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Usability Analysis of the Human-Machine Interface in the Tetra PlantMaster

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Master Thesis

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Abstract

The goal with this master thesis is to examine the usability in the Tetra PlantMaster. Tetra PlantMaster is the control system for the dairies that Tetra Pak develops.

Tetra PlantMaster is the system which the operator uses in order to govern the entire process when raw milk becomes a product ready to be delivered to the grocery stores. This includes applications to produce soured milk, yoghurt, icecream and numerous other dairy products.

The idea behind Tetra PlantMaster is that one or a few operators are supposed to run and control the entire process from when the raw milk arrives at the dairy to the point when the finished product leaves the plant. In order for a few operators to maintain the entire plant it, is crucial that they can absorb much information from all parts of the process in a very effective way and that all adjustments can be done in an available and effective way.

In order to examine if that is the case, a study in mainly three parts have been made. The needs of the operators have been surveyed and compared with Tetra Pak internal guidelines on usability and a thorough investigation of the technical literature on the subject.

Through interviews with the operators in connection with a visit on a dairy, interviews with engineers that have big customer contact and questionnaires to Design Owners, the needs and wants of the operators have been surveyed. Several different document concerning Tetra Pak internal guidelines have been studied and technical literatures have been studied in order to understand what good usability really is.

These three parts have been compared in order to analyze how good Tetra PlantMaster is in comparison to prevailing scientific theories. In order to be able to compare the different part in a good way an analytical tool called GOMS have been used.

The result is a point out regarding the weaknesses of Tetra PlantMaster and a number of recommendations on how to prevent these weaknesses.

Sammanfattning

Syftet med detta examensarbete var att undersöka användarbarheten hos Tetra PlantMaster. Tetra PlantMaster är styrsystemet för de mejerier som Tetra Pak utvecklar.

Tetra PlantMaster är det system som operatören använder för att styra hela processen när råmjölk blir färdigförpackad mjölk som är färdig att levereras till butikerna. Vidare finns också applikationer för att tillverka filmjölk, yoghurt, glass och en mängd andra mejeriprodukter.

Tanken med Tetra PlantMaster är att en eller ett fåtal operatörer ska kunna köra och styra hela processen från det att det kommer in råmjölk till mejeriet till att det blir någon form av mejeriprodukt. För att styra en hel fabrik med endast ett fåtal operatörer krävs det att de kan tillgodose sig mycket information från alla delar av processen på ett effektivt sätt och att alla justeringar och inställningar kan göras på ett tillgängligt och effektivt sätt.

För att undersöka om så är fallet har en studie i huvudsakligen tre delar gjorts. Operatörernas förhållanden och behov har kartlagts och jämförts med Tetra Paks interna riktlinjer för HMI och en grundlig litteraturstudie.

Vilka operatörerna är har kartlagts genom, intervju med operatörer i samband med ett besök på ett mejeri, intervju med ingenjörer som har stor kundkontakt och frågeformulär till Design Owners. Flera olika dokument angående Tetra Paks riktlinjer för HMI har studerats likaså har facklitteratur studerats för att förstå vad bra användarbarhet är.

Dessa tre delar har sedan jämförts för att analysera hur bra Tetra PlantMaster är i förhållande till rådande teoribildning. För att kunna studera relationerna mellan de olika delarna på ett så bra sätt som möjligt har ett teoretiskt analysverktyg, kallat GOMS, använts.

Resultatet blev ett påpekande om var Tetra PlantMasters svagheter ligger och ett antal rekommendationer på hur dessa kan förebyggas.

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Design Owners for answering the questionnaires.

Thank you!

Anders Lyddby

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1 Introduction

1.1 Background

The Tetra Pak group is a one of the world's major supplier of beverages for dairy products and liquid food. The company have over 20 000 employees and is operating in over 165 markets world wide.

In 1991 Tetra Pak expanded into liquid food processing, cheese manufacturing equipment and plant engineering. Today it is the only international company able to provide an integrated processing, package and distribution line.[1] Now Tetra Pak can deliver a complete dairy, including pasteurizers and other needed processing units, where raw milk is being processed into many different dairy products.

In order to sustain this process a supervising system and a certain number of operators is needed. For the supervising system the Tetra PlantMaster is developed and it is constantly further developed and restructured in order to improve the working environment for the operators.

In order to fulfill the requirements from the users, in this case the companies that order the plant, Tetra Pak provide a template which is customized according to the desires of the customer. To make the process of adjusting the template to the requirements of the customer, the templates need to be developed constantly.

A crucial part in the templates of the Tetra PlantMaster is that the interface between the operator and the Tetra PlantMaster is effective and that the operator finds the system understandable and easy to use.

The process of design is iterative. A design is made, and then it is evaluated and redesigned in accordance with the outcome of the evaluation. This master thesis will consider the design of parts of the interface in the Tetra PlantMaster. And it will serve as a part of the design process that will develop the Tetra PlantMaster.

1.2 Goals

The goal with this thesis is to uncover shortcomings which may, or may not, be found in the usability of the interface in the Tetra PlantMaster. If any shortcomings are found in the interface, the intention is to provide recommendations on how such shortcomings can be eliminated.

To reach the goal of this thesis three different parts have been compared.

1. The operators have been surveyed
2. Scientific papers have been studied
3. Tetra Pak internal guidelines have been studied

[1] http://www.tetrapak.com/ 2008-01-15

These three parts will be compared and analyzed and thus providing an appropriate foundation for uncovering any shortcomings and if such shortcomings are found, also provide an idea on how they are eliminated in a easy way.

1.3 Limitations

There are two main reasons to put limitations in the investigation of the Tetra PlantMaster.

1. Tetra PlantMaster is a very big system. If the whole system where to be thoroughly investigated it would be very time consuming and it would not fit in to the scope of one master thesis.

2. The whole system has not yet been developed. Only those parts that have been developed to the degree that they can be investigated in a meaningful way are included, thus putting very clear limitations to the investigation.

3. A Simulation tool (InTouch) has been used to theoretically study The Tetra PlantMaster. Since there was no real process running, parts of the system had to be shut down in order for the simulation to work.

For these reasons two different kinds of limitations had to be made. Some limitations where made due to the early stages of the developing process. The initial idea was to include the alarm handling process in the investigation. Due to the third point made above, the alarm handling could not be studied theoretically. Due to the early stage in the developing process only one process cell was in working order. This meant that the overall picture, overview and cooperation between the different process cells in the system could not be studied theoretically. The emphasis on this investigation is therefore within one process cell.

Even within one process cell there are a vast number of applications and functions. To further limit the scope of the investigation, all the operators, engineers and Design Owners were asked to list the five most frequently used applications. The five applications that turned out as the most frequently used are the ones chosen to be most thoroughly examined. Also the consistency in the interface will be examined and if there is good consistency in the process cell statements can be made about the entire process cell.

2 Usability in theory

2.1 What is Usability?

The word usability means that the people that use a product can do so quickly and easily to accomplish their own tasks. This definition comes up from four points, which are essential for understanding what usability really are[2].

1. Focusing on the user[1]
2. People use products to be productive[1]
3. Users are busy people trying to accomplish tasks[1]
4. The user decides when a product is easy to use[1]

This means that to develop a usable product it's important that the developer know, or understand, how the potential user works. No one can fully replace the potential user, hence the first point.

How easy a product is to use is often evaluated in terms of how easy it is for the user to predict the next correct action to take, the number of steps one have to go through to accomplish a given task or simply the time it takes for the user to get what they want. Therefore, to achieve good usability, you have to be aware of the tasks that will be automated using a certain product, and hence the second point.

Usability is connected to productivity. Everybody wants to accomplish their goals both at home and in the office. If one wishes to listen to music, the users' goal is to listen to music and the stereo is the tool the user uses to accomplish the goal. The manual for the stereo is in turn a tool for helping the user to use the stereo. The time that the user is willing to spend on learning to use the stereo is often very low. I.e. the time people are willing to spend on learning to use something is often very low, hence the third point.

Neither designers nor developers decide when a product is easy to use, the user does. The user constantly balances the time it takes to learn something with what they think they will gain from learning it. This often leads to the user reaching a level of knowledge and then staying there. Imagine the percentage of the available functions in Word that the average user uses. The reason why users do not learn all of the applications in for instance Word is that it is not easy enough to use, hence the fourth point.

Generally it can be said that there are two types of products. Products that are supposed to be used by everyday users and products that is supposed to be used by users with a special competence within a given area. The first product type can typically be a cell phone or a stereo. Users are supposed to be able to use these at once preferably without using the manual. Hence, the system should be very easy to use and very easy to understand.

[2] A Practical Guide to Usability Testing p. 4

On the other hand, if the system is developed to be used by an expert user with an education on the given system, then it does not have to be as easy to understand. Instead the focus should be on flexibility and response time in the system.

However, there are still a lot of things the two types of systems have in common. The easier a product is to use, the more logical and predictable it is and the more people will use it. They will also learn and work faster and most of all, they will use more of the product. This means that the easier the product is to use the more they will use it.

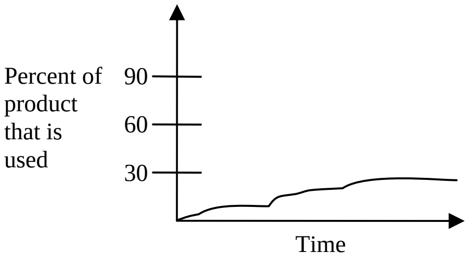

Figure 1a. With bad usability

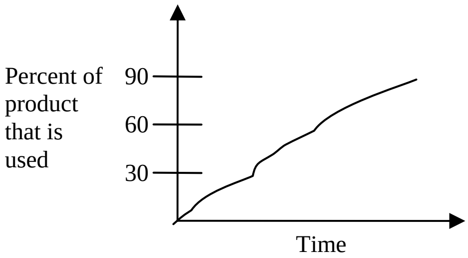

Figure 1b. With good usability

Figure 1a[3] and 1b[2] shows the impact good usability can have on a product. From this it becomes very clear why usability should be part of the design process in general, and in interaction design in particular.

2.2 Why Human Machine Interaction (HMI)?

During world war two human factors was developed by the US-army. Human factors was developed as an attempt to reduce the injuries among their own troops caused by their own equipment. It was soon realized that in order to create a good interface between the soldiers and their machine, the developers needed to understand how the human mind works, so that they could make the machines usable. This, in turn, lead to the science that is called Human Machine Interaction.

Today Human Machine Interaction is much more complex. It has gone from being an interaction between one person and one machine, to being an interaction between many persons and many Machines in many different situations. This has led to the need for many more specialists to participate in the development of HMI or human factors.

[3]Authors interpretation from A Practical Guide to Usability Testing p. 6-7

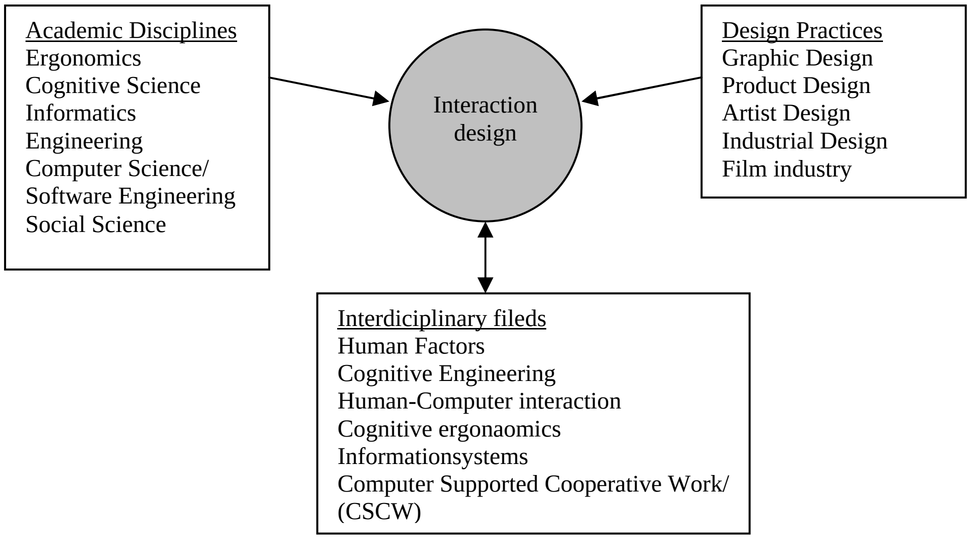

Figure 2. Authors interpretation from Interaction Design p. 8

Today Human Factors or Human-Machine interaction is almost synonymous with Human-Computer interaction since most machines are runned by, and controlled through, a computer. Never the less, this unavoidable leads to the question, what is good Interaction design, or what is good Human-Computer Interaction?

Finding usability for an interface means that you want to optimize the interaction between man and computer. According to Preece et al computers, or any interactive product with good usability, are supposed to:

1. Match wants
2. Support needs
3. Extend capabilities

It is easy to think that “match wants” and “support needs” are the same thing, but it is not. Match wants is very straight forward. It simply means that the computer shall provide the functions that the user wants.

To support needs and extend capabilities is not that simple. Most of the time the user does not really know what they need. This could be to the fact that they don’t know what is possible or the fact that the user doesn’t know what they “need” until they have it. Imagine asking people in the mid 80’s what they need to improve their working environment. Very few, if anyone, would answer: I need access to a good part of the worlds combined knowledge through the world wide web, or even fewer would answer, I need one gadget that combines my phone, calendar, business contacts with the World Wide Web, and it needs to be portable so that I can carry it with me everywhere. Hence, the way to identify needs and extend capabilities is not simply by asking a question what the person need, it is rather a question of understanding their capabilities and characteristics, and trying to understand what they are trying to achieve. Then there is the question of whether they achieve their goals more or less effective using the tools you want to provide.

2.3 The process of designing a usable interface

From this explanation it is clear that it is not easy to design a usable product. When designing a usable product, or designing a usable interface, the design process has to be iterative. In order to smoothly go through the design process, usability engineers and designers have developed numerous models and templates which help in the process of testing and evaluating the design. Some of them are explained and used in this thesis.

The iterative process also means that one have to define usability goals (i.e define requirements and identify needs), design a prototype, test the prototype, evaluate and then redefine the usability goals, and so on.

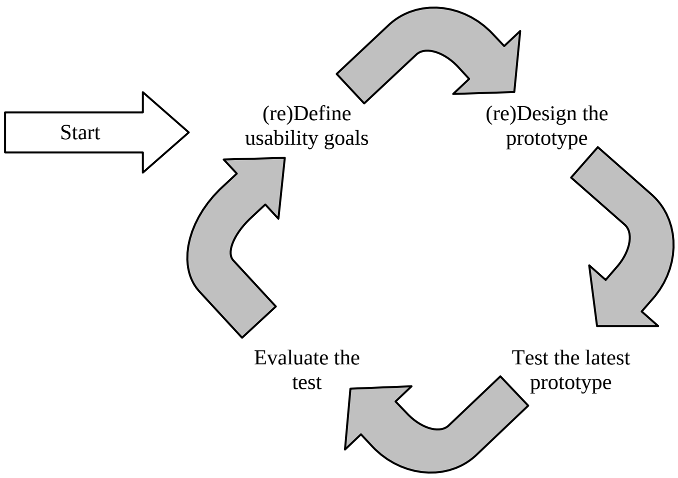

Figure 3. Authors interpretation of a design process found in most literature on Usability.

