Designing an energy production management system using a contextual design approach.

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1. Introduction

This report will describe the process we propose to use for the design of an energy production management system. This system will be used by the personnel of an energy management control center in a energy production company. The method we will use is for the design process is Contextual Design (Beyer & Holtzblatt, 1998) which is method supposed to promote a user centered approach. We have however made changes to the suggested methods in some places were we did not agree with them.

Because we were not provided with much information about the actual work practice of the people for whom we design this system we had to make some assumptions. These are the following:

There are five control centers in the company, situated in different countries. Every control center has 5 people working with the energy management system. These people use the system to monitor the different power production plants, keep an eye on the market prices and environmental factors, make decisions about how much power to produce on what moment in order to keep a balance on the power net as well as maximize the company's income. They all work together in this, but all focus on a different part of the process. The 5 control centers are in constant contact with each other and the different facilities that they rely on.

This report will first provide a theoretical introduction of Contextual Design as a design method. Then the proposed design process will be presented in detail after which we will reflect on the proposed method, to provide the reader with the potential short comings.

2. Background

Contextual design promotes the gathering of good and useful user data before start working and develop the system. Contextual interviews with the users are a the way to get into their work. To get a better view of the whole work environment, several interviews with users that have widely different roles should be done. At least 10 to 20 interviews will be processed where the interviewer must pay attention to the user at all time and keep the user from summarizing the work.

There are usually a lot of people with different backgrounds on a design team. In order for them to communicate and talk about work we need a common language of work. Contextual Design uses work models as this common language. It is a graphical language, because this has several advantages over textual languages that are very useful for design.

There are five different kinds of work models that all focus on a different aspect of work. There is the flow model, representing the communication involved in doing the work; the sequence model, describing the work steps needed to achieve an intent; the artifact model, presenting the physical things produced to help work; the culture model, revealing the influence policy, culture and value have on work; and the physical model, which represents the physical environment of the work and how it affects work.

The models are created during interpretation sessions. During interpretation sessions one team member walks through an interview he has taken. Other team members ask questions, record ideas and draw the work models that represent the work of the person that has been interviewed. After an interpretation session, the whole team has a common understanding of the work of this person and
has recorded all the relevant data.

After work models have been created for each separate user, more general overall models must be developed. The purpose is to properly reflect the organizations requirements instead of just the individuals that make out the organization that is to use the system. This is basically done by consolidating the existing work models and creating an affinity diagram.

In more specific terms, the consolidated work model brings together all data that was collected during the individual interviews. These separate consolidated work models reveal common strategies and intentions while keeping individual variances intact in the individual models. The affinity diagram is a hierarchical construction of post it notes that merges issues and other insights into groups. The end result is a diagram that reveals how big of an issue is or how great impact an insight would have on the system.

By conducting this work, the design team receives a single shared picture on the common patterns and work structure that is being present in the studied organization.

Design teams delivers new work practices, not tools and it is important that even the smallest tool fits in to the larger work practice. Therefore it is important to always have a work redesign step in a system development model, where you use gathered data to generate new innovations.

Customer data never indicates what to design and design team members will often disagree upon solutions and approaches. Use “visioning sessions” to come up with different visions and then create a common direction that is opposed of all the visions envisioned during the “visioning sessions”. Make a vision drawing that shows the hole vision and use that to make a storyboard that will show how tasks will be accomplished in the new vision.

Use the vision and storyboard to start designing your system. Before designing an “User Interface” you have to make an “User Environment Design”. The UED is the system work model in Contextual Design and is used to bridge the gap between the storyboard and the UI. UED show all parts of the that the user care about and can be considered a “floor plan” for the system. UED models what aspects each part of the system supports and what parts relate to each other.

The next step is to make the UI, and for this we use both the storyboard that is sequential and the UED that is structural.

Prototyping is conducted through creating paper mock ups that represent the system under development. The purpose is to use the paper prototypes as both a design tool and as a communication platform to the customer. By prototyping and iterating these tests frequently, better informed decisions can be made and costs reduced.

The paper prototypes are tested in cooperation with the customers by having the design team to replay real life situations. While testing, the user discovers problems which the designer goes back to redesign in order develop a prototype that better fits the user needs.

