'iteration cycle'. "When the real machine is available the amount of feedback increases and it has to be handled quickly." (P2) According to this the text was changed and one arrow was added since any more did not fit to the diagram properly. All of the changes seemed to clarify the procession of design and implementation since when changes were made the point did not draw as much attention to it. There was also a proposition of presenting the design and implementation phases as one circle where all of the boxes under both phases are. That was considered but it would have needed much more work to make it look clear. When the boxes were organized as a circle it made the whole diagram look very hard to read. The idea could have been possible if there had been more time to think different approaches.

Tips

The round yellow tips that are positioned around the main phases of the diagram were mostly viewed as positive thing. Their content was considered useful. Tips are not the main content of the diagram, but they tell important facts. The first version of the diagram had five tips and during development one was added. In GUI-box under design there was a note 'When user interface designer has designed the main views, others can help design lower priority views to speed up the process' that did not really belong to the general form of the phases. That is why it was turned into a tip. It was also tried to put all of the tips into one box under headline 'Tips' but then the diagram did not look pleasing to the eye. There were many boxes around the main diagram which took too

much space. It also turned over the idea of the tips which was that they are quick to read. If all of them would be in the same box, it probably would not be read as often as the separate tips.

Layout

All of the interviewees focused first on the main diagram in the middle, gates and phases. After that they started to read other things in the diagram. Roles box draw attention to it but user study box was sometimes ignored.

Since the diagram has a lot of information in it, it was tried to divide it for two pages leaving the gates and phases to other and moving all of the extra information to another. That made the page with gates and phases half empty. Of course the boxes could have been made bigger so that they would have filled up more space. So the real problem was the other page with all the extra information. Since the page would have had just many boxes with lots of information there is a doubt if people would actually read it. There might be a better chance for the extra information boxes to be read if they are in the same page as the rest of the information and so they were left to the same page. The people who read the diagram are engineers who are used to having lots of information in a same place although the diagram does not represent the way that user interfaces should be designed.

Roles

Role listing was considered important since it is not always obvious who does what. Since the role descriptions were mostly based on what the interviewees in the first round had said it was verified in the second round that they are accurate. Most discussion was caused the names of the terms. Some of the participants thought that system engineer term should be replaced with term product owner. But others thought that term product owner is not as widely known. In the end the term was changed to 'lead system engineer' because everyone understands the meaning of that. Lead system engineer can have a team of system engineers who do similar tasks but not all that are mentioned in the role description.

One of the participants said that it would be important to have under user interface designer's tasks that he has the ownership of the user interface. "It is not enough that the user interface is designed and implemented and bugs fixed. User interface designer have to own the user interface and continuously follow the making of user interface and supervise it." (P4) Therefore the text 'Continuous quality control of UI' was added to user interface's task list. The next participant complimented that task so it seemed to be a good addition. The second participant noticed that the first task under system engineer was bit strange. It said 'Checking functionalities of user interface' when it should have been about making sure that the functionalities do exist. The task was changed to 'En-

suring that all functionalities of user interface exist' which did not cause any more astonishment from other participants. Also task 'Making sure that production line is happy' was added to system engineers tasks. It was discussed in the meeting with people who are in an early phase project.

Documentation

Documentation icon was added after the first interview. It was added next to the main parts that have to be documented. The meaning of the icon was explained at the top of the diagram but since there was only one other explanation they were easily missed. Many of the participants asked if the icon meant about documentation so they did understand it but were still a bit unsure if it was what they thought. The final version of the diagram has explanations for the colors so the explanation of the documentation icon should also be easier to spot since they are all in the same place.

Few of the participants wished for some kind of clarification for where the documentation is supposed to be written and found. 'Where to document' –box was added because of that. It explains what information should be found from the wireframes, project management tool and visualizations.

User study

User interface designer values the part about user study more than others since they are rarely done but making them would be very valuable. Others do not see the benefit of making user study but the cost and time they take. That is why the box about the reasons to do user study was initially made. One of the participants suggested that the heading could be 'Why to make user study?' instead of just 'User study' which sounds more descriptive and was therefore chosen.