To be able to test a prototype, evaluate the test and define usability goals, it is of great importance that the person conducting and evaluating both the test and the goals have some theoretical knowledge. Also the person reading the valuation need to have some basic knowledge about designing HMI and human cognition to fully understand the choices and conclusions that are made from the evaluation.

2.3.1 Basic cognition

Basic cognition is what goes on in the head when someone carries out their everyday activities. It includes things like thinking, daydreaming, reading, seeing, writing and talking. These processes have been separated into different categories which, among others, include:[4]

Attention: This is the process of sorting out what to concentrate on from the many available choices at any given moment. It allows people to focus on what is relevant to what they are doing at the moment.

[4] Interaction Design p. 75 ff.

Perception: This is the process of acquire information through the different senses and turning it into experiences. This is a very complex process and involves many other different cognitive processes.

Memory: This is very versatile and it enables us to do many things. It is the memory that allows us to act in a suitable way in any given situation due to the knowledge stored there. The Memory can be divided into long term and short term memory. Long term memory enables us to remember things in the long run. This memory works quite slowly and it takes time both to store information there and to retrieve it once it is needed again. The short term memory is a lot faster. But as the name suggests it only works in the short term, which means that information stored there will be lost if not used immediately. It is also very small. It cannot hold more than five through nine variables at the same time.[5]
Furthermore, the process of remembering is not without problems. Most people forget things they want to remember and vice versa. So the question is: How does the filtering process work? Essentially it works with encoding. You determine which information is important and you put it in the environment around it. So seeing things out of context could lead to that you would not recognize the person or object just because it is out of context. Another well known fact is also that people are much better at recognizing than on remembering.[6]

Problem solving, planning, reasoning and decision making: These are processes that are known as processes involving reflective cognition. They include thinking on what to do and what the probable consequences could be. Therefore they often engage conscious processes. What decisions people make depends on their previous experiences. Especially a beginner tends to make decisions on knowledge from prior comparable situations. This could lead to a trial and error approach, which makes them quite ineffective. On the other hand, a skilled user will be able to make adequate decisions and choose appropriate actions to achieve their goal. Thus, they are more likely to think ahead.

2.3.2 Things to think about when designing a usable interface

As mentioned, there are a couple of things to think about when designing a usable interface. Many of these are thoroughly explained by Dan Norman in the design of everyday things. Here are some of the definitions revised in short.[7]

Mapping: This is the relationship between the control and the impact that the control have on the system. Good mapping means that by looking on the control it is understood what that particular control does in the system. Furthermore, this is not limited within one control button. The relative position between the different controls is equally important. The later is to show the relative function between the buttons. A good example of this is the relative position of the rewind, play and fast forward buttons on a media player.

[5] Interaction Design p. 82
[6] Interaction Design p. 79
[7] The design of everyday things p. 10 ff

Consistency: Human cognition suggests that a person who is faced with a certain problem often tries to solve the problem using prior knowledge. To make use of this, it is of great importance to be consistent when designing an interface. Similar functions should use similar controls to reach similar goals. A consistent interface should also follow rules, i.e. use the same procedure to select an object in a menu regardless of where in the interface it is. This will lead the operator to learn how to maneuver the interface faster and more efficient. In a big system consistency is even more important. There it is impossible to have all the controls visible at the same time. Therefore they have to be organized into subgroups which means that the operator has to learn how to use the system. Furthermore, how the functions are structured within subgroups must also appear consistent. From this rises a new problem. What should be consistent with what?

Affordance: This term is used to refer to what kind of action the visual attributes of an object invites a user to do. For example, the wheel on the mouse invites scrolling and the button invites clicking. Therefore the wheel *affords* scrolling, and the button affords clicking. This definition was introduced buy Norman in the mid 80's and to afford means "to give a clue". However, Norman points out that affordance is not the only tool when it comes to designing interfaces. Other tools and concepts like mapping conventions, feedback and cultural or logical constraints are equally important and effective.

Feedback: Another important aspect of designing interfaces are the impact of feedback. Feedback is the process of sending back confirmation about an action to the user. When users try to perform a task they generally need some kind of feedback. This could be in form of sound or a visible effect. For example, changing color or changing structure of the buttons. It is also possible to use different combinations of these. Deciding which combination to use for different actions is crucial. The feedback should be proportional, meaning that major actions should give major feedback and small actions should give moderate feedback.

Visibility: Visibility is closely connected to feedback, and it is of equal importance. The more visible a function is, the easier the user will understand what to do next. On the other hand, if the function is "out of sight" it is a lot harder for the user to understand how to proceed.

Constraints: This is different ways of limiting the user to perform certain tasks that would be wrong in any given moment. A classical constraint would be to gray shade certain functions in a computer interface when they are not available for selection. This is simply to constrain a user from using them in order to avoid mistakes.

According to Dan Norman these constraint can be divided into three groups. Physical, logical and cultural. Physical constraints is simply making it physical impossible to perform a task in the wrong way, or make a choice that is wrong at the moment. An example of this that an USB-cable can only be connected to a computer in one way and that is the right way. Logical constraints rely on people's way of thinking about their actions and corresponding consequences, i.e. logical constraints are built on people's common sense and their understanding of how the world works. For example, gray shading options that are not available for selection in a menu is a logical constraint. Cultural constrains uses learned conventions. An example could be the use of red for warm or warnings. Since these conventions are often quite abstract they can grow in any direction therefore they have to be learned by the user. Once they are learned and adopted by a cultural group, they can be used extensively.

2.3.3 Using the definitions to make good design

Just theory can be very hard to absorb and the expressions and language can be hard to understand for those how do not have the time to get familiar with it. It also takes time to get aquatinted with the way of thinking within a certain subject. Therefore, researchers are trying to help in different ways. To make the theories simpler to understand they have introduced different sets of tools including:

1. Design principals and concepts
2. Design rules
3. Analytical methods
4. Design and evaluation methods

Common for all these are that the emphasis is on applying theoretical knowledge on design tools in order to make them more practical, and to make them usable even with the latest research development in mind.

Conceptual- and mental model: An important aspect of usability design is to create a good conceptual model[8] and mental model.[9] The concept of mental models and conceptual models are connected very close together and they are often interchangeable.

A mental model is the model that the user develops in their heads in order to try to put the different parts of the system together. It is their model of how the different parts of the system are linked.

A conceptual model also has to do with the general structure of the system. It is the designer model of the way that things are supposed to be connected. There are numerous ways to display the conceptual model and each have their own advantages, depending on what you want the user to be able to do. If the users should be able to use and develop their own understanding of the system, then the conceptual model should be more detailed. If the designer just wants the user to be able to use the interface without any knowledge of how the system works or possibility to gain more understanding of the system then another type of conceptual model can be used. This is called a black box model. This means that the user only has to provide the input data and the user will not see anything of the process, they will only receive the results.

However, a mental model and a conceptual mode that looks the same for an interface does not necessarily mean that it is a good design. Not if the conceptual model of the interface is bad, then the design will be bad even though the two models are alike. The important thing is that the two models relate to the real interface and real system in a

[8] Human-Computer Interaction p. 66-69
[9] Handbook of Human-Computer Interaction p. 21

appropriate way. If the designer of the interface manages to make the interface so good that the user develops a mental model that is the same as the conceptual model and relates to the true model of the interface and system in a useful way, then it is a good design.

Recognition: To achieve a good design, the system should be built on recognition rather than memory.[10] This increases the usability in the system considerably, and it basically means that the user should be able to recognize one part of the system after learning to use another part of the system and it is not limited to that. As mentioned before, users tend to apply their prior experiences when trying to solve a problem. This is especially true for beginners, hence the consistency in the design plays a big role.

Grouping: Another important aspect of mapping is the need for grouping things in the right way. Users tend to think that buttons that are placed together have similar, or related, functions. That raises the question whether these functions should have similar symbols or not. If the users know what the icon for a given function looks like or if the icons have very good natural mapping, then the sought icon pops out from the rest if it is a bit different. On the other hand, if the user need to read on the names of the icons then it is easier to have similar icons. This makes the names of the icons stand out more.[11]

Error handling: When a problem of any kind arises, the user tend to forget all about the previous actions and only focus on the problem at hand. This is called selective action and it is very common for any kind of user. Since the users only focus on the problem at hand they can neglect to check other crucial variables, which could lead to errors. Also, when adjusting for the first error, the user often fail to recognize the correlation between the adjustment and the effect it has on other variables. So by adjusting for the first error they will create another error.

If an error can be made, sooner or later it will be made. This is something that the designer needs to keep in mind when they design an interface. There are several ways to design for errors. The best way is to design the interface so that the only way to carry out an action is the right way. This is called using a forcing function[12] e.g a choice in the menu is only available for selection when it is the right choice to make. In many cases it is not possible to design things using only forcing functions. If that is the case then the designer should make the design so that no crucial errors can be made and it should always be possible to go back one or more steps in the interface. This is a way of making the impact of the errors as small as possible.[13]

From the points made above, many general principals concerning HMI have derived. This is good because they describe the core of what a usable product should look like. And when testing whether a user interface is usable, consistency with these principals is the thing that would make an interface usable. And inconsistency with these principals is what makes the interface less usable.

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[10] Interaction Design p. 79
[11] Handbook of Human-computer Interaction p. 807
[12] The design of every day things p. 132 ff
[13] The design of every day things p 200

One of these sets of principals was developed by Ben Shneiderman in 1992. And it is called *the eight golden rules of usability design.*

These are:[14]

1. **Strive for consistency**: A user should be able to recognize different parts of the system even though they have only seen one part before. This is easier if the designer is consistent in every way, meaning that similar situations require similar actions and that the design is consistent in the layout in terms of colors, buttons, shapes and icons, throughout the whole system.

2. **Enable frequent users to use shortcuts:** As the user becomes more used to the system the requirements from the user changes. Expert users user wants the system to be fast and they want to reduces the number of steps that needs to be taken in order to achieve their goal. This can be done using shortcuts for the frequent users.

3. **Offer informative feedback:** In any situation feedback is crucial. The meaning of informative feedback is that the feedback should be semantic, e.g. it should be proportional to the impact of the action taken, i.e. minor action should give modest response and major actions should give major response.

4. **Design dialogs to yield closure:** When the user needs to perform a task the interface should be made in a way that makes the user feel satisfied and ready to move on to the next task when the fist one is finished.

5. **Offer simple error handling:** the best design does not allow errors to happen. However, this is impossible - errors are unavoidable. Therefore the system should support the user to find their way back after an error has occurred.

6. **Permit easy reversal of action:** Always try to make an action reversible. This makes it easier for the user to explore the system. Also, the nervousness will be minimized when the user knows that there is a possibility for reversing a wrong turn.

7. **Support internal locus and control:** users should feel that they are in control of the system. Therefore they should be the initiators of any action and they should feel they are the ones making the decisions. If that’s not the case, the users will be more anxious when using the system.

8. **Reduce short term memory load:** As stated before the short term memory is quite limited. For that reason it is desirable to reduce the short term memory load. This can be achieved by keeping the interface simple, and by designing the interface in a way that makes use of the users past experiences. Also, good natural mapping makes the interface understandable, which in turn leads to a reduction of the memory load.

[14] A Practical Guide to Usability Testing p. 55 ff

These rules are generalized and can be compared with other sets of rules, developed by other interaction experts. They also have a couple of things in common; they all stress the need for:[15]

1. Giving the user control
2. Strive for consistency
3. Smoothing human-computer interaction with feedback
4. Supporting the user's limited memory

These four point are essential for usability and can be used as a central guidelines or starting point when designing a usable interface.

2.4 The need to define goals

The need to identify goals, and thereby requirements, for the interactive product is important. Actions take place in order to achieve a goal; therefore goals should be as important as the task in the design process. In some cases the user does not care about the task that needs to be performed. They only care about the results, or the goal, and getting there as easy as possible. The goals are also important from the designers' point of view. Obviously the designer must know what to aim at before they start to design the product. However, in order to make the goals usable in terms of making them realistic for the intended user and for the task at hand there are some things that need to be thought of before setting up the goals.

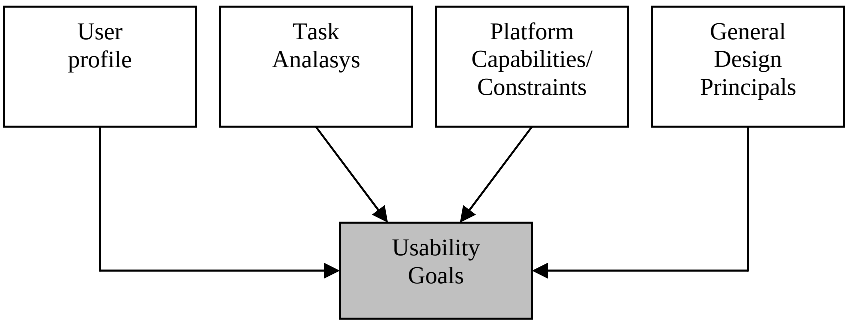

Figure 4. How to set up usability goals as a part of the usability engineering lifecycle from Interaction Design p. 194

This is also true for usability goals. Usability goals are often divided into different subgroups. One subgroup can be reviewed as a separate goal. The specific subgroups are[16]:

1. effectiveness
2. efficiency
3. safety
4. utility
5. learnability
6. memorability

[15] A Practical Guide to Usability Testing p. 56
[16] Interaction Design p. 14

These all derive from the more general goal concerning usability, which is that the product should be enjoyable from the users´ prospective.[17]

1. **Effectiveness** is a quite general goal and it shows how good a system is at doing what it is supposed to do.

2. **Efficiency** is related to effectiveness and it refers to how well the system supports the user in performing the task.

3. **Safety** relates to environmental requirements discussed later in this chapter. It refers to protecting the user from hazardous situations and unnecessary risks. It also refers to the users perceived fears of doing something wrong and the effects of that action.

4. **Utility** is about allowing the user to do what they want by providing the right kind of functionality.

5. **Learnability** refers to how easy it is to learn how to use a system. As stated before, a user does not want to spend much time learning how to use a system. They want to get stared straight away. However, with a bigger variety of applications in the system the users are willing to spend more time learning to use the system.

6. **Memorability** refers to how easy it is to remember certain functions in the interface once it has been learned. As mentioned before, the human memory works in a special way and because of this the interface has to be structured in a certain way. Sequences of actions need to be logical and icons need to be logical and meaningful and they should rely on natural mapping.

So far, we have stated general principles for usability design. But in order to make a design usable for a specific task it is important to take the requirements for that specific task in account when designing an interactive product. This means analyzing the intended user, the task that need to be performed, and the surrounding in which it needs to be performed.