When prototyping, testing usually starts by testing one part of the system that is being covered in the User Environment Design. These are structural tests that eventually go into a more storyboard design that tests the UI of the system. As the testing more and more goes into testing UI, another part of the system starts to be tested. By doing this, several simultaneous tests try out different structural parts of the system and their corresponding user interfaces.
3. Preparations

Our team will consist of 10 people. 1 HCI specialist, 6 software engineers, 2 GUI specialists and 1 project manager. We involve people with different backgrounds to make sure the problem is approached with views from different angles. But there are more benefits besides this. Having the HCI specialist on the team helps in executing the tasks involving users in an appropriate way. Because the task involves a lot of information that might need to be displayed, the GUI experts on the team might prove to be a valuable addition. The software engineers are involved because they have to create the actual system. It is important to include them in the design process, because then they know how it was created and why it looks the way it does. The project manager will be there to make sure we stay on schedule and everybody knows what to do. To keep it manageable, there will be only 3 software engineers and 1 GUI specialist working on the design full time. The other 4 will be only partially involved, for example during the interpretation sessions. Contextual Design promotes using a small group of people with different backgrounds to do the actual design.

We will start by having some people of the energy company coming over to our office to give presentations on what they are doing. The entire team will be present and it will give them some feeling for what the domain is like. Afterwards the project manager will create a project plan and contact the control centers to schedule the interview sessions. We assume all control centers are willing to have us come over and consume some of their time in order to create their system.

4. Budget and Time Line

When constructing the budget some simple assumptions was made. For example, the budget originates from the idea our firms consultants should individually account for approximately a little more than 1 million SEK in yearly turnover. Also, all employees are assumed to cost the same hourly fee since we have little knowledge of what would be a realistic cost structure. The result of this is that all employees charge an average fee of 500 SEK per hour and person. Related to the time estimation is that the team works ordinary, eight hour workdays.

| Budget* |
|-----------------|-----------------|-----------------|
| Project part     | Time estimation (Days) | Number of staff involved | Cost         |
| Interviews       | 35               | 6                 | 840 000,00 kr |
| Interpretation sessions | 15               | 10                | 600 000,00 kr |
| Creating affinity diagram | 1               | 10                | 40 000,00 kr  |
| Consolidating work models | 15              | 10                | 600 000,00 kr |
| Additional interviews | 7               | 6                 | 168 000,00 kr |
| Completing the models | 4               | 6                 | 96 000,00 kr  |
| Model Analysis   | 3                | 10                | 120 000,00 kr |
| Visioning sessions | 12              | 10                | 480 000,00 kr |
| Vision drawing & storyboard | 2              | 10                | 80 000,00 kr  |
| User Environment Design | 5               | 6                 | 120 000,00 kr |
| Prototyping (assuming 5 UED parts) | 50             | 10                | 2 000 000,00 kr |
| TOTALS           | 149             |                   | 5 144 000,00 kr |

*Budget assumes 8 hour workday and an hourly fee of 500SEK/hour and person. Travel expenses are excluded from the budget.
5. Data Gathering and Processing

The first step is to gather user data to guide the design process. We will do this by interviewing people working in the control centers. We will interview people from different control centers to get a good overall picture of the work and discover possible differences in work practice between the different centers. Because they are situated in different countries there is a big chance that especially the informal part of the work differs quite a lot between the different centers.

The HCI specialist, the GUI specialist and three software engineers will be doing the interviews. All of them will do one interview after which five interpretation sessions are held to process the user data gathered during these interviews. The project manager will be involved in these sessions as well by managing information, schedule interviews and work as a contact person for the company. There will be one interpretation session for every person interviewed. We will try to let every session take about two hours, although the first few may take a little longer, since we need to get familiar with the domain. We will schedule two days to do the interpretation sessions for a series of interviews. Doing three sessions on the first day and two on the second. If it turns out three sessions on one day is too much and creativity suffers, we will schedule 3 days to do the sessions.

5.1 Interviews

Since there are five workstations located in different countries, the plan for the interview structure is scheduled to be nine to ten days to complete one workstation. One day to travel to the workstation, about six to seven days to do the interviews and to observe and then there is two to three days scheduled to travel back to the office and do the interpretation sessions. After this is done the team has collected all relevant data that is needed to continue with the next control center.

The reason why six to seven days is scheduled is because the design team most likely are new to the workplace and needs to discover unusual events during the days. Unusual in this case could for example mean papers that needs signatures from the user that is being studied, minor or major
complications could occur that needs the user to abort the current work in some way. So in this way, unusual is good for the design team because more data can be collected and this will converge into better work models.