Content

Some of the boxes under research phase were so similar that it was logical to put them in the same box as turned out in the first interview. Those were: 'Understand and specify the context of use', 'Find out what the user really needs', and 'Use the knowledge of in-house experts'.

During the first interview round interviewees thought that it would be good to show in the diagram that different types of projects require different phases. If the project is only about updating the user interface to new style or platform there is not as much to do as if the project is about making a whole new machine. Showing that in the diagram was not solved when the second interview round started so the participants were asked if there is still a need for separating these kind of projects when that they could see the actual diagram. Most of the participants said that there is no need to separate different types of projects. "Different types of project do not have to be shown. Project manager

has to be able to pick important parts from the diagram." (P3) It is better to show everything that can be done and then project teams can decide if there is something that does not need to be done. That way there has to be always explanation if something will not be done. The diagram represents ideal situation that the projects should follow but in practice there is always changes.

There was a mention 'select hardware' under concept design's GUI box. Several of the participants noticed that it is actually chosen earlier by other people so it was removed from the diagram.

Many of the participants were a bit confused about the models under concept design. Models were taken from contextual design -method and they had not been used at Sandvik before so it was not a surprise. "Models are interesting but they have not been used in practice." (P1) Most of the participants thought that models could be useful but they needed more explaining. One of the participants pointed out that the models differ from other boxes under the phases since it tells who things should be done as others tell what should be done. Therefore models were moved from concept design to a separate box and explanation for each model was added.

Update-phase was added after gate five since user interface design does continue even after the machine is ready. "The work concerning user interface design does not end as soon as the machine is ready. There will be new features and updates." (P6) That is good to show in the diagram.

The first participant noticed that making competitor analysis was missing from the research phase and it was added since there was no reason not to. Other participants pointed out that it is a good thing so it was verified that it was a useful addition. In a later interview the participant said that there should also be an existing machine analysis since it has to be done in some extent even if user study is not made. It was added to same box with competitor analysis.

During the meeting with people of a current project the matter about proofreading arose. It is an important part of user interface design so it should be mentioned in the diagram. It was added under design's GUI part as 'Proofread all of the texts in UI'. That was complimented by interview participants.

Feedback from field tests is important since the person who gives feedback is the end user. One participant asked to put field tests and review at test machine to the evaluation box of implementation phase so they were added there. Other participants did not criticize them so they stayed to the diagram.

There was a box in support phase saying 'Answer to questions' which was a bit too generic since obviously questions are supposed to be answered. It was replaced with the suggestion of one participant. "We have a problem that everyone does not know why

things are made to the user interface as they are. It would be nice that people who are behind the decision would explain it to others since there can be some usability reason that cannot be understood without explanation." (P4) According to this comment the text was changed to 'Train others about the user interface decisions'.

One of the participants suggested that the gates could show how much time and effort each phase takes by coloring the hexagon by the amount of how huge part of the project is done when the gate ends. "It could be marked to the gates, how much of the work is done after each gate. It would show the workload that is left". (P5) That is illustrated in figure 7.1. That idea was dismissed since it might not bring any new information to the diagram and projects are different so it is hard to evaluate how much work is done in each phase. Also now that there is an update phase after the fifth gate it would be misleading to say that all of the work is done when gate five is over.
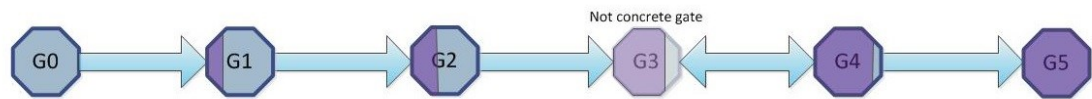

Figure 7.1: Example of colored gates

8. THE FINAL DIAGRAM

According to the phases explained in the previous chapters, the new user interface design process diagram was created. The final version can be seen in figure 8.1. All of the parts in the diagram are explained below.

The first thing in the upper left corner is the name of the diagram 'User interface design diagram' and on the right side text 'Check also general project model' so that people who read the diagram will know that more information about the gates in machine building project can be found from other diagram. There would be direct link to the actual project model but since it was under changes during the make of user interface diagram there is only a request to look for the other diagram.