2.5 Every design is different.

Every design is unique in one way or another. Therefore there is a reason for understanding what the product should do and thereby establish requirements[18].

Most people have an intuitive understanding of what the word means. But it is needed to be a little more specific about the meaning of the word when it comes to establishing requirements for an interface. The requirements when designing an interface needs to be as clear and comprehensible as possible. Even if the overall goal can be vague, it needs to be broken down into smaller parts, which are very clear and

[17] Interaction Design p.15 ff
[18] Interaction Design p. 204 ff

easy to understand in order to realize the goal. For instance, if the goal is that the product should be appealing to the user then the developer must find out who the users are, and what is appealing to that specific group of users? In the case with usability, if the goal is that the system should be self instructing, the developer must find out what the criteria for a self instructing system is, i.e. what need to be fulfilled in order to call a system self instructing?

Traditionally, two kinds of requirements have been identified, functional and non-functional requirements. They say what a system should do and what the constraints are. However, in usability design, these are not always enough thus they need to be redefined.

2.5.1 Requirements can be divided into subgroups

Functional requirements: tells what a system should be able to do. Understanding this is essential for making the product usable.

Data requirements: This is requirements concerning the data that needs to be handled by the product. All types of interactive products handle some sort of data. Data requirements tell which amount of data that needs to be handled and how long it has to be saved and so on.

Environmental requirements: tell the designer what type of surrounding the product should operate in. This can be broken down into four different subgroups.

1. **Physical environment:** What physically surrounds the working environment (lights, noise, protective clothing and so on).
2. **Social environment: A**ddresses the social environment. How different people work together, how the data needs to be shared and so on.
3. **Organizational environment:** Addresses how the organization in the environment is structured, i.e. how is the management built, how good can the support be expected to be, and so on.
4. **Technical environment: C**overs the technical aspects of the environment, i.e. what is possible to do with the technology at hand.

User requirements: This is for capturing the intended group of users, and the specifics of this group. Obviously different groups have different requirements. A beginner needs an interface that is easy to follow and step-by-step instructions, an expert needs a dynamic and flexible interface. After that all the user requirements have been collected they will form a user profile. Note that one device may have many different user profiles.

Usability requirements: This is a refinement of the usability goals. These are established early in the design process and they are then used to track the progress of the development.

As mentioned, it is important to analyze the intended user and task in order to make the product as usable as possible. For this reason it is appropriate to build a user profile in order to map the design with the intended user.

2.6 User profiling

User profiling is a collection of attributes that are typical for the intended user i.e. it is a group of user characteristics. The goal of user profiling is very simple. Resolve who the intended users are, their needs and the characteristics of that specific group.

This can be done in several different ways. Tools for this can be observations or conducting interviews, whichever is appropriate. The important thing is that the goals are qualitative. Sometimes logistics demands that other techniques are used. If the users are spread throughout a nation, or even a continent, questionnaires can be used. However, as a consequence the results will be more quantitative.

2.6.1 Interviews

There are generally three different types of interviews.[19] These are structured, semi-structured and unstructured interviews[20]. Each has their own benefits and drawbacks. The questions used in the interviews can also be closed or open. Closed questions means that the one being interviewed must answer from a limited number of answers. And open interview means that the interviewee must formulate their own answers.

Structured interview is used when the goal of the interview is clear and the specific questions can be identified. This means that all the questions are predetermined and often they are closed. Important to think about is that the question should be short, clear and standardized so that each participant understand the questions and unnecessary mistakes are avoided.

Unstructured interviews are often used in an early stage of the developing process. The whole idea is that the interviewee will steer the direction of the interview with their answers. This is achieved using open questions. When using open interviews the person being interviewed often mention things that the interviewer or developer did not think about, thus providing the developer with valuable data that have not been considered before.

Semi-structured interviews are a combination of structured and unstructured interviews. Therefore both open and closed questions can be used. When conducting a semi-structured interview a basic plan have to be predetermined so that all the interviewees will cover the same topic. There must still be an opening for the person being interviewed to elaborate their thoughts on a given subject. By using this technique the developer has the possibility to both get personal answers, possible new ideas and a statistic foundation from the interviewees.

[19] Intervjuteknik p. 59 ff
[20] Interaction Design p. 211

There are some drawbacks using interviews, but if the interviewer knows about them they can be eliminated, or at least the effects of them can be minimized. Interviews are hard to carry out in big numbers. An interview takes some time to perform which makes it very time consuming if you have many participants. Another drawback is that interviewees tend to answer what they think the interviewer want to hear, and not what they really mean. It may not be possible to do anything about this but it is important that the person doing the interview knows about this effect and reduces the effect, e.g. by combining different techniques or using a larger number of interviewees.

However, concerning usability, interviews are useful tools. They provide qualitative answers and that is valuable when the goal of the survey is to evaluate usability.

2.6.2 Questionnaires

The biggest benefit with questionnaires is that they can easily be spread throughout vast areas and many people which give a good quantitative foundation. It is an established technique for collecting information on opinions towards a given organization or system. The process of developing the questionnaire is quite tedious and time consuming, but once it is done the questionnaire can be spread relatively easy too many receivers. Consequently the workload does not grow very much with the number of receivers. This makes it possible to reach big quantities of people and that is the biggest advantages with questionnaires.
On the other hand, they need to be thoroughly tested before put into use. If a question is not very clear and understandable there is a risk that the person intended to answer the question will get it wrong. As stated above the process of making the questions clear and understandable are quite time consuming.[21] Another drawback is that it can be difficult to receive the answers to the questionnaire. Usually are not more than 30 percent of the questionnaires returned with answers.

2. 7 Task analysis

Task analysis is mainly used to investigate existing configurations. It is not used to come up with new ideas or visualize new systems. The emphasis on task analysis is to find out what the user really does when using a product. The analysis is trying to provide answers to the following questions. What the users are trying to achieve, why are they trying to achieve it and how does they carry out the task at hand. As stated, task analysis does not provide brand new ideas but it does provide a good foundation for developing an existing product and groundwork for developing a new set of usability requirements.[22]

Task analysis can seem to be a very vague term and this is because it is an umbrella term for all the available techniques to examine the physical and cognitive actions that take place when a user is trying to perform a task using a given tool. All these

[21] Interaction Design p. 211
[22] Interaction Design p. 231

techniques have a couple of things in common. They all use a high level of abstraction and work in great detail. The reception for these techniques has been mixed. However, one of the most well known task analysis techniques is GOMS-analysis[23] (Goals, Operators, Methods, and Selective rules). It was developed by Stu Card, Tom Moran and Alan Newell in 1983 and the purpose of it is to connect the cognitive processes and the physical actions connected to performing a given task.

2.7.1 GOMS-analysis

The intention of the GOMS-analysis is to monitor the cognitive processes and the physical actions that take place when a user interacts with a system. The model tries to show this by dividing the whole process from having a goal to achieving it. Along the way it takes all the physical and the cognitive steps taken into account. The four steps are:

1. **Goal**: This is the intention that the user has, or the state he or she wants to achieve. Goals can be divided into one superior goal and one or more subgoals. If that is the case, the sub goals need to be fulfilled in order to get to the superior goal. This is also where the analysis starts, by defining the goal.

2. **Methods:** These are the different steps that need to be performed in order to reach the goal. These are learned procedures and they show the idealized plan of action to achieve the goal. Much of the work in analyzing the user interface lies in specifying the actual steps users carry out in order to accomplish their goals. Hence, the emphasis on this type of task analysis is on describing the methods.

3. **Operators:** These are used to implement the methods. It is the cognitive and physical tools used to go through with a method. These operators are divided into many different groups. In many cases the analyst starts with a high-level operator. The characteristics of a high-level operator are that it can be divided into smaller pieces, i.e. it can be replaced by a group of smaller and more primitive operators. The process of replacing higher level operators can be executed repeatedly until only primitive external operators remain.

   Furthermore the operators can be divided into external operators and mental operators. The external operators are the physical actions that can be observed and measured; these could be things like moving the mouse or pressing a key. Mental operators are internal operators within the user that are executed when the user tries to achieve a goal. These operators correspond to the cognitive processes or the cognitive architecture inside the user and typical mental operators can be; making a basic decision or recalling an item from either short term or long term memory.

[23] Usability Engineering p. 234 ff

4. **Selective Rules:** If there are more than one method or operator to choose from there must be a way to tell when to use which. Therefore the user needs rules to know which method to use in a particular situation. These rules are called selection rules. There are many ways to represent the selection rules. One common way is to let the rules correspond to the general goal by telling the user the appropriate course of action in a specific context. This type of selective rules can be compared to an if-rule used in most programming languages.

It can be troublesome to know when an operator can be considered a high-level operator or when it is a primitive operator. This has to be judged by the analyst, who continuously makes decisions about:

1. How users view the task in terms of their natural goals.
2. How they decompose the task into subtasks.
3. What the natural step is in the user's mind.

These are decision made upon the judgment of the analyst's rather than from data collection. However it is possible to collect data on how the user view and understand the data but it is not practical and very time consuming to do so. This also means that the analyst is creating a psychological model or theory on how the user performs the task. The GOMS-analysis is a hierarchical structure. Therefore, the analyst also has to decide on which level the analysis should be conducted and a lower level of analysis requires a more accurate psychological models and more knowledge of the product.

How these parts are connected can easily be illustrated using a flowchart. Where the start would be defining a goal and the circle would be completed when returning to the goal.

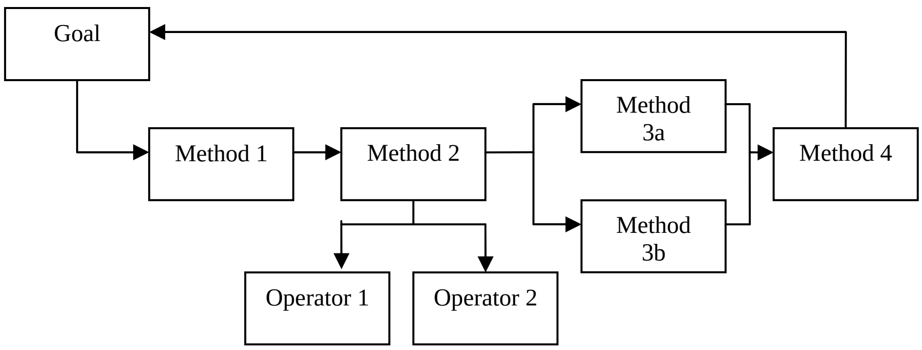

Figure 5. Authors interpitation of GOMS-analysis from Usability Enginering p. 236.

Once this schematics has been applied to a given task it can be combined with human performance data and estimate the time it takes to perform that particular task. Typical times to perform a task are the following.[24]

[24] Interaction Design p. 451

Description	Time (seconds)
Pressing a single key or button	0,35
Pointing with a mouse or other device to a target on display	1,10
Clicking the mouse or similar device	0,20
Homing hands on the keyboard or other device	0,40

Combined with empirical data in form of user behavior this model can help the designer to understand why a user does not act the way that is intended and where the problem is.

The GOMS-model can be applied at any time in the design process, but as with any model it has to be appropriate for the purpose. However a detailed GOMS-analysis can be very useful in number of ways.

1. Check for consistency
2. Check for efficiency
3. Checking that the most common goals are achieved with the quickest methods
4. Check for completeness and naturalness
5. Check for complexity
6. Compare different designs

Through these checks numerous faults can be detected including inconsistency and efficiency problems. It had been known to reveal some major faults in systems saving companies a lot of money and time.

Despite the fact that the model seems very good it had a cold reception when it fist was introduced, and that is not entirely unjustified. The GOMS-method has some major drawbacks and it is important to know the limitations of the GOMS-analysis.

One of them is that the model has a very limited scope. This means that it can only model very small computer based tasks which are highly routine in character. Furthermore it can only predict expert behavior in the sense that it does not allow for errors to be made or modeled. This makes it hard to model the average user. Moreover it cannot model human behavior when it comes to multitasking, ability to learn or problem solving. These are aspects that can be quite important. When conducting evaluations of this kind another tradeoff has to be made. Model of performance can yield precise predictions of user behavior, but the time spent building such models can take attention away from higher-level human behavior such as learning, problem solving and social relationship.[25]

The GOMS-Model has received massive critic. According to Helander it is “A method for predicting expert users’ behavior on specific task with a given interface”. But when the model is used in the right way it can be very useful.

[25] Usability engineering p. 237

2.8 Evaluation.

It is not unusual that designers think that if they find a product attractive, so will the user. This is seldom the case. However, it is the main reason for the designer to evaluate a design and it costs both time and money. However, a bad design that is launched may cost even more time and money to redevelop and that is another good reason to evaluate. Bruce Tognazzini, who is a successful usability consultant, states that:[26]

> *Iterative design, with its repeating cycle of design and testing, is only validated methology in existence that will consistently produce successful results. If you don't have user-testing as an integral part of your design process you are going to through buckets of money down the drain.*

He further introduces five good reasons for investing in user testing.

1. Problems are fixed before the product is shipped, not after.
2. The team can concentrate on real problems, not imaginary ones.
3. Engineers code instead of debating.
4. Time to market is sharply reduced.
5. Upon first release the sales department has a rock-solid design it can sell without having to pepper their pitches with how it actually will work in the next release.

But what does one mean by evaluation? There are many different evaluation methods and many different definitions. Some involves the user directly and other indirectly. The common divider is that they stress the need for collecting data to get information about a particular product, with a particular group of users in a particular environment. This means taking the users´ needs into account throughout the whole developing process and it is why the design process is iterative, as stated before. Because of the many different methods available there is a need for the designer to know what kind of evaluation method to use in which case i.e. decide when and what to evaluate.

The goal of evaluation is to estimate how well a design meets the users' needs and what they think of it. In case of a brand new product designers often assist in the market research process by designing prototypes to be tested on the potential user in order to get reactions concerning usability. This helps understanding the users' needs and requirements in an early stage in the developing process. From that point the design process is iterative meaning that evaluations should be made every time a "circle" is completed in the design process.

In case of an upgrade the iterative design process is well suited to usability engineering. At this point the possibilities to make big changes are very small and the focus should be on improving the overall picture.

[26] Interaction Design p. 319

The way to conduct evaluations change throughout the process. Evaluations done during the development phase are known as formative evaluations. These are made to make sure that the design meets the users' needs continuously. When a product is finished and the evaluation is made to judge the satisfaction for the finished product among the users it is called summative evaluation.

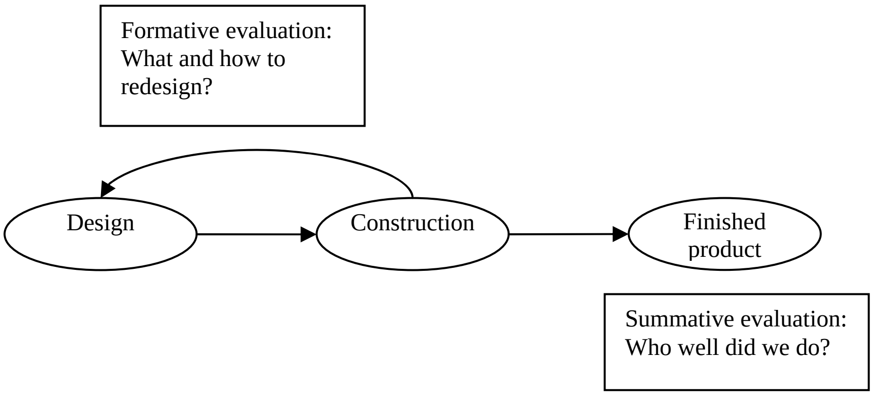

Figure 6. Authors interpitation of formative and sumative evaluation from usability engineering.