Another reason to have six to seven days scheduled for interviewing and observing is if more interviews has to be done after observing something that wasn't there before, for example situations described above.

Since there are five interviewers the interviewing work will be in parallel and therefore very efficient. A tape recorder will be used in every interview to release the importance of taking notes and instead concentrating on the actual work. Of course permission from the user must be granted to start the recorder.

The day will start with a short and brief session where the user and the interviewer presents themselves. This session should not grow into a friendship, the focus must be on the actual work that have to be done. If the user feel more comfortable by having a cup of coffee together with the interviewer before the interview starts that is fine but the focus must not be forgotten. This presentation session will take approximately 15 minutes.

After the presentation session the interviewer and the user; feeling more comfortable with each other, continues on to the next session that is the actual contextual interview. First of the topic of focus is discussed. This will cover the interviewers reason for the study and what's important. By discussing this the user knows what to concentrate the explaining on. The contextual design guideline is to design for the users by using their natural behavior and according to the contextual inquiry the best way to learn how users are doing their work is to visit them in their working station. After connection with the user, a relationship between interviewer and user should be established. The design team will use the master/apprentice relationship model.

By carefully observe the user while doing work is a great way to learn how the work is being done. An even more efficient way is to put the user in a master role where he or her teaches the apprentice (the interviewer) while work is being done.

In every master/apprentice interview session, the focus is on collecting relevant data while keeping the user from summarizing the work. Users that are summarizing have to be interrupted because every little detail of how the user is working is important and should not be left out. What the interview team also have to watch out for is hesitations, short answers like “yes” or “no” and answers that are fuzzy or unsure. If the answer is “uhhmm yes”, that answer is actually most likely a “no”.

The interviewer will follow the user everywhere and ask about everything. If a colleague to the user wants to enter the room but is hesitating because of the interviewers presents, he will be asked to come in. If the users talked to someone in the phone the interviewer should ask who it was and the purpose of the call. Breaks are of course allowed whenever the user wants to and this could be a great chance to look over the notes.

As the day goes by the user should continue teaching the interviewer step by step. If something is unclear for the interviewer the work is stopped and a more detailed explanation is made. Of course the interruptions cannot be done if critical work is being done, this has to be remembered and discussed later on.
In the end when the interviewer feels that he has collected enough data with the user, the wrap up session starts. This session is all about confirming the notes and thoughts the interviewer got so far. This wrap up session will take 15 minutes. After this session the interviewer will process the data he gathered into a cohesive whole that can be presented at the interpretation session. Because the interpretation sessions will only take two hours, the data need to be pre-processed in order to be able to finish. If the interviewer has the feeling he has too much data to cover in a two hour session he will have to let the team know, so multiple sessions for this interview can be scheduled.

5.2 Interpretation Sessions

During an interpretation session all the ten members of the design team are present to ensure different points of view. We will walk through an interview and everyone can comment, ask questions or propose ideas. The sessions will be held in a meeting room with a big table were everyone can sit around. In this room we need five flip charts to draw work models on. We also need a laptop and a beamer to note and display insights gained during the session.

Because we have quite a lot of people present at every session we can divide responsibilities. The person doing the interview will be walking through the interview and drawing the physical model on one of the flip charts. One person will draw the flow model, one the cultural model and another the sequence model. Together they draw the artifact models when artifacts come up in the walk through. There will also be a team member recording all insights, key observations, design ideas, etc. using the laptop and displaying them using the beamer. This way all important insights gained during the meeting are present and saved for later use. We also assign someone to be the moderator. This team member will keep the meeting going in the right direction and makes sure everybody gets a chance to speak. Then there is the so called "rat hole watcher", who will notify the team when the discussion wanders of from the main topic. Because we have to do a lot of interpretation sessions we want them to be efficient. This means the rat hole watcher and the moderator will be important people during the sessions. The other three members of the team will be participants in the meeting but have no special responsibilities besides the ones every member has. So they will make comments, suggest ideas and ask for clarification when something that is presented is unclear.