Under the headline is an ellipse that says 'User interface designer along the project'. The meaning of that is to remind that user interface should be informed about the project as soon as possible since he can be useful member when the first concepts are thought over. The rest of the top line is filled with gates and arrows. Gates come directly from the phases of building the machine. The arrows show the direction that the project proceeds from gate zero to gate five. There is also one arrow backwards from gate four to gate three since that is the only phase where it is presumable to move back. As a matter of fact gate three is not concrete in software process so the phases between gate two and four happen simultaneously. That is emphasized by making gate three more transparent than others and there is also a text 'Not a concrete gate' above gate three.

On the left side are explanations for the colors used in the diagram. The matters related to user study, HMI, GUI and evaluation have their own background color. Also the documentation icon, which shows the most important parts that have to be documented, is explained at the same place. Apart from user study the meaningful colors are used only in the phases under the gates. The color of user study is also used in the box that explains why user study would be useful to do. The other colors used in the boxes and circles outside the main diagram are mostly for decoration.

User Interface Design Process

Check also general project model

User interface designer along the project

G0 — G1 — G2 — G3 (Not concrete gate) — G4 — G5

Legend:
- User study
- HMI
- GUI
- Evaluation
- Other matters
- Documentation

Tip: Hold regular internal demos to keep everyone updated

Research

Understand and specify the context of use
-Find out what the user really needs
-Use the knowledge of in-house experts

Existing machine
Competitor analysis
Use cases

Contextual inquiry one useful method
-Make user study plan

Tip: Use mutual platform for discussion to keep track of conversations

Concept design

Conduct user study
User study report
Personas
Navigation map
Remember standards and common guidelines

HMI: Define control types and functionality
Concept

GUI: Start making wireframes

Evaluation:
-Reviews
-Usability tests on in-house experts
-Paper prototyping

Iterate

Tip: When user interface designer has designed the main views, others can help design lower priority views to speed up the process

Design

HMI: Design detailed layout
Carry out industrial design
Design decals and symbols

GUI: Finalize wireframes
-Graphic design
Visualizations

Evaluation:
-Usability tests on in-house experts
-Paper prototyping
-Heuristic evaluation
-Reviews

Tip: Communication improves when whole team sits in the same room

Iteration cycle

Implementation

HMI: Manufacture the first working HMI Panel(s)

GUI: Proofread all of the texts in UI
-Implement software
-Working GUI

Evaluation:
-Usability tests on in-house experts
-Checking if the outcome is what was originally wanted
-Review at simulator and test machine
-Field tests

Tip: If project produces something to patent, it has to be done before the machine goes to the client

Support

Train others about the user interface decisions
Make changes to found problems according to field feedback
-If possible make field tests yourself

Tip: Further develop-ment ideas could be gathered to one place so that everyone can see what have been planned

Updates

Make updates and new features by repeating previous phases

Where to document
-Wireframes show what screens look like
-Project management tool shows how things work
-Visualizations show what the screens look like in detailed level

Sequence model
-Represents observed tasks step-by-step

Flow model
-Shows communication and movement of artifacts between the user and other persons or the system parts and the user

Physical model
-Represents the physical environment

Culture model
-Represents the culture, attitudes and values that affect how the work is done

Artifact model
-Representation of something physical or electronic that is used by the user

Different models that can help the design

Why to do user study?
-Time consuming but rewarding
-Most useful when the machine or user interface designer is new
-Helps to gain domain understanding
-Speeds up the design process later since there is more knowledge of the actual use of the machine