How does one know when a product is usable? Unfortunately, you cannot really measure the usability until you bring the system to use, and there are no general goals or guidelines to use in this case. It has to be defined in every individual case when a product can be considered to be usable with regard to the usability goals. The only rule that can be used is that the product is never perfect. As mentioned, design is an iterative process and most of the times the design improves with every iteration but it never becomes perfect. Instead it is budgets and time limits that states when a product is through the iterations. However, iterating towards a usability goal is very hard if you can not measure how close you are. Therefore, some models to measure how the product is to the usability goals have been developed.

One method to estimate usability at an early stage in the developing process was developed by Löwgren. The approach is called REAL[27] and that is an abbreviation of (Relevance, Efficiency, Attitude and Learnability)

1. **Relevance** of a system is how well it serves users' needs.
2. **Efficiency** states how efficiently the user can carry out their tasks using the system.
3. **Attitude** is the users' subjective feelings towards the system.
4. **Learnability** of the system is how easy it is to learn for initial use and how well the users remember the skills over time.

This model works both ways. As said is can be used to validate the goals. But is can also be used as a foundation to set up goals or revise the existing goals for a product.

[27] Human-Computer Interaction p. 52

2.9 Error handling

Donald Norman states that *"If an error is possible, someone will make it"*[28]. An evident goal in any usable system is to minimize the number of human errors. This is done by carefully designing and evaluating the system. However, it is impossible to prevent all human errors. In some cases it is desirable to it help the user to explore the boundaries of the system.[29] Either way, human errors cannot be completely eliminated or separated from human performance. Therefore should the system, whenever possible, capture the error at the earliest possible moment and provide specific feedback that is useful in correcting the error. This is achieved by using the guidelines and rules stated in the theoretical chapter in this thesis.

2.10 Tradeoffs

Almost every time there is some drawback or downside to any model, inspection method or evaluation. Therefore tradeoffs have to be made almost every time. Usability checklists can produce rapid feedback, but there is a risk that it pays attention to a relatively unimportant problem that does not occur very often in real life usage. Also interaction design or HMI is very much about tradeoffs. What is good for one user is not usable at all for another user. This is often the case with a novice versus an expert. The novice requires highly understandable user interfaces and the expert requires much more flexible interfaces. This is one of the reasons that it is impossible to design an interface that is useful for everybody. Hence, the trick is not to find an interface that is understandable and easy to use for everybody, but to find out who the intended users are, what their requirements and needs are, to construct an interface that is understandable and easy to use for them.

[28] Handbook of Human-Computer Interaction p. 489
[29] Usability engineering p. 275

3 Method

As stated the overall goal in this masters´ thesis is to investigate the correlation between the latest research findings concerning HMI and the interface of the Tetra PlantMaster. In more detail this means that a comparison needs to be made between a set of different factors. These are:

1. What the latest research concerning usability states.
2. What Tetra Pak usability guidelines states.
3. What the end users want and need.
4. The way the interface works.

In order to create a usable interface, it is important to involve the user early in the design process. The user needs to be involved so that the designer knows where to go with the design and how to redefine the goals and restructure the interface once it has been evaluated. This is the main reason to evaluate the usability together with the user. The evaluation will be made as a part of the evaluation cycle described in figure 3, and it will serve as the foundation for the next iteration in the design cycle.

In order to evaluate the interface with regard to the four points above a series of steps needs to be taken. The evaluation of Tetra PlantMaster is conducted in an early stage of the design process and only parts of the design are in working order. In order to make an evaluation that is correct, many different techniques will be used. Furthermore, the techniques used are selected as being appropriate with regard to the limitations of the interface stated in the beginning of this thesis.

In order to get an initial understanding of how the interface works a simulated version of Tetra PlantMaster was used during a week. From that week a mental model was constructed and compared with the conceptual model of the Tetra Pak internal guidelines. This was only to reach basic understanding of how the Tetra PlantMaster works and it has not been used in the evaluation. The mental model and the conceptual model are enclosed in Appendix A.

The methods to gather the required information that was used to evaluate the interface are the following:

1. Literature study.
2. Study of the Tetra Pak internal standards concerning usability.
3. Interview with process and automation engineers.
4. Visit to a plant that uses the Tetra PlantMaster.
5. Interviews with operators.
6. Questionnaire to Design Owners.
7. Mapping of the interface.
8. GOMS-analysis of the most frequently used functions in the interface.

The main objective with the literature study is to find the most recent theories within usability engineering. By comparing many different and independent sources it is possible to describe the latest research in a very comprehensive way. This will provide facts about what the latest research concerning usability states. The literature study will also provide the foundation in the first of the four parts that needs to be compared in order to assess the usability in the Tetra PlantMaster.

By studying the Tetra Pak internal documents and comparing them with the literature studied it is possible to compare the documents and the literature in terms of updates and in terms of what they each consider good usability engineering. This will provide the facts about whether the Tetra Pak internal guidelines are good and up to date from a usability design point of view. This part will provide the second part, concerning what the Tetra Pak usability guidelines states, of the four parts that will be compared in this thesis.

For the third part that needs to be evaluated, the operator's needs and wants, a number of methods have been used. As stated earlier in this thesis it is not trivial to understand what the operator needs. For this reason many different techniques may be used to understand what the operator needs. Therefore this part will consist of three different subparts.

1. **Interviews**: Interviews will be conducted with two primary groups, process/automation engineers and operators. This will give information about what the operators wants and an idea of what the operators needs. Finding out what the operator wants will be achieved through interviews with the operators. The question of what the operators need will partially be answered through the interviews with the operators and the process/automation engineers. The later are the persons how make the final adjustments of the product and implement the product at the site. This means that the process/automation engineers have very good knowledge about the site, the process that needs to be performed and the operators. The interviews will be semi structured in order to ensure that the most relevant questions are answered and still providing a good chance for the interviewees to elaborate on their own thoughts and ideas.

2. **Questionnaires**: The questionnaires will be intended mainly for the Design Owners. They are the people that are supposed to be expert users and they have both theoretical and practical knowledge of how the Tetra PlantMaster works. They also have the technical responsibility of the Tetra PlantMaster within their own market companies. The questions in the questionnaires will be decided through the help of experienced automation engineers and the questionnaire will be carefully tested before put into use in order to avoid unnecessary mistakes and misunderstanding. A pilot test with five different participants will be conducted and three different persons will look at the questionnaire in order to ensure a good layout. The questions will mostly be open which should provide a more balanced picture of what the Design Owners think of the operators and the interface. The questionnaire will also work as a template for the interviews to ensure that all the involved parts will receive the same type of questions in a similar order.
3. **Theoretical analysis of the interface**: This is mainly to understand how the interface works today and how easy it is to use. The GOMS-analysis is used to monitor the most frequently used applications in the interface and to analyze whether they are easy to use from a cognitive perspective. The interface will also be used and tested in order to generate an idea of how the interface is

structured. This will lead to a mental model that will be compared to the conceptual model described in the Tetra Pak guidelines.

The interviews with the operators will take place at a plant that uses Tetra PlantMaster. That makes it possible to combine the interviews with observations of how the Tetra PlantMaster works under real conditions and to study how the operator uses the interface. This is also very useful when The Tetra PlantMaster is evaluated in terms of usability.

These different parts will be put together and compared in order to analyze the interface, which will lead to a judgment about the interface and recommendations concerning the interface. The recommendations may concern things that need to be added, restructured or deleted.

A template will be made in InTouch to visualize the possible changes that should be made in the interface. However, these possible changes can only be displayed in a very limited way due to the early stage in the development process.

4 Results

In the literature on the subject of usability, it is shown that the there are not many right or wrongs. How a good interface should be designed is impossible to answer if one does not know who the final user is.

4.1 The literature

If the end users are inexperienced, the interface has to be very easy to understand and to follow. This means that the designer should emphasize the need for understandability and ease of use rather than flexibility and short response time in the system.

On the other hand, if the system is supposed to be used by an expert user in an expert context, the designer should strive for flexibility and effectiveness rather than understandability and ease of use.

Different users have different wants, needs and capabilities. For this reason it is impossible to state what a good interaction design is just by studying the literature. The design depends on the user in many aspects. However, there are some general guidelines to keep in mind when designing an interface. They are slightly different depending on where they derive from and depending on who wrote them. The most famous are maybe *the eight golden rules of usability*. They are developed by Ben Shneiderman and they are described earlier in this thesis. *The eight golden rules of usability* have been compared with other sets of rules (Simpson 1985 and Dumas 1988)[30] and they all have four common denominators, which are explained earlier in this thesis.

According to usability experts and the technical literature the four points are essential for usability in any user interface.

4.2 Tetra Pak internal guidelines

The internal documentation within Tetra Pak concerning the user interface states both what the Tetra PlantMaster and the Tetra Pak Operators Panel should look like. There are a number of different documents concerning the interface in the Tetra PlantMaster. Two of them have been studied more carefully for this thesis. These are the KA271710 and the PAP-General-106-PRS_HMI guideline documents. The reason for studying these two in particular is that they are the most recent updated guidelines and the fact that they can be used as complements to each other.

The structures of these two guidelines are a bit different in some ways. The PAP-General-106-PRS_HMI guideline is very specific concerning the number of pixels between two items in a window and the color of an item. These information are stated

[30] A Practical Guide to Usability Testing p. 55 ff

for the whole interface and very detailed structure of any window can be derived from this document.

The KA271710 consider the terminology and definitions. This document states what everything is. For example what an indicator, button or a symbol is. This document also states what the overall goal is and what they are trying to achieve. Furthermore, this document states what a good interface is, according to Tetra Pak, and what the designer should think about when designing the interface.

4.3 The Operators and What the operators think of the interface

In order to find out who the final user is, a series of interviews have been conducted. Two different kinds of employees have been interviewed. One group is process/automation engineers. They are the engineers who deliver the Tetra PlantMaster to the customer. This means that they take the Tetra PlantMaster to the factory, implements it and train the operators on how to use it. It also means that they have good contact with the operators and good insight in who the operators are. The other group that was interviewed was the operators. They are the ones how actually use the Tetra PlantMaster in their work and they have good knowledge from both the advantages and disadvantages of the Tetra PlantMaster.

The interviews took place in the natural environment of the interviewees. The interviews of the operators took place in the maneuver room at the dairy where the operators worked, and the interviews with the engineers took place in the development division at Tetra Pak. The interviews were all semi-structured and the questionnaire that was used to survey the Design Owners was also used as a template for the interviews. This means that all the interviewees have received approximately the same questions, with small variations, due to the fact that the interviews were semi structured. However, all the interviews covered the same areas.

The interviews with the three operators, and the engineers, showed that almost every operator did not have any higher education. During the course of the investigation one operator with higher level of education was found. They have all received similar educations on the system when they started working with it, both theoretical and practical education. The operators did all agree on that the Tetra PlantMaster is easy to learn and to use in general and that it is easy to solve most problems that occur in the day to day work.

One of the operators mentioned some things, which according to her, were shortcomings in the visual design. The tanks should have a size relative to each other that is equal to the relative size in the real world. Furthermore, the same operator pointed out the need for more information in some parts of the system. This was the level of liquid in some tanks and the progress of the washing program in the system. Furthermore, all the interviewees mentioned that lack of overview as a major problem. A special problem was that if a machine stopped and the overview of that particular machine was not on screen at the time of the stop, the operator would not notice the problem. According to the operators this was time consuming and annoying.

In total there were three different pointers made from the operators, of which two where mentioned by all the operators. These two was the following:

1. Problems with the alarm handling.
2. Problems with the overview of functionality.

The third comment was from only one operator. It was the following:

1. Problems with some information parts.

The interviews with the engineers showed that they had a very clear picture of the operators and the benefits and drawbacks of the Tetra PlantMaster.

Their idea of the operators was that the operators had a low level of education and no specific computer skills. But the operators do get some education, both theoretical and practical, on the Tetra PlantMaster before they start working on the system.

When asked for the usability of the Tetra PlantMaster and the advantages and disadvantages, they answered that the system is easy to learn and easy to use. Batch applications are particularly easy to use and if anything is hard to learn it would be how to find a fault once it occurred. They also mentioned the lack of overview, and the process of finding and correcting an error as problems in the system.

A third group was also approached in order get an idea of what the operators and the developers think of the Tetra PlantMaster in general. The third group approached in this survey was the Design Owners.

Due to the geographical diffusion of the Design Owners they where approached with questionnaires instead of interviews. However, the questions in the questionnaires are the same questions that were used as a guideline in the interviews.

All the Design Owners had a similar picture of the operators and this was that the typical operator had a very low education, never more than high school education. There was also a mix of all ages among the operators; possibly with a stronger representation in the range 30 to 50 years old, and the operators did not have any prior computer skills.

Concerning the education at the time the operators start to work with the PlantMaster there are three different approaches. When the operators start using the PlantMaster they receive either a practical and theoretical education, a practical education or no formal education.

The Design Owners were also unanimous concerning the strengths and weaknesses of the Tetra PlantMaster. They all answered that the Tetra PlantMaster is easy to use in general and that the operators learn to understand the system very easy. When asked if there was anything that was particular hard to learn, there were three different answers. None of their three answers where more frequent than any other. The three answers were as follows.

1. Working with batches.
2. Working with recipes.
3. Fault finding.

However, none of the answers were very frequent and most of the Design Owners could not see any features that were particularly hard to learn.

One Design Owner answered that there was one feature that could be found unnecessary and that was the *Control module.*

Apart from that there were comments from Design Owners that some things should be changed. These comments were isolated and never commented by more than one Design Owner.

1. Need for bigger buttons.
2. White background on the alarm handling page.
3. More text in the existing information windows.
4. More popup windows for overview.

On the question whether anything should be added or restructured the Design Owners where very clear. The two things that need to be restructured according to the Design Owners are the alarm handling and the plant overview. The alarm handling was in some cases listed under things that need to be added in the interface instead of under things that need to be restructured. This can be interpreted as an indication that some Design Owners find the Alarm handling nonexistent rather than poor. The missing thing in the plant overview is that there is no way to see which parts of the system that is in operation and which parts that is idle.

All the participants were also asked to list the five most frequently used applications in the interface. The answers to that question were used as a foundation to the theoretical analysis of the interface.

4.4 The results from the theoretical analysis

The method that has been used is the GOMS-analysis method. That is a way to structure the different applications in the interface. It is also a way to study if the interface is structured in a good way and if the sequence of actions that need to be executed in order to reach a goal is efficient.