5.3 The Work Models

Every interpretation session has the purpose of structuring and formalizing the user data. At the end of every session there will be a series of documents produced that will be the basis for the next step in the design process. We will have produced the five work models:

- flow model
- sequence model
- cultural model
- artifact model
- physical model

The flow model is very important in this case, because energy management requires a lot of communication between people and facilities. If we want to create a system to assist in this we need to know what communication is taking place when, where and between who.

The sequence model will allow us to gain insight in the different parts the work of the controllers consists of. Because of the complexity of the task, the sequence models we construct at this point will only include high level work steps. Getting into too much detail at this point will cause us to lose track of the bigger picture. After consolidating the different sequence models later in the design
process, we will do more in depth interviews to gather more detailed information about the work steps involved. This general version of the sequence model we construct at this point will be more of a flow diagram to indicate how all the different aspects of the work interact and trigger each other.

The cultural model will be made for every person interviewed. The general culture in one work station will probably be the same for all the people working there. But the cultural model also involves entities or persons that have an influence on the work of the person in focus. This requires a different model for every employee.

The artifact models will represent all the artifacts the people use. There might be zero to multiple artifact models made per person interviewed, depending on how much artifacts this person actually uses during his work.

The physical model, will be made for every person interviewed. Although groups of them work together in the same control center, there might be differences in the way their work stations are organized.

Next to these we will also have the list of notes made by the recorder and finally a list of mayor insights gained during the session. This list will be made at the end of the session when every participant lists his personal top insights for that session. This list is not very formal, but it is there to make sure no design ideas or insight go to waste, because they are forgotten. The created work models will be the formal description of the user data and form the basis of the rest of the design process.

6. Creating a common picture of the organization

6.1 Affinity Diagram

For creating a common picture of the organization the whole team need to be involved and present in consolidating the work models and creating an affinity diagram. In creating the affinity diagram the team will sit together in the team room and construct an affinity diagram consisting of post it notes. The post-it notes represents issues, worries and key elements that were identified during the interview phase.

The work is basically done by first writing all the captured notes onto small post-it notes. After that the team is to put one note up at the time, having the following team members to put similar notes together with the first one. After the wall is starting to get too many groups to look after, the team will begin to label the groups with post its of another color. When post its are sorted into groups the existing notes should be broken down into no more than four notes per group. The post it notes are based on all the users in involved in the system. That is 5 workers at each work site which ends up at 25 workers being represented. The team has supposedly collected 50-100 notes per customer.

The purpose of the affinity diagram is to be able to identify the broad scope of problems quickly instead of delving into detail. It is a way of making sense of all notes without adding assumptions or prejudices. The team will likely find the task very tiring and tedious and therefore it is important to set a strict deadline that the affinity diagram will finish on. In our case we will only work with the affinity diagram for one single day. Otherwise there is a great risk that the diagram will never be properly developed.
6.2 Consolidating the work models

The first step before doing any consolidation of the flow models is to select about six to nine individual flow models that are complex and cover key variants in the work domain. The consolidation is then performed by compiling a full list of all individuals responsibilities. By doing so the different roles are being captured. In this step it is likely that the team discovers overlooked responsibilities which then has to be added to the list. The consolidated flow model maps players in the customer population. The key purpose of the flow model is to identify similar responsibilities.

The purpose of consolidating sequence models is to reveal how tasks are structured and what strategies that are common across the company. However, not all tasks are consolidated. Only tasks that the system will support or be redesigned are necessary to consolidate since these tasks requires a thoroughly understanding. The tasks that are to be consolidated are identified by studying the consolidated flow models which highlights tasks that are vital for accomplishing the users central responsibilities.

When consolidating artifact models, the first step is to group relevant artifacts of similar type together. After identifying and grouping relevant artifacts, common parts are selected for further analysis regarding their intent and usage. When the team have an understanding of chosen artifacts and understand common structures and usages within each part, then the team can start to build a "typical artifact". By doing so a new and general artifact show all common parts, usages and intents.

By putting together the individual physical models, a common physical structure show the limitations and constraints imposed by the physical environment. It is necessary that the system that is developed adapts to our physical constraints or provide a way to overcome them.

First the individual physical models are grouped together by type of place. By walking these models in turn, labels are placed onto places within the model. For these identified places relevant artifacts and tools are identified and properly marked. Also essential in this step is to study movements within the physical models. Lastly, a common consolidated model is created. All intents, usages and breakdowns from the individual models are transferred to the new consolidated model. In addition, all insights during the work related to the physical work space is written down where appropriate.