Roles of people participating user interface design

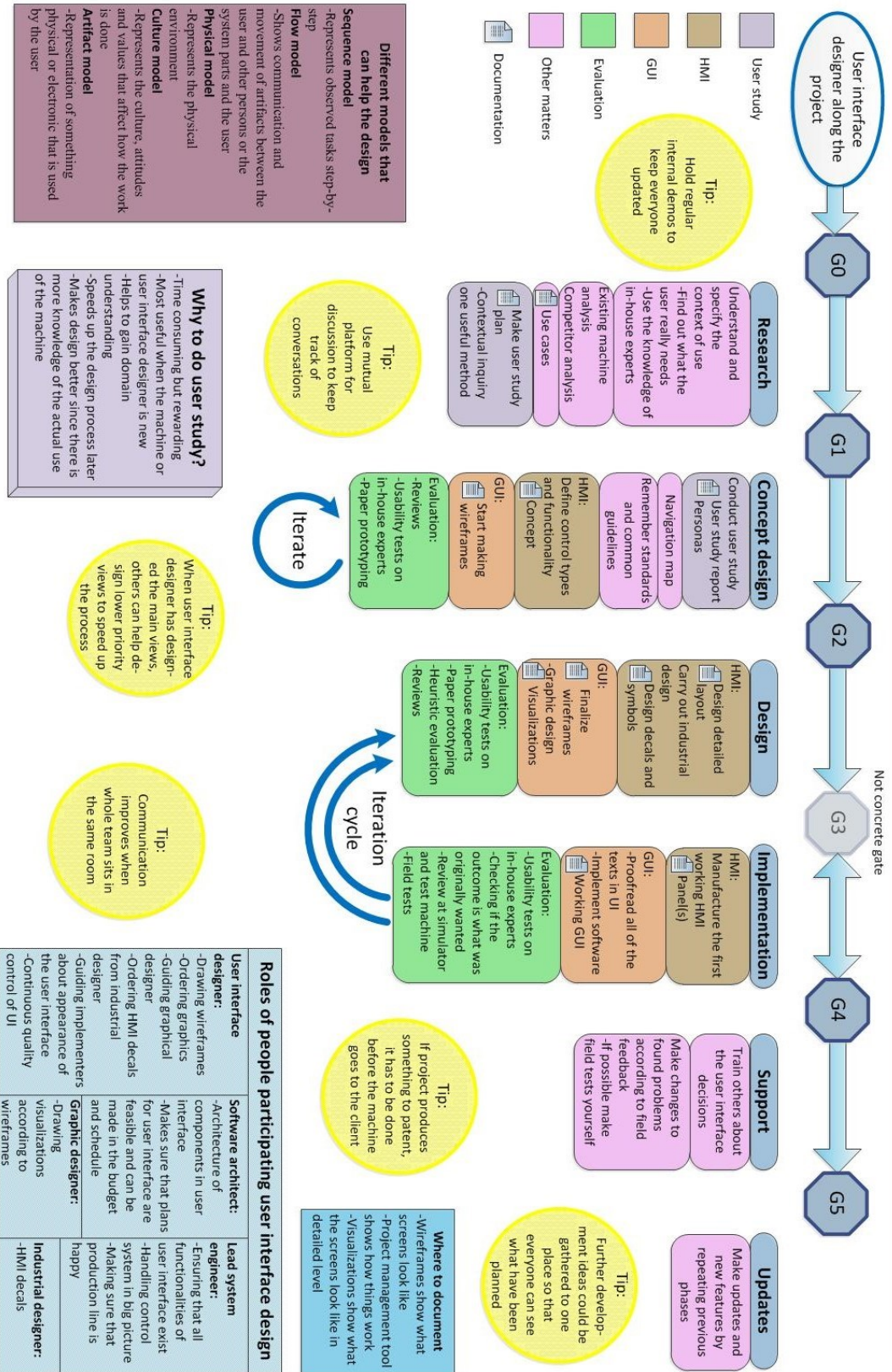| User interface designer:	Software architect:	Lead system engineer:
-Drawing wireframes	-Architecture of components in user interface	-Ensuring that all functionalities of user interface exist
-Ordering graphics	-Makes sure that plans for user interface are feasible and can be made in the budget and schedule	-Handling control system in big picture
-Guiding graphical designer		-Making sure that production line is happy
-Ordering HMI decals from industrial designer		
-Guiding implementers about appearance of the user interface	**Graphic designer:**	**Industrial designer:**
-Continuous quality control of UI	-Drawing visualizations according to wireframes	-HMI decals

Figure 8.1: The final version of the diagram

Under the gap between phases are boxes which tell what is done in each phase. The phase between gate zero and gate one is called research. Under the headline are four boxes that explain what is done in the phase. The firs box says 'Understand and specify