The five most frequently used applications are the following.

1. Start a production line.
2. Stop a production line.
3. Changing a batch.
4. Adjust a parameter.
5. Cleaning the equipment.

An analysis has been made for four of the applications mentioned above. Cleaning the equipment could not be tested since the interface is in an early stage of the development and the cleaning process is not yet implemented.

The result of the theoretical analysis is a GOMS-analysis of four different actions. They have been presented as four different flowcharts and are presented in Appendix B.

5 Analysis

The results from the investigation and the analysis of the results are only valid for this specific process and they cannot be used as general guidelines in other projects. However, for this particular case the answers from the interviews, answers from the questionnaires and results from the theoretical study and the literature were very unanimous. This made it very easy to interpret and analyze the results of the investigation.

5.1 Literature

The literature has not changed very much the last decade. The new literature still mentions the same models and guidelines as older literature. Also the internal HMI-guidelines within Tetra Pak are very clear and specific. They are also very extensive. They specify both more general rules like that the overall feeling in the interface shall be calming, as described in KA271710 and very specific details like how many pixels there shall be between two buttons as described in the PAP-General-106-PRS_HMI guideline.

When the internal guidelines are compared with the literature the two parts match very well. For obvious reasons there are some differences in the Tetra Pak internal HMI-guidelines and the educational literature. The HMI-guidelines states only how it is supposed to be and the technical literature states why it is supposed to be in a certain way.

5.2 The Operator

The operator is, with very few exceptions, a person with limited education. There are no general age of the operator, instead is the age of the operators at many plants a mixture of all ages. In some cases does the operator start to work directly after they have finished school and stay on the plant for the rest of their working life. It was also found that once the operators have learned to use the system it is very unusual that they stay at the plant for less than one year. This means that the duration of time for the employment for the operator range from approximately one year to their hole working life.

The interviewees and the design owners were also asked to list the five most frequently used applications. And just below top five, on the sixth, place the application “using a shortcut” was found. This implies expert users.

This picture of the operator was given throughout all the interviews and questionnaires. This means that everybody throughout the design process and development process has a clear picture of who the users are and therefore they can design the interface accordingly.

Since the operator work for at least one year with the same system and uses shortcuts to a great extent they must be regarded as expert users. This is not because they have prior computer skills but because they work with the same system for a long duration of time. Therefore the system must be built on flexibility and effectiveness rather than understandability. This means that the focus does not have to be on making all the symbols very easy to understand. Since this should be regarded as a system that the operator needs to learn how to use, the system developer should focus on providing the effectiveness and flexibility required for an expert user.

All the participants in both the interviews and the questionnaires also agree that the Tetra PlantMaster is easy both to learn and to use once they have learned it, and the overall opinion of the Tetra PlantMaster was good.

Even though the overall opinions were good, there were comments concerning the effectiveness of the Tetra PlantMaster. Three different drawbacks can be isolated in the system, and two of these are very clear. The third comment was only pointed out from one operator.

The two major drawbacks in the system were the following.

1. Alarm Handling: This was pointed out by all the groups that have been asked to comment on the Tetra PlantMaster. This problem was also noticed during the interview with the operators. There were alarms to the extent that the operator did not even bother to read the alarm text. Instead, they only acknowledged the alarms directly without reading or reflecting over the alarms.

2. Plant Overview: There were also many comments concerning the lack of overview in the system. In this case, the overview is not about how the different machines are connected. The lack of overview is about seeing which machines/processing units are in working order and which machines are not in working order. The operator saw this as the biggest drawback in the system and as the one thing that slows down their daily work. Also all the Design Owners, with very few exceptions, commented this as a drawback in the system. The engineers, however, did not comment on this as much.

Concerning the alarms the problem is the quantity. There are many alarms and they did not seem to be organized into subgroups more than that they are displayed with different colors. This problem is of the magnitude that some of the design owners did not list this as a feature that should be restructured but as a feature that should be added. That could be interpreted as an indication that to some extent the alarm handling is nonexistent.

Concerning the overview, it is not the overview itself that are bad. It is the overview of functionality that is missing. It is clearly visible how everything is connected but it is not visible which of the machines/processing units that are running at the time or, even more important, which of the machines that are not working properly at a specific time. In the prolongation this means that machines/processing units can be down for quite a long time before the operator notice just because they do not have the right window at display at the moment. The reason that engineers did not comment on this could be that they do not work with the system in the same way on a daily basis and therefore simply have not noticed it as a problem to the same extent.

The third comment from one operator was concerning information in the system. This is not nearly as widely mentioned as the other two and it is only mentioned by one operator. Hence, that specific drawback can be regarded as a fault on the specific plant where the operators were interviewed and not as a general fault in the Tetra PlantMaster. However it should be viewed as a heads up since lack of information is likely to cause bad decisions among the operators. The relative size of the tanks on screen should also correspond to the relative size of the tanks in the real process in accordance with the theory of natural mapping.

More than that there was only very few isolated comments on the system.

1. Need for bigger buttons.
2. White background on the alarm handling page.
3. Better information in the existing information windows.
4. More popup windows for overview.

None of these comments have been commented upon by more than one person and for that reason they cannot be regarded as a common opinion. These comments also contradict the HMI guidelines of Tetra Pak or the theories of usability and for that reason they will not be commented further in this thesis.

5.3 Theoretical analysis

The theoretical analysis of the system has been conducted on the five most frequently used applications in the interface. These five applications are derived from the interviews and questionnaires. The following five applications showed to be the most frequently used.

1. Start a production line.
2. Stop a production line.
3. Change product.
4. Adjust parameters in the process.
5. Cleaning the equipment.

All these are investigated using GOMS-analysis except ”Cleaning the equipment”. The reason for this is that due to the early stage in the developing process that specific functionality has not been implemented yet.

The GOMS-analysis of the other four applications is presented in flowcharts. They all proved to be good from a usability perspective, meaning that all these applications are very easy to perform. This is easy to see from the flowcharts, see Appendix B. However, two of the applications have selections rules inside the flowcharts. Therefore those parts will be more carefully explained in the analysis.

The flowchart of the application “Stop a production line” is the following: (see Figure 7)

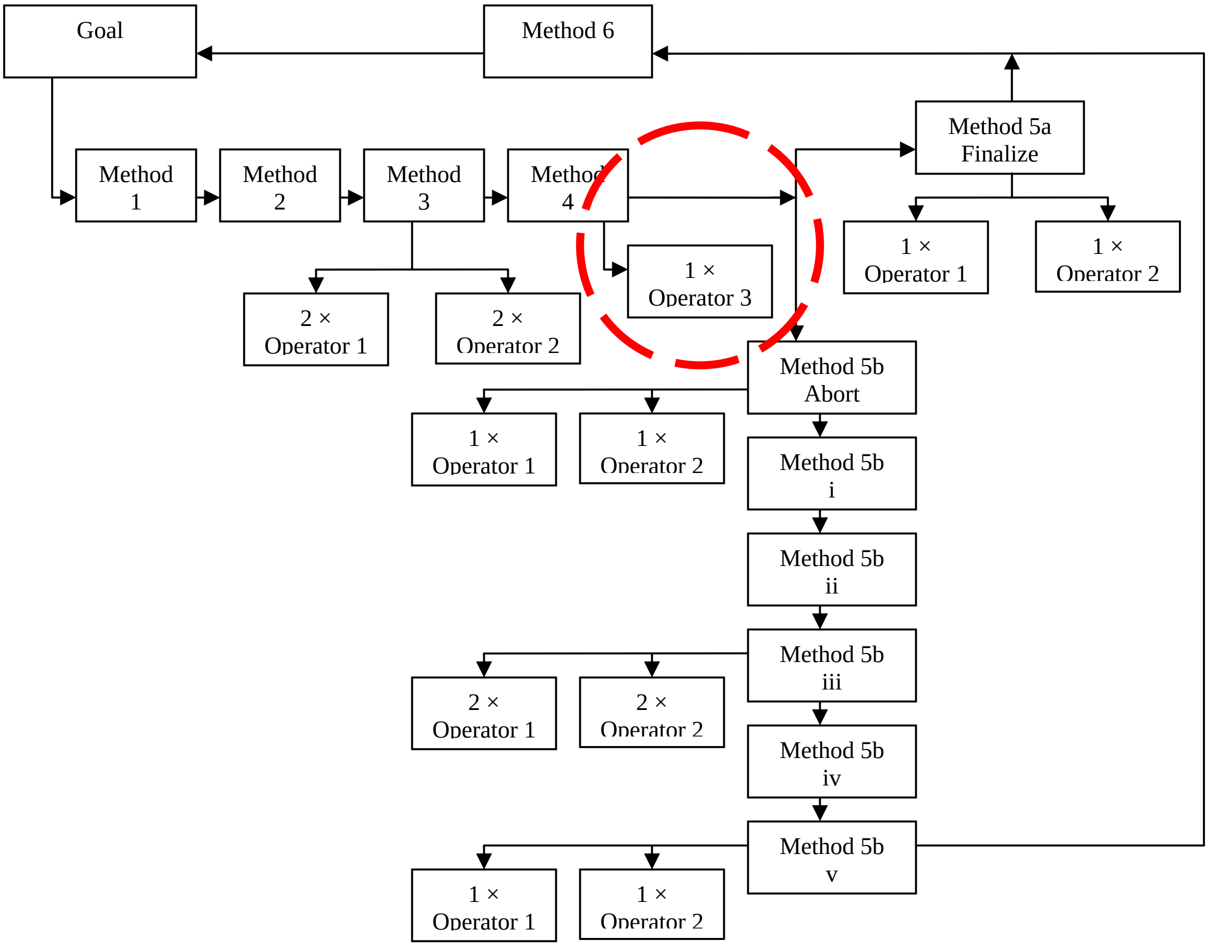

Figure 7: GOMS-analysis of the application ”Stop a production line”.

In this flowchart Operator 3 is a *mental operator*, which consists of deciding which *method* to use when performing this operation. The *selection rule* derives from this. There is a reason for having two separate methods for this.

The first method, method 5a Finalize, is the easiest to use. This is also the method that is used most of the time. It is always used when a production needs to be stopped and everything is in working order. The other method, Method 5b Abort, is used when there is something that does not work properly and the process cannot be operated. When the Abort application is used, the system stops without flushing and draining itself, which leads to big losses of production material, relatively to using the Finalize method. The reason for having two different methods is that they are needed in two different situations, namely Finalize during normal operation and Abort during incomplete operation. Abort is used as an override when an problem in the production line occurs.

Furthermore the procedure of Abort is longer and more complicated than the Finalize operation. And that is a good thing. The Abort method should not be used unless it has to be used and for that reason it should be a bit more complicated to perform. Still, it has to be logic and easy to understand since it is not supposed to be used on a daily basis. The GOMS-analysis shows that this balance is good in this application.

The Abort application is slightly more complicated to perform than the Finalize operation, but still it is very easy and logical.

The other one of the two applications that contain a selective rule is the “Adjust parameters in the process“ application. The test the “Adjust parameters in the process“ consist of two parts since there are two different levels to adjust parameters on. The full analysis of this application is shown in Appendix B.

When adjusting the parameters they can be reached in two different ways. In this case that means that to reach some parameters the operator has to enter a deeper level of some menus. This is unavoidable due to the vast numbers of parameters. If they were not structured in levels the operator would quickly loose the overview. But to make the analysis as complete as possible both levels where evaluated with the GOMS-analysis.

When evaluating the deeper level of the application “Adjust parameters in the process” the result was the following. (See figure 8)

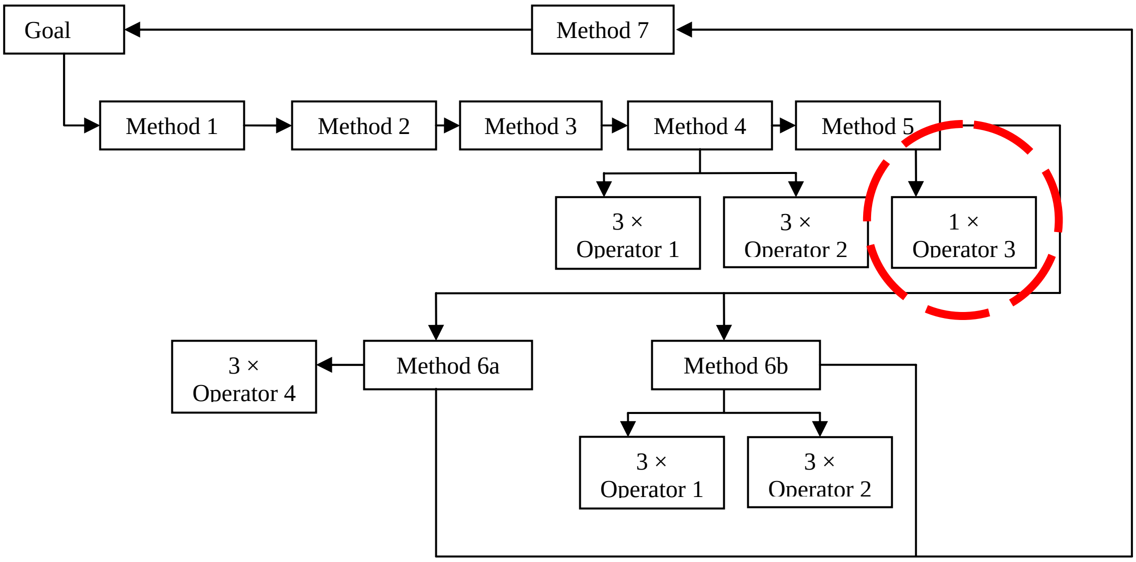

Figure 8. GOMS-analysis of the application ”Adjust parameters in the process”.

As with the application “Stop a production line” the focus is on Operator 3. Also here it is a *mental operator*. This is needed due to a numeric keypad that is shown on the screen when the operator tries to adjust a value at this level. (See Figure 9)

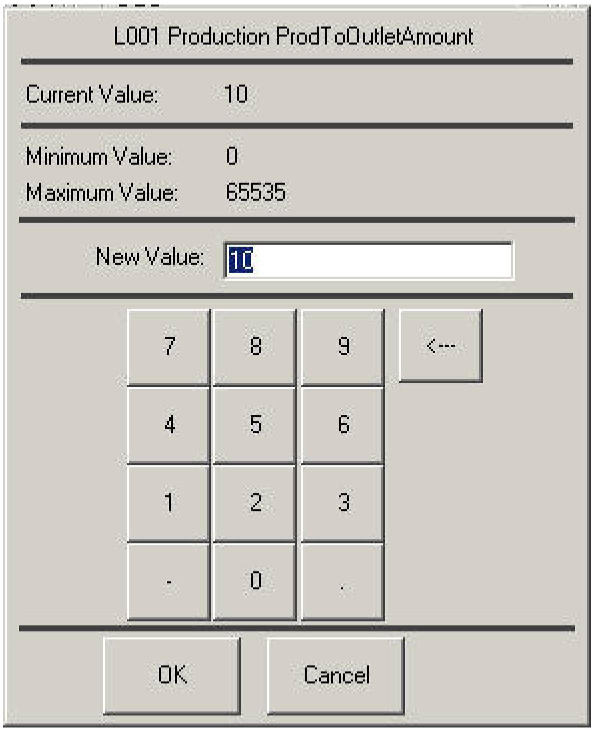

Figure 9: The numerical keypad in the Tetra PlantMaster.