In order to be able to consolidate cultural models, each individual model must be walked through, cataloged and grouping influencers using bubbles. Grouping is basically done by identifying actors who constrain work in the same way. When all influencers are found then all unique influences are added between the influencers. In doing so, all duplicate influences are discarded. Finally, when all this is done, a final model can be drawn. In the final model all unique influencers and their influences are shown. The purpose is to show what pressures users feel and respond to.

6.3 Expanding the sequence model and filling the gaps.

After consolidating the work models, we need to extend the sequence model, because it only covers very general steps of the work process. In order to design the system we need more details about the work steps. In addition to this we need more information to fill potential gaps in the consolidated work models. To do this we will need to perform more interviews and observations. We will go back to one of the control centers and do more interviews and observations. Here we assume that the work practice of the different control centers is more or less the same. If the earlier interviews indicate that this is not the case than we will have to reconsider this decision.
The interviews will be performed by the HCI specialist, the GUI specialist and the three software engineers that are working on the project full time. First there will be interviews with the 5 employees of the control center. The interviews will consist of two parts. The first part will be dedicated to obtain as much detailed information about the work steps as possible. The second part will consist of specific questions to get the information we need to fill the gaps in the consolidated work models. After a day of interviews there will be a three day observation period in which the findings of the interviews will be verified. After the observation, there will be another day of interviews. These interviews will consist of specific questions that address possible inconsistencies or missing pieces of information.

The information obtained by these interviews and observations to expand the sequence model is processed in three groups of two people. The people involved at this point are the six team members working on the project full time. Each group will walk through part of the consolidated sequence model and try to expand the steps as much as possible. When finished the groups will come together to present and combine their parts and maybe change some aspects if problems arise. After the expansion of the model, it will be presented to the entire team in order to create a common understanding. This way a very detailed version of the sequence model is created that can actually be used to guide the design process.

The same method will be used to fill the gaps in the other models, although these sessions can be fairly short. If correct and to-the-point questions have been asked during the interviews, the sessions will really be only a matter of filling the gaps. We will schedule 4 sessions, one for every model. Every session will be attended by three team members and two sessions will be held at the same time. The team members involved at this point are still the ones working on the project full time. The sessions should not take more than one or two hours, depending on the number of gaps. After all the models have been completed, a day will be scheduled where the entire team walks through all of the models. This will help the team to see the total picture and perform another check to see whether the models are complete and do not contain any errors.

This process will take about 11 days in total. First there will be 7 days for the interviews. This includes the two days to travel back and forth to the control center. Then there will be two days scheduled to combine expand the sequence model and present the result to the entire team. And there will be two days scheduled to complete the other models and walk through them with the entire team. After this process is completed we should have five complete consolidated work models which we can now start to analyze to create a common vision.

7. Model Analysis

In order to understand how we should design the new system we need to analyze our consolidated models. Analysis of the model will expose problems and reveal how the work is carried out. Three days will be spent by the hole design team analyzing and reviewing the consolidated models. The design team will use the result from analyzing the model as an guide when creating the vision for the new system.

The design team will use the flow model as a starting point their starting point establishing what work roles are related to which user or user group. By mapping roles to individuals the design team can use the flow model to investigate if there are problems with the current work routine. The team will primarily look for unnecessary role switching, role strain and role isolation. Unnecessary role switching occur when a person switches between too many different roles and role strain is when
people aren't able to perform well because they have to act in to many roles at once. This model will also be used to identify role sharing problems. Role sharing problems are when many users are sharing the same roles regardless of their actual job or skill set.

Analysis of the cultural model will reveal to the designers what cultural values the company and the users have. It will also reveal relationships between users and user groups. This cultural insight will help the design team to identify interpersonal frictions and unofficial policies. The model will help the team recognize need for change to managerial structures or processes.

The physical model evaluates how physical space and environment affect the work routine and the team will use the model is to see what what physical constraints there are, and what can or cannot be changed. In the model the the design team can review the physical structures users create around them selves and analyze what actually is used to carry out the real work. The flow of movement of users and artifacts show important stages of the work and the physical layout and can reveal additional work routines and work strategies. The designers can use the physical model to identify key procedures that are vital and match the physical workspace with the work routine.