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the context of use' and it has two specifying points 'Find out what the user really needs' and 'Use the knowledge of in-house experts' It is very important to understand the what the user really needs and not to blindly believe what user says he needs. When the context of use is understood it helps with recognizing the real needs. Since it hard to meet the actual users in-house experts, who know the most about the users, are the best equivalent for them. The second box says 'Existing machine analysis' and 'Competitor analysis'. Those mean studying the existing or competitors' machines for getting information about how the old machines are experienced and what should be changed or kept. The third box is 'Use cases' and it has a documentation icon next to it meaning they have to be documented. At this point at least the main use cases should be defined. Use cases are explanation of actions that has to be taken in order to achieve certain goal. The last box in research phase is about making user study. It starts by making and documenting the plan. The diagram has also a suggestion for one possible way to conduct the study which is contextual inquiry.

The phase between gate one and gate two is concept design. That is the phase where user study is made as the first box indicates. User study produces user study report, which has the findings from the user study, and personas that are used as tool for the design. The next box contains navigation map which shows all of the different views and transitions between them. The third box says 'Remember standards and common guidelines' that is there to remind that standards and guidelines exists and they have to be followed from the start or it will cause major changes later. HMI design starts at this phase. Control types and functionality are defined and concept documented. On GUI side first wireframes are made and documented. Concept design phase is evaluated by reviews, usability tests on in-house experts and paper prototypes. Paper prototypes have been rarely or not made at all at Sandvik so there is a change to try something new. Under the phase is an iteration arrow which tells that according to the results from evaluation iteration is made.

Between gates two and three is design phase. On HMI side detailed layout is designed and documented. Then industrial design is carried out and decals and symbols are designed and documented. On GUI part wireframes are finished and documented. Graphic design is made and according to it are drawn visualizations which show how every detail in the screens look like. The evaluation methods in this phase are usability tests on in-house experts, paper prototypes, heuristic evaluation and reviews. Heuristic evaluation is also rarely used method but it could be useful because of its cheapness and quickness.

Implementation phase between gates three and four means manufacturing the first working HMI and making and documenting panels. GUI side includes proofreading all of the text in the user interface. The software is implemented and working GUI is documented. Basically implementation is not part of user interface design but since user interface is never ready without implementation it is included to the diagram. When the

user interface is implemented, it is again evaluated by making usability tests on in-house experts, review at simulator and test machine and field tests. It is also checked that the result matches with what was originally wanted from the machine. Since design and iteration phases go hand in hand they have one common iteration stage. Since the iteration in these phases is so rapid the iteration is pictured with two nested arrows and with text 'iteration cycle' instead of just 'iterate'.

When the user interface is implemented, it is time for support phase. In that phase people who have participated user interface design should inform others about the decisions between the design solutions. There can be some usability reasons behind the design that all do not understand. Training them about the user interface would decrease confusion. Feedback should be received from the field and if problems are found they are corrected if needed. If there is a possibility for the user interface designer to make field tests himself it would be valuable.

When the machine project is finished and the machine is at use, the user interface design of the project is not necessarily over. After gate five comes phase updates in which user interface is updated and new features are made. Some features can be purposely left outside the scope of the project and made after the machine is already at the client or something is noticed missing. Then they have to be done after the end of the project. New features will follow the same phases as the rest of the project but the extent depends on the complexity of the new feature. In the diagram this is expressed just by saying that updates and new features are made by repeating previous phases to keep the diagram simple. If there were arrows to the beginning of the diagram it would make the diagram harder to read.

The yellow circles that go around the diagram are tips that are good to keep in mind throughout the process. They suggest keeping regular internal demos, using mutual platform for ease of discussion, helping the user interface designer with design of secondary screens, sitting in the same room for better communication, patenting things before the machine goes to the client, and gathering further development ideas to one place.

The box in the lower left corner recommends using different models as the starting point for the design. There are five different models which are good for different needs. Models are named and each is given a short description. When they are made once, other projects could use the ready models as modify them for their own needs. These models have not been used at Sandvik before but they could be useful for thinking about the design from a new angle. Therefore they were added to the diagram. The headline has slightly smaller font than few other boxes' since the models are not core matter in the diagram.

Next to the model box is another box which contains additional information for user study. A box 'Why to do user study?' explains the positive results that making user

study can lead to. It has been rare to do user study at Sandvik so there was a need to justify making it. Hopefully this box will help to increase the amount of future user studies.