A decision has to be made by the operator whether to use the physical keyboard or the mouse combined with the numeric keypad on the screen to adjust the parameter. Once that decision has been made the operator has to execute the task. This analysis shows that method 6a, using keyboard strokes, are more effective than the method 6b, using the mouse combined with the numeric keypad on screen. Not only is the number of operators in method 6a less than the number of operators in method 6b. It is also shown in other studies that the time it takes to execute operator 4 is significant less than the time it takes to execute operator 1 and 2 combined. During the test period no other reason to use the numeric keypad on screen was found. That led to the selective rule that the mouse and the numeric keypad on screen is hardly preferable to use.

When all the GOMS-analysis's are looked at it is clear that in the Tetra PlantMaster all the tasks are very easy to perform. There was no analysis that showed more than twelve methods combined with three operators or seven methods combined with four operators and that is good. It means that all the main tasks in the Tetra PlantMaster are quick and easy to perform. The number of methods and operators mentioned above are comparable with the number of methods and operators involved when deleting a sentence in word and that must be considered very low.

5.4 Summation of the analysis

The three different parts that are compared all match very well. The HMI-guidelines match well to the literature and the interface follow the directions in the HMI-guidelines. During the evaluation of the interface two details where noticed. Since this system that is considered to be a system that the operator needs to learn how to use, they do not have to be changed. The operator simply has to learn how to use it, but in accordance with the theories mentioned in chapter two it would be preferable to change them in the following way.

When an icon in the interface is pointed at with the mouse a frame appears around it as shown in Figure 10 below.

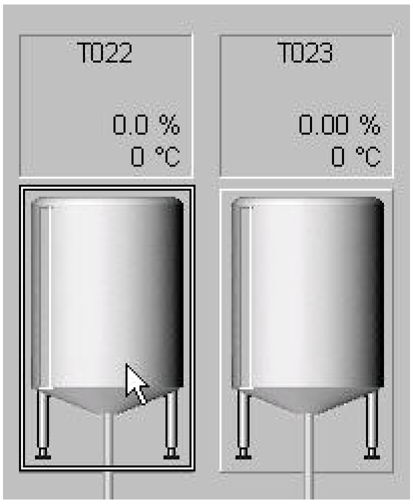

Figure 10. The frame around an icon appears when the mouse is placed on the icon.

When the operator tries to select the chosen icon then it shows no visual feedback in the interface. In accordance with the theory about direct feedback there should be some visual feedback when the operator tries to select a given icon.

In the maneuver windows do not show an overview over every single valve or engine, and there should not be. The maneuver windows are supposed to control the process, not a single valve, engine or regulator. It is possible to reach the regulator both from the maneuver window and the unit window as shown in the pictures.

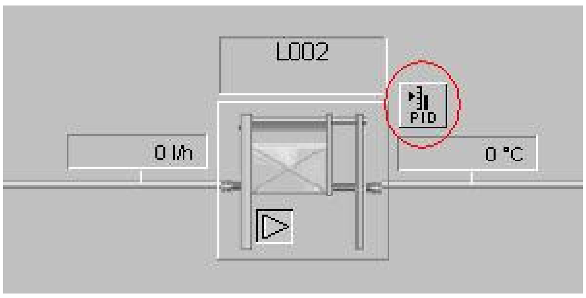

Figure 11a. The Control module at Process cell level.

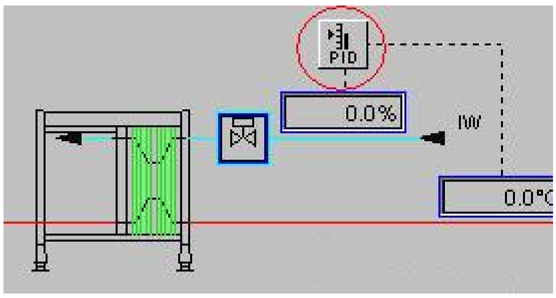

Figure 11b. The Control module at unit level.

The regulator is reachable from both the maneuver windows and the detailed unit level windows. Since this can be regarded as a very detailed operation it should only be reachable from the unit level windows in accordance with the theory of consistency.

The evaluation that have been conducted here show that the level of applications that have been thoroughly evaluated here are very good. The problems mentioned in this thesis exist at a level that not has been as carefully tested. Apart from the things mentioned in this chapter, the analysis shows that this can be considered a very good and user friendly interface. Both the interviews, questionnaires, literature study and theoretical analysis are unanimous.

6 Recommendations

As stated before this is a very usable interface. The parts that has been evaluated properly are very good. All the evaluations where made at the process cell level and they all showed that the interface is usable at the process cell level.

Concerning the three different drawbacks that were found in the process level there are some recommendations on what should be done.

In the matter with the numeric keypad on screen, (see Figure 12 below) the GOMS-analysis shows that it is hardly preferable to use the mouse combined with the numeric keypad on screen to adjust the parameters in the interface. Since it usually is preferable to use the keyboard there is no need for the numeric keypad on screen and therefore it may be removed.

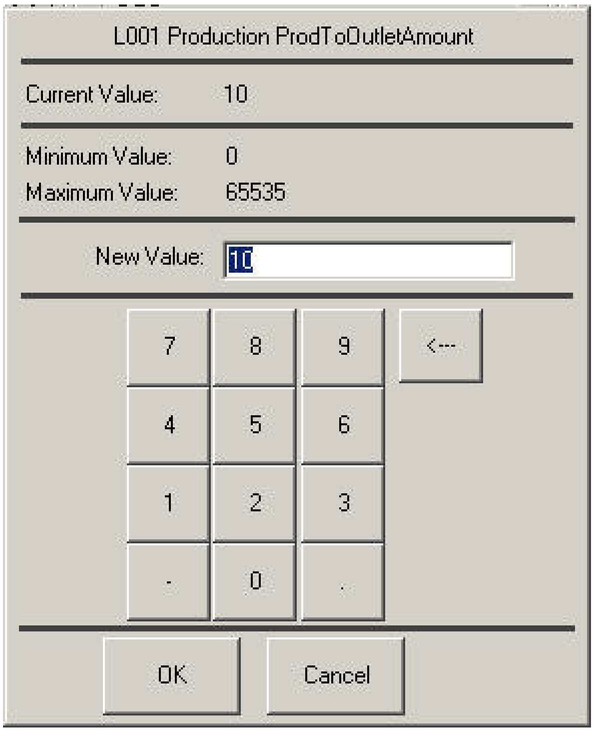

Figure 12. The numerical keypad in the Tetra PlantMaster.

Furthermore it is stated in the Tetra Pak internal HMI-guidelines that the interface should give a calming impression and according to the literature this is achieved by reducing the number of popup windows. And that is yet another reason for removing the numeric keypad on screen.

The regulator should be regarded as a unit level application (see Figure 13b). Therefore it should not be accessible from the process level. It should only be accessible from the unit level.

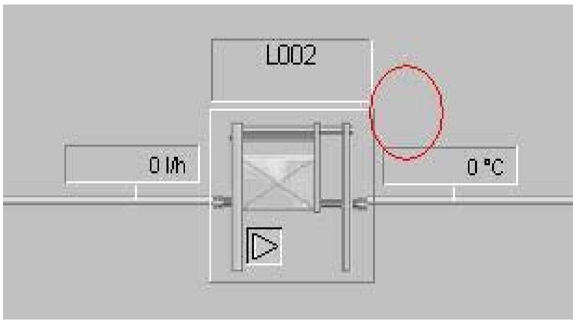

Figure 13 a. Process cell level without control module.

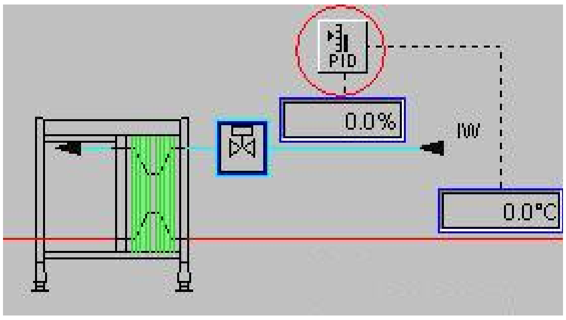

Figure 13 b. Unit level, still with control module.

It can be argued that the regulator is an application that is too advanced for the normal operator and that it should not be accessible unless an engineer is logged on. However, according to some of the engineers more accessibility in the lower level applications in general stimulates the operator to work longer with the interface, therefore, it do not have to be removed from the unit level.

The feedback is as important in this system as in any other system. So it should be a noticeable difference in pointing at an icon and clicking on the same icon.

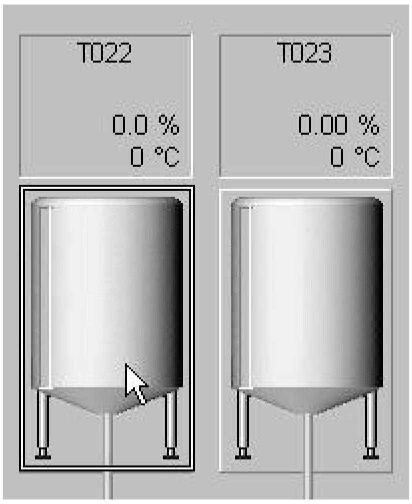

Figure 14a. The frame around an icon appears when the mouse is placed on the icon.

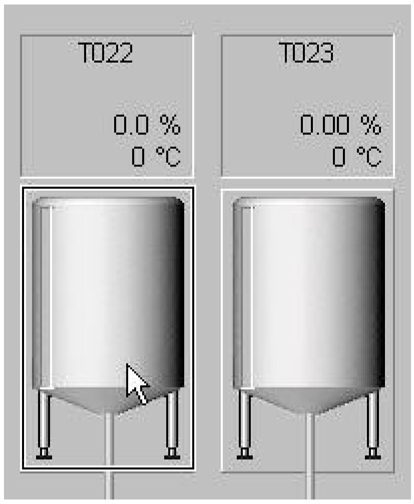

Figure 14b. A suggested change in the frame when the mouse is being clicked.

With the system that is being used today (InTouch) this is not possible according to the HMI-responsible developer. This is due to the fact that the frame that appears around the icon is an internal function inside InTouch. Therefore the developer can only chose to either have it there or not have it at all. Even though it is not perfect, it does provide some feedback and that is better than nothing.

If it in the future becomes possible to change this so that the frame can be made to change when the icon is being clicked on, one possibility is that the frame shows up when the mouse is being pointed at the icon and then the frame invert itself when the operator is clicking on the icon as shown in figure 14b. This is only one of many options. The point is that some feedback should be provided whenever the operator is performing an action.

The other two issues, the alarm handling and the status overview at plant overview level, are both of a different magnitude and at a different level. The problem with the alarm handling and the status overview are both at the plant level. It is very important to be clear about that this level have not been properly evaluated. The problems revealed themselves after the interviews and questionnaires. This is why no proper solutions can be made concerning these two problems.

However, these are two major issues that where commented upon by close to everyone who took part in the investigation. And once they had been commented on the shortcomings where obvious.

When the theoretical evaluations where conducted on the simulated process the alarm handling had to be suppressed in order for the interface to work. This is due to the fact that there are no real processes running in the background, hence there are no real alarms. There were no simulated alarms on which the Tetra PlantMaster could be evaluated.

Due to the early stage in the developing process, only one of the process cell level windows had been implemented. Therefore it was impossible to analyze how the different process cells worked together. This is why neither the alarm handling nor the status overview of the entire plant could be tested thoroughly.

These are two issues that must be investigated further once they have been implemented. A proper course of action can be to launch a more solid investigation when these parts are implemented. The thing that needs to be done is to develop the alarm handling and status overview at plant level and then evaluate these two applications in a new investigation. This can be done in a new master thesis project. The person writing the master thesis sees the interface from a new perspective and it is very cost effective for Tetra Pak.

7 Discussion

During the course of this evaluation there have been some questions regarding the accuracy and reliance of the investigation. These questions must be discussed in order to make the conclusions more reliable and thought through.

The Tetra PlantMaster is a very big and complex system and for that reason the analysis must be reduced to certain parts or made in steps. In this case the analysis has been made in only one part of the PlantMaster. That part is the process cell called L001-L002. This part have been tested theoretically and the results where clear. Only one theoretical model was used in order to investigate the interface. It can be argued that using only one model to analyze an interface is not enough since only one model does not provide a complete picture of the usability in the interface.

However, different evaluation methods are used and given the interface and the user profile the GOMS-analysis is expected to provide the most accurate answer. The GOMS-analysis is supposed to be used when modeling expert behavior in very short time periods. That is exactly what has been done in this case, hence the GOMS-analysis a may be regarded as a choice.

The questionnaire is used to find out who the operators are and what they think of the system. The operators have little or no education before they start to work on the Tetra PlantMaster. A reasonable question is therefore how they can be regarded as expert users when they do not have any education prior to their work with the Tetra PlantMaster.

The PlantMaster is assumed to be quite easy to learn and to use and given the duration of time the operators work with the system, they can be regarded as expert users after working with the system for a certain duration of time. The assumption is consequently that the operators may be considered experts and therefore the GOMS-analysis could be used. This assumption where proven right by the GOMS-analysis and the system was in fact easy to use.

The questions in the questionnaire are regarding the user, the specific applications and the benefits and drawbacks in the interface. It is from the questionnaires the applications that was investigated in the GOMS-analysis where chosen.

The questionnaires and the interviews also showed very unanimous results concerning the overall picture of the system. The statement is that the system is easy to use and that it is, general, a very good system. Two things where pointed out, problems with the alarm handling and problems with the overview of functionality. The reason why these two problems not have been theoretically investigated is that the model that was used to perform the GOMS-analysis did not have those applications implemented. Hence, those specific applications could not be theoretically tested. For the same reason no proper recommendations can be made. The suggestions concerning alarm handling and overview that are made in this thesis are only ideas and they have not been tested or evaluated in any way.

Both operators and engineers have been asked to comment on this evaluation. Furthermore have the Tetra Pak internal guidelines on usability and technical literature on the subject been studied thoroughly. This has been done for the part that originally where intended to be evaluated. Therefore the evaluation of that specific part of the Tetra PlantMaster may be regarded as solid and reliable. During the course of this investigation some problems in other parts of the system where uncovered and they have not been properly evaluated. Therefore the only proper conclusion and course of action is that these are potential problems and that the potential problems should be investigated further.

7.1 Reliance of the survey

As stated above the analysis has been conducted from different perspectives, from the developer point of view , from the operator point of view as well as from a theoretical point of view. Given all the perspective the analysis can be considered very solid.

The shortcomings of this analysis is not the number of angles from which the interface has been analyzed. It is the quantity within each angle that can be discussed. The numbers of operators that were interviewed where only three, and they were all working at the same plant. This is not satisfactory from a quantity point of view. More interviews with operators should have been conducted and more important, they should not work at the same plant. Also the quantity of the interviews with the process/automation engineers should be larger. In this survey only three engineers where interviewed. As in the case with the operators, this is to provide a statistical foundation for the conclusions made from the interviews.

Since the results both from the interviews and questionnaires were clearly unanimous the effects of the small quantities are reduced. If the results where incongruous the small numbers of interviews would make the interviews useless.

7.2 Sources of error

The lack of quantity in the interviews can lead to errors in the conclusions. Due to the strong unanimity in the answers the risk of errors in the analysis of the answers to the questionnaire are reduced. However, errors can also be made in the formulation of the questionnaire which could lead to that the persons that answer the questionnaires misinterpret the questions thus providing a false picture of what they think of the interface. The risk of misinterpretations is reduced by testing and redesigning the questionnaire several times before using it.

Also the interpretation of the literature and the GOMS-analysis can lead to misuse of the theoretical tools.

Once again the unanimity in the answers implies that the negative effects of the kind mentioned above are reduced. The risk of misinterpreting all the different parts in a way that makes them fit together to the extent shown here are very unlikely. Furthermore both the questionnaires and the theoretical tool have been commented on by a third party before being put to use.

7.3 Interpretations and expectations

There is always a risk that the person who is conducting the analysis will interpret the results in accordance with the previous expectations of the analysis. This means that if the analyst expects a certain outcome of the analysis the analyst will interpret the results to match the expectations.

In this particular case the outcome of the analysis is not expected. Even though the results are very clear and easy to interpret they were not expected and as in the previous cases, when the results of the questionnaires and interviews as are as clear as here there are not much room for misinterpretations.

8 Thoughts and ideas

As stated before no theoretical investigation has been made on the two major issues that have derived from this thesis and that's the reason for launching an investigation with emphasis on these subjects once they are developed.

Since Tetra Pak has expressed a wish to hear some thoughts and ideas on how to redesign the alarm handling and overview of functionality in order to improve the design, some ideas are presented here.

It is very important to realize that the ideas presented here have *not* been tested and developed in any way, and they are only to be regarded as initial thoughts and ideas on how the design of the alarm handling and the system overview can be structured.

In the case with the system overview an idea could be that every process cell has an icon that shows the status of the entire cell (see figure 15).

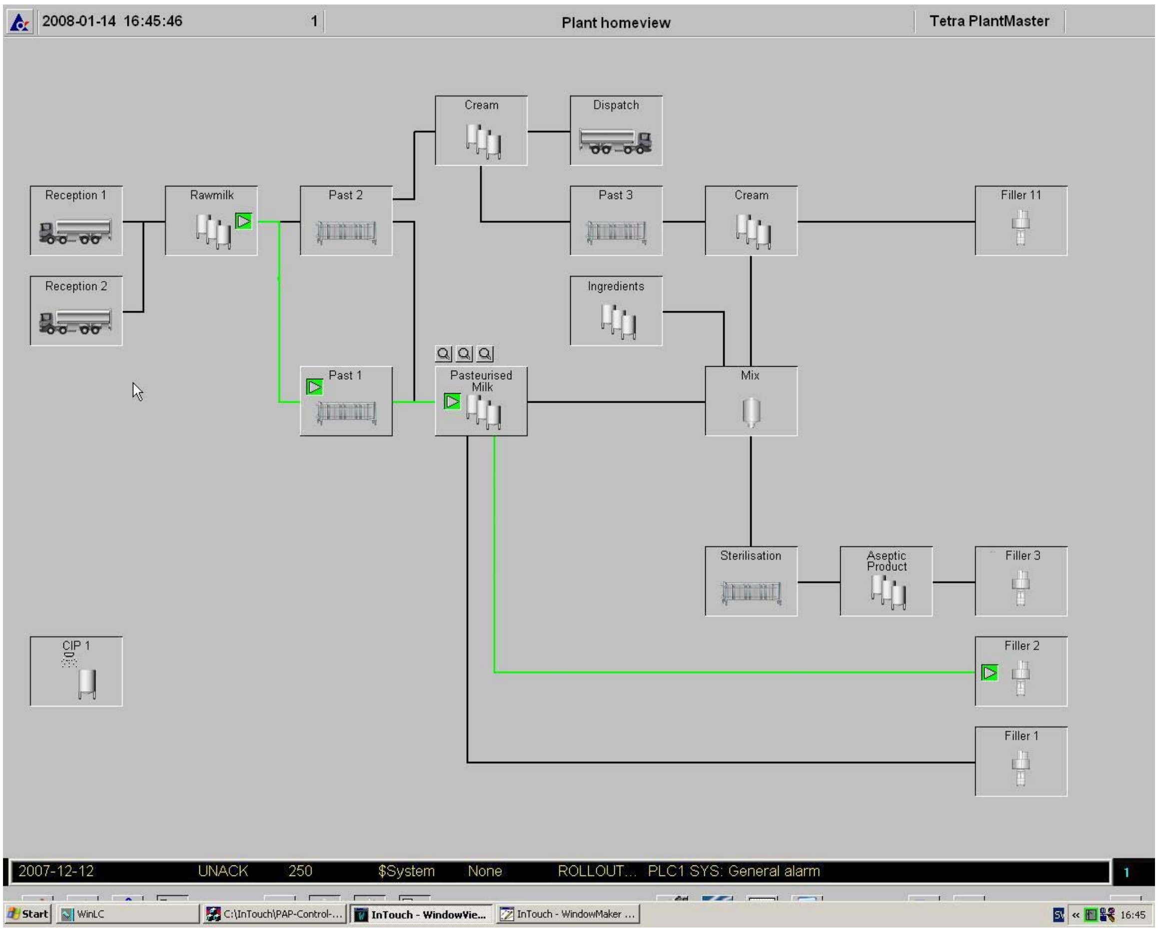

Figure 15. A possible way to provide an overview of functionality at Plant home view level.

In this case there would need to be an order of priority within each cell. If only parts of one cell are in working order it should be displayed that the cell is not in working order to draw attention to that specific cell (see figure 16).

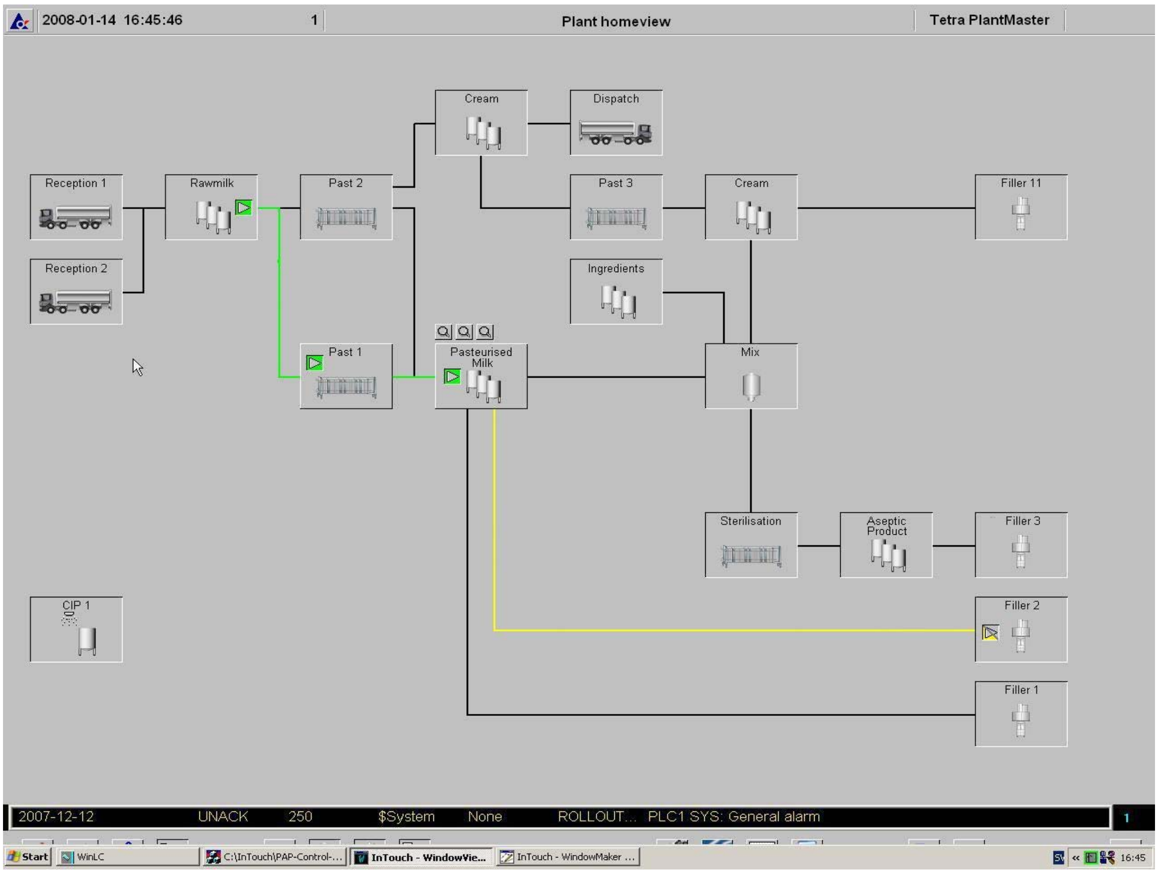

Figure 16. An example where filler 2 is not completely operational which is displayed on plant home view

How to develop the alarm handling system is a bit more complex. The way Tetra PlantMaster works now is that there are three different levels of alarms, depending on severity of the alarm. They are displayed with three different colors in the same window. They could be displayed in three separate sub-windows, and even with different rules on how to acknowledge them.

The system could also have some order of priority. Less severe alarms from the same valve or engine does not need to be displayed when there are more severe alarms from the same valve or engine.

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ISBN: 0-444-81876-6

Björn Häger, Intervjuteknik
Förlag: Liber AB 2001
ISBN: 91-47-05094-2

Papers:

Else Nygren: Grafiska användargränssnitt, några tips.

Tetra Paks Interna HMI Dokument:

PAP-general-106-PRS_HMI_guidelines_vXXXX
KA271710
KA271720
KA271730
PAP-General-100-PRS_Production Tank-Line-Tank concept_vXXXX

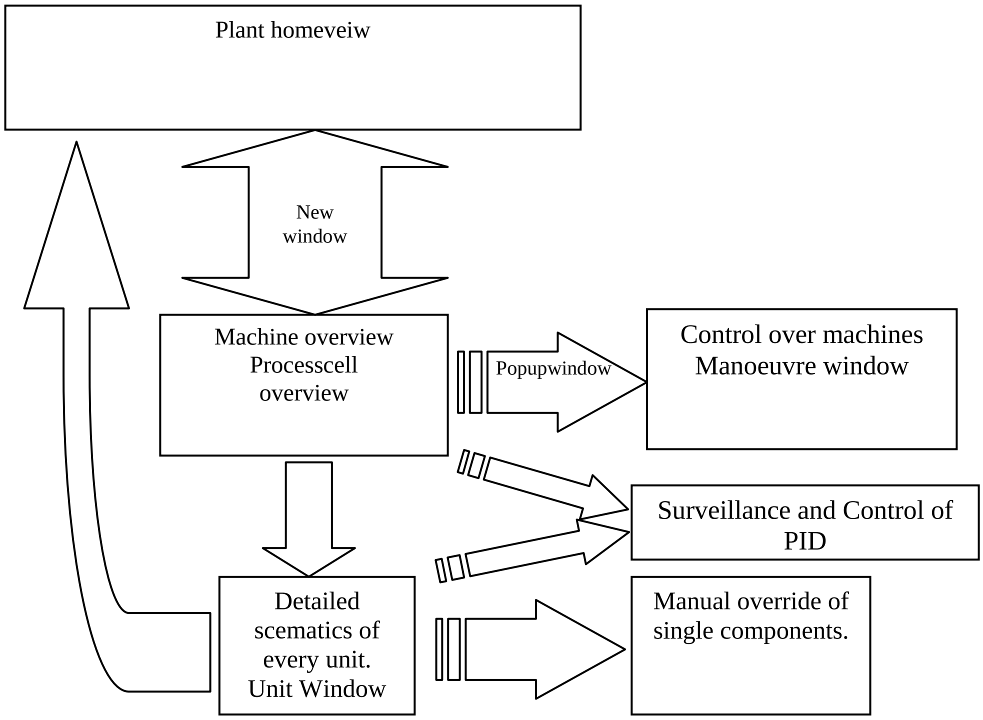
Internet:

http://www.tetrapak.com/ 2008-01-15

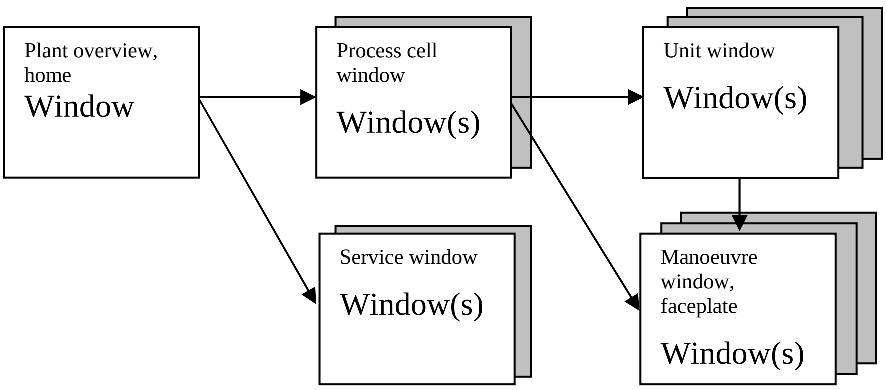
10 Appendix

A. The mental and conceptual model

Mental model - Derived from how the author understands the Tetra PlantMaster.



Konceptual model – From the Tetra Pak guidelines on HMI within Tetra PlantMaster



B. The GOMS-analysis

To start a production line

Goal: To start a production line in a production cell where all the tanks and lines are flushed and ready to use in every way. The process cell window is displayed, all the volumes are adjusted and the proper tags are marked. The only thing to do is to the flow through the process.