The sequence model is a direct overview of the work tasks broken into activities and the design team will use it as a guide to see the structure need to match and extend the way users approach an task. Every sequence in the model has an intend, the reason an task is being carried out. The designers must design an system that accounts for all the intends of the users but in an more affective and direct way. This model will help the design team to identify and analyze steps that are unnecessary, steps that do not help to archive the tasks intend, and reflect over what gets users attention. Because we have extended the sequence model with a more general flow model of the work and how different tasks interact and trigger each other we are able to get a better overview of the complete task of energy production management. This will be needed to design a system for this task, because there are a lot of different aspects to it. Some subtasks might be inefficient or are often performed in sequence or together in parallel. We need to know this in order to create a system that supports the entire process.

The design team need to see the detailed structure underlying a task and how that plays out when it is made real as artifacts. For this they use the artifact model that shows the common structures and intends of the different artifacts used.

8. Vision & Storyboard

After analyzing the models and establishing the current work routines the design team use the findings to create a vision for the new system. The designers will trough visioning sessions, that will be repeated over a period of time in various forms, form a vision.

The vision sessions will conducted by a session group consisting of all the design team members and four users. They will be six sessions in total and the four users of the session group will be rotated, meaning there will be two sets of users with four in each set. Each set will be given three session occasions. The series of sessions will be conducted during the span of twelve days with one session being conducted every two days, meaning the design group will have one day after every session to review it. One of the design team members will act as the “pen” during the sessions, that person will coordinate the sessions and he or she will be changed for every new session. All ideas and suggestions will be considered during the two first sessions. The members will then discuss and reflect over possible solutions during the remaining sessions. The group will systematically dismiss
too ambitious and incorrect solution. After all six sessions are completed the group will have a set of visions for the new system. These visions will be composed by all the different ideas and approaches wanted by all session group members.

Instead of picking just one of the vision envisioned during the visioning sessions the design team will create a common direction that is composed of all visions envisioned at the sessions. The team will do so by identifying all positive and negative parts of each vision and create a new common vision consisting of all the positive part of each of the different visions. This common vision will now be the teams guide line to the new system. A vision drawing will be created to get a clear overlook of the hole vision. The vision drawing will be a single drawing showing all parts of the vision together.

The vision drawing will be used to make a storyboard that will show how all tasks will be accomplished with regards to the vision new vision. Every frame in the storyboard will describe an event taking place in the new system. The storyboard that is based on the new vision will follow the structure of the consolidated sequence model. The design group will spend two days after the visioning sessions deciding the vision and creating the vision drawing and the storyboard.

9. Design

In order to maintain a successful design process, the design team will alternate between sequential cases and structural models. Before designing the user interface the structural design will be completed and this will be done during 5 five days in form of an User Environment Design (UED). The UED design group will consist of two GUI specialists, three software engineers and one HCI specialist.

The UED will be made to represent the system work model and it will show all part of the system the users know or care about, what aspect of the work each part supports, and how parts of the system relate to each other. The UED will help the design team to bridge the gap between the storyboards and the user interface and aid the overall planning.

The goal of the UED is to present structural issues, making the key considerations silent for keeping the user’s work coherent. In the UED places are represented as focus areas, where you focus on doing a certain kind of work and every focus are has a purpose. The focus areas will be linked to others focus areas while performing an tasks, and focus areas can be in the context of other focus areas. The designers will use the storyboard to make the UED. Unlike the storyboard that is sequential and run a single thread the UED will be structural and reveal how all the threads fit together coherently. The design team will generate the actual UED by discussing each cell in the storyboard that identifies and captures new focus areas and existing focus areas.

Only what the users care about and interact with will be visible in the UED and it will represent both the software and the hardware. Both the storyboard and the UED will help design the User Interface (UI). Having both the storyboard and the UED as foundation when making the UI will enable software developers to make the system that will support unforeseen ways of working.
10. Prototyping

Prototyping and prototype interviews should be done no later than a month after consolidating the models first started. By now the team should have a mutual understanding of the customers work and a vision through the UED and storyboards.

So how do our team communicate design ideas to the customers and get proper feedback on them? One issue is that we want the customers to act as co-designers and make them contribute to the design development. Also, by having the user co-design the system we will build a trusting relationship and build a mutual understanding of the system. A vital result of this is that the customer builds acceptance of adopting the system.