On the right side of the diagram is box called 'Where to document' that briefly explains what is documented to wireframes, project management tool and visualizations. Wireframes tell how the screens approximately look like, project management tool how things work, and visualizations the detailed look.

Lastly in the lower right corner is the most important box outside the main diagram. It explains the roles of people who are part of the user interface design. The point of the box is to clarify who is supposed to do what, so that it does not have to be cleared in every project. The roles are user interface designer, software architect, lead system engineer, graphic designer, and industrial designer. User interface designer guides graphic designer and industrial designer in their work. He draws wireframes according to the information provided by software architect and system engineer, guides implementers about appearance of the user interface and does continuous quality control of user interface. Graphic designer draws visualizations and industrial designer makes HMI decals. Software architect designs components' architecture in user interface and keeps track of budget and schedule. Lead system engineer ensures that all functionalities of user interface exist, handles control system in big picture, and makes sure that production line is happy. The lead system engineer can have a group of system engineers with him sharing the workload.

9. CONCLUSIONS

The goal of this thesis was to create a new user interface design process diagram customized for Sandvik. The information that was used for making the new diagram was gathered studying user interface design process models, Sandvik's old user interface design process diagrams, and interviewing Sandvik's employees. When the first version of the diagram was made more Sandvik's employees were interviewed and the diagram was polished into its final form according to them.

The diagram describes an ideal situation of the process but in practice everything does not go according to it. The diagram is a reminder of how things would go if there was unlimited amount of resources available.

What made the development of the diagram challenging was the fact that most of the information gathered was based on the personal opinions of a few employees. Their opinions had lots of differences since everyone looks the progress of the process from their own point of view. Something that was important to other was irrelevant to another employee. Some balancing was needed when employees' opinions were refined into the diagram.

More time could have been used for polishing the diagram. Relatively short time was used for it because the time used for making other parts of the thesis had already lasted for too long. Therefore it was decided to set a deadline for making the thesis.

The user interface design process diagram created in this thesis reflects the current situation of user interface design with some additions of what would be useful to do in the future. The process of user interface design will surely change in the future and the diagram should be updated according to the changes so that it will stay relevant. That job will probably fall for the responsibility of user interface designer.

It was not possible to test the diagram in an actual project since projects are long and the time frame for making thesis limited. Therefore it would be good to check the diagram one more time after it has been used in a few projects and make changes if needed.

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APPENDIX A: INTERVIEW QUESTIONS ROUND ONE

Interview questions

Schedule

How long did the project last?
Were you in the project for its whole duration? If not, how long?
Did the actual schedule differ from the original?
How many employees were in the project?
How accurately was the schedule of user interface design and implementation thought over?
What kind of phases the project had?
Which phase had the most changes?
Did user interface design go ahead of implementation?
How many changes did the user interface had during the project?
How design was able to react to the change requests?
What caused changes?

Communication

How communication worked in the project?
How often you had meetings?
What other communication methods were used?
Were used methods effective?
Did information reach all?
How communication could have been improved?

Roles

What was your role in the project?
How well did you understand at the beginning of the project what will be done and how?
How clear it was to others?
Was there anything unclear about who does what?
Did something get delayed because nobody was willing to do it?
Were tasks divided equally among the project team?
How tasks were prioritized? Who prioritized them?
Did all of the team members have similar goals about the end result?

User interface designer

How useful it was to have a user interface designer in the project?
Was the user interface designer along till the end of the project?
Would it have been useful to have him/her aboard till the end of the project?

Problems/successes

Did everything go as planned?
What was successful?
What went wrong?
What caused the most problems?
What would you do differently?

Process

Were you aware of the existing process descriptions of user interface design?
Did you use them in the project? If not, why?
Did you use some other way to do user interface?
What kind process description about user interface design would be useful?
How much new came to the user interface and how much old could be used?
Did some changes stay undone because it was not possible to do them? (lack of time for example)
How user interface was tested?

User study

What kind of user study was made?
How useful it was to make a user study?
Was the time used for user study enough?
Was the user study comprehensive enough?
What could have been left unnoticed if no user study were made?