Methods:

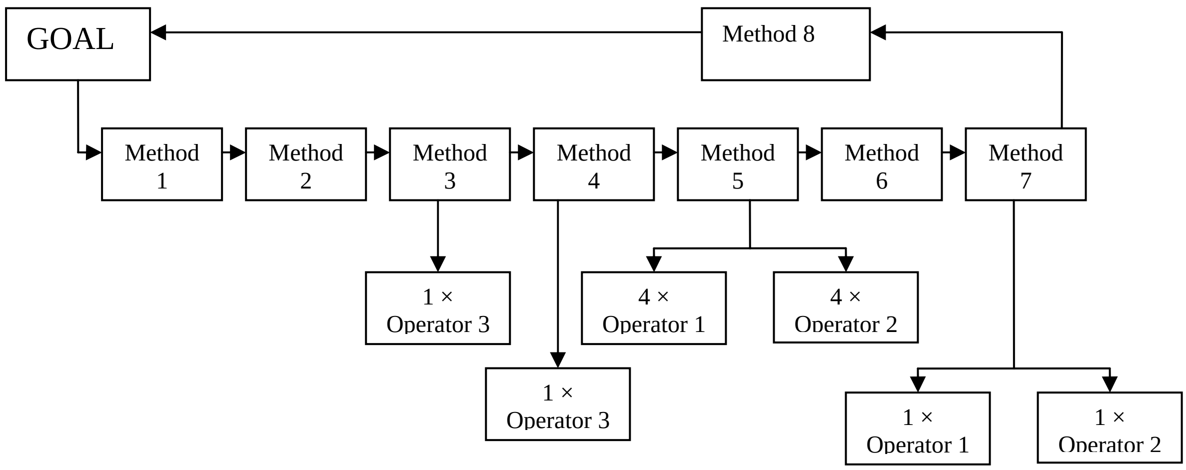
1. Understand that start needs to be clicked.
2. Understand that the pasteurizer needs to be clicked.
3. Understand to choose the right source (More than one to choose from)
4. Understand to choose the right destination (More than one to choose from)
5. Implement the action. (Operators)
6. Understand that finalize need to be clicked.
7. Implement finalize (Operators)
8. Return with command accomplished

Operators:

1. Move the mouse to the right position.
2. Clicking the mouse.
3. Make a decision to use the right source/destination

Selection rules: Here are no selection rules since there is only one way to perform this task.

The Goal, Operators, Methods and selection rules are displayed in a flowchart to make it easier to get an overview.



To stop a productionline

Goal: To stop an ongoing production line Process cell window are displayed and the production is running. The only thing to do is to stop the production and there are two ways to do this

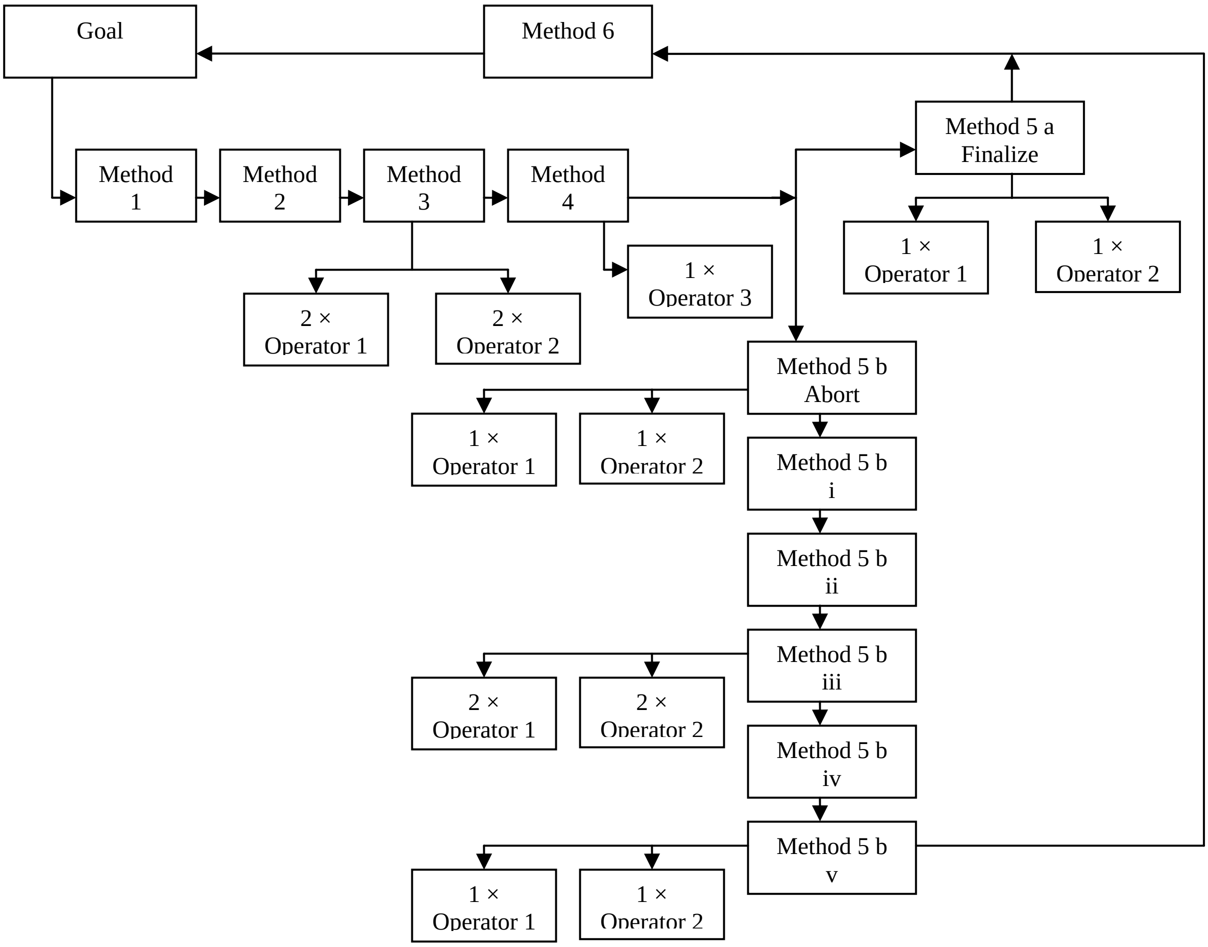
Method:

1. Understand that stop needs to be clicked.
2. Understand that a specific cell needs to be accessed.
3. Implement the action. (Operators)
4. Understand that finalize or abort needs to be clicked.(Operators Mental)
5. Implement the action.
    a. Finalize (Operators)
    b. Abort (Operators)
        i. Understand that the system only is paused and not stopped.
        ii. Understand that stop needs to be pressed again.
        iii. Implement the action. (Operators *2)
        iv. Understand that the action needs to be confirmed.
        v. Implement the action. (Operators)
6. Return with command accomplished

Operators:

1. Move the mouse to the right position.
2. Clicking the mouse.
3. Make a decision which method to use.

Selection rules: Use finalize when the system is in working order and use abort when an error occurs.



To change a product

Goal: To set up a secondary production line in queue while another line is running. The production cell window is displayed and all the parameters are adjusted. The only thing that needs to be done is to choose the line that is supposed to be in queue.

Method:

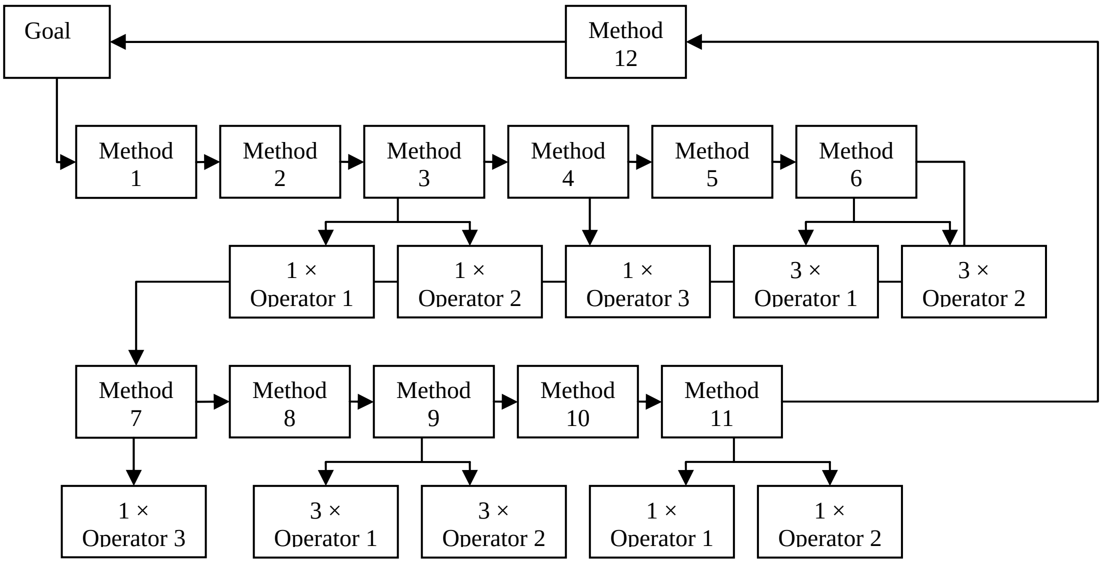
1. Understand which batch to put in line.
2. Understand that the pasteurizer needs to be clicked.
3. Implement the action (operators)
4. Understand to choose the right source (Mental operator)
5. Understand that the source needs to be queued.
6. Implement the action (operators *3)
7. Understand to choose the right destination. (Mental operator)
8. Understand that the destination needs to be queued.
9. Implement the action (operators*3)
10. Understand that the product needs to be queued.
11. Implement the action.(Operators)
12. Return with command accompished.

Operators:

1. Move the mouse to the right position.
2. Clicking the mouse.
3. Make a decision to use the right tank

Selection rules: Here are no selection rules since there is only one way to perform this task.

The Goal, Operators, Methods and selection rules are displayed in a flowchart to make it easier to get an overview.



To adjust a parameter

Goal: To adjust a parameter when the production is running. Process cell window are displayed. Since there are two different ways to adjust the parameters, two cases will be tested. The two cases that will be tested are ”production target amount” and ”fill to drain time”.

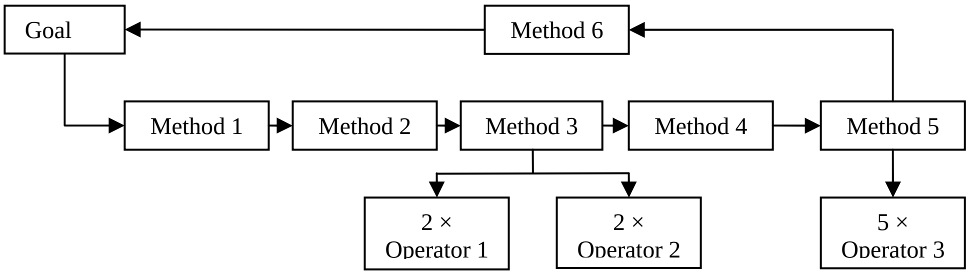
Case 1: Production target amount. (four figure numbers are to be filled in)

Method:

1. Understand that target amount needs to be selected.
2. Understand that a unit cell needs to be selected.
3. Implement the action. (Operators* 2).
4. Understand that target amount needs to be filled out.
5. Implement the action. (Operators* 5).
6. Return with command accomplished.

Operators:

1. Move the mouse to the right position.
2. Clicking the mouse.
3. Type the keyboard



Case 2: Fill to drain time. (Two figure numbers are to be filled in)

Method:

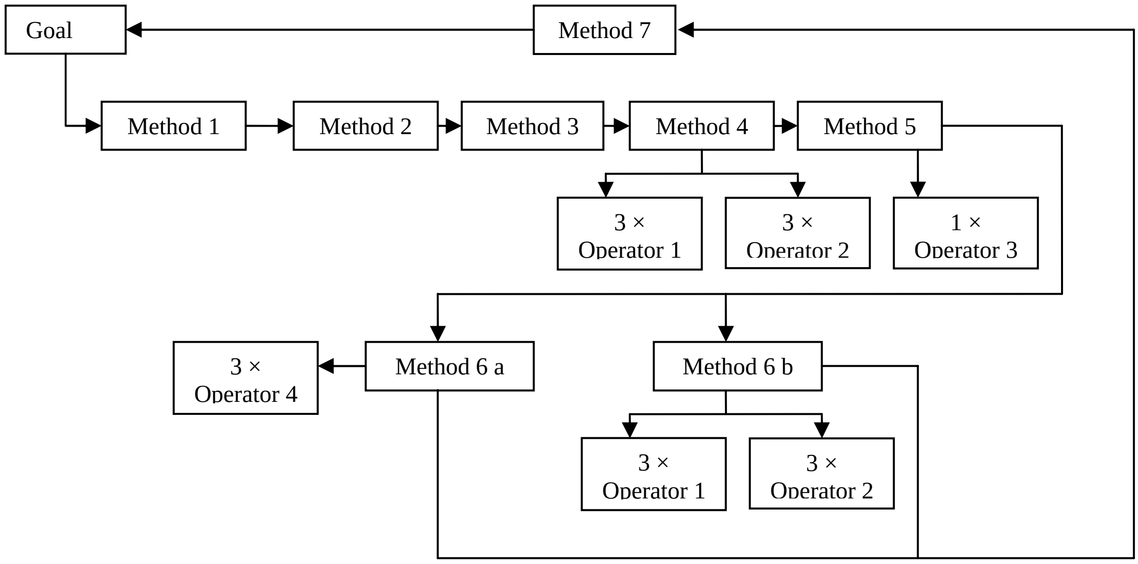
1. Understand that fill to drain time needs to be selected.
2. Understand that production variables needs to be entered
3. Understand that a unit cell needs to be selected.
4. Implement the action. (operators*3)
7. Understand that Fill to drain time needs to be filled out. (Mental operator)
5. Implement the action.

    a. Use keyboard strokes (Operator *3)
    b. Use numeric keypad and the mouse (Operator *6)

6. Return with goal accomplished

Operators:

1. Move the mouse to the right position.
2. Clicking the mouse.
3. Make a choice on which method to use
4. Type on the keyboard



Selection rules: Always use the keyboard.

C. Questionnaires

Evaluation of the Tetra PlantMaster User Interface.

This evaluation form is part of a project to evaluate the usability of the Human-Machine Interface in Tetra PlantMaster. The project is a joint project between Tetra Pak Processing systems AB/Plant Automation and the Lund Institute of Technology. This questionnaire is part of a survey of the operators and is of great value to us. Please take a few minutes to answer the following questions.

What is the estimated average age of the operators?

☐ under 30 ☐ 30 – 40 ☐ 40 – 50 ☐ above 50 ☐ Mixture of all ages

What is the average duration of the operator's employment?_______________________________

What is the average level of education for the operator?

____

Does the average operator have any technical or computer orientated education? If so, please elaborate.

____

Do the operators receive any formal education or user manual when they begin working with Tetra PlantMaster? If so, what kind of education or manual do they receive?

____

Do the operators find it hard to learn the applications used in the Tetra PlantMaster?

Easy	☐	☐	☐	☐	☐	Difficult
	1	2	3	4	5	

Are there any particular applications that many operators find easy or difficult to learn?

____

Do the operators find it easy to navigate the Tetra PlantMaster?

☐ Yes ☐ Depends on the task ☐ No

If the answer to the last question was ”Depends on the task”, which task is the most difficult to perform?

____

Which applications are the five most frequently used in Tetra PlantMaster? Please rank them from one through five.

- ☐ Start a production line
- ☐ Stop a production line
- ☐ Clean the line and the tanks
- ☐ Change product
- ☐ Adjust parameters in the process (Time-scale or quantity)
- ☐ Using shortcuts in the interface
- ☐ Something else____

Have there