One of the most important tools when the design team is to communicate design ideas are paper mock-ups. These mock-ups are based on the User Environment Design and storyboards that was created during the design phase. A major advantage when using mock-ups is that the customer articulate their tacit knowledge and thus transfer this knowledge to the interviewer and the design team. Another advantage using paper mock-ups is that the customer doesn't get distracted by fancy user interfaces, focus on structure instead and invite change suggestions. Our team will use basic on the shelf products such as tape, post-its and "brown paper" for creating prototypes. It is very important to make the creation of mock-ups as easy as possible for the staff to be willing to create them.

Prototyping using mock-ups are divided into several interview sessions. The first round of interviews focus on basic work structures and requirements on the system. In all sessions however, the interviews focus on pretending to do real work and discussing the interaction of the system.

An important issue which the design team will have in mind during prototyping is to iterate quickly and not to invest too much time in one design alternative nor discussing the alternatives. Since we iterate quickly and test the paper mock-ups on the users, the user will be the decision maker. A good guideline is to construct a paper mock-up for one or two days only and then test it on customers the very next day. However, our aim will be to visit the customer every ten days for testing purposes. By having regular contact our team will naturally move forward.

We expect that three iterations with the customer will settle each part of the User Environment Design. Hence, each part will approximately take about 30 days to test. As the parts starts to focus more on user interface issues than on structural issues, testing another part of the system starts. Hence, the parts are not tested in a sequence but instead testing of another part will start as one start to settle.

Another issue to have in mind when interviewing is that there is a great chance that new structural issues that haven't been thought on will show up in the prototype interviews. Therefore our interviewers need to be able to quickly switch to gather contextual interview data. If this happens, the interviewer brings back this information to the design team to go back a few steps in the design process. Thus, our design team will likely need to improve existing models and visions with this new information. It is important to note though that this is not done for minor issues that doesn't have a structural implication.

When the design process has come so far that prototypes starts to finalize, it should be a system that is very close to the users requirements and needs. Also, by continuously iterating design suggestions our team should have constructed a detailed user interface design which is stable,
consistent and useful. The end result is a complete system that is illustrated through paper mock-ups which also is the end deliverable. Now we are ready to take our project to the next level and make the transition to a planned implementation.

11. Discussion

Contextual design seems to be a reasonable method for user involved design. There are however a few remarks to be made, because we do not agree with some parts of the method.

The method is very labor intensive. A lot of models need to be produced and this can be a disadvantage if time is limited. Also if a system needs to be designed for a very diverse group of users the amount of models needed can get out of hand. For some smaller projects this method might not be worth the time it takes to properly execute it. One could leave out some aspects of the method to make it easier and quicker to execute, but it is hard to know what can safely be left out.

Next to this, the information from the five different work models might be hard to combine when creating a vision. They all contain important information, but there is no display of a possible connection between parts of information in the different models. When integrating the information from the models it might be easy to miss some connections that should have implications on the design. A more comprehensive total model including the aspects of these five distinct models might be a better solution, but whether it is possible to include everything in one model is subject to debate.

We think the models do contain important information and are very useful for design, but in our opinion the sequence models are not sufficient for modeling the work practice. They are very linear and this seriously limits their expressiveness. We extended the way sequence models should be made with a general version that shows how different aspects of the work interact and trigger each other. This is a flow diagram, which tries to overcome the limitations of the linear nature of the traditional sequence model. There may still be the risk that aspects of tasks interact with each other on a lower level. So maybe the sequence models should be totally replaced by another modeling method.

Contextual design has a good focus on keeping in touch with customer, but there is still a huge part not involving the customer where only the cross cultural team is involved. A possible solution would be to make iterations in shorter cycles, thus keeping customer interaction more frequently. We tried to convert contextual design to a more iterative approach, but we could not find a solution. The artifacts produced, such as the work models, are quite specified to cover the entire work process and are hard to incorporate if the approach is made iterative.

The method used in studying and data gathering is a great method because it is based in the center of work where the action is. The result is good quality data which depends on how long time the interviewer stays. In this case we think good data are collected if the user study covers at least six to seven days. If it takes less time, there could be a lack of information about the workplace and the user's way of working. The interviews is a vital part of the whole design process so this is a section that you don't want to miss out of. If you have to pick the right users to follow, you have to describe the focus so the users really understand it and you have to ask the right questions because you base the new design on what the users tells you. It is very hard though to make a decision on how long to plan for interviews.
12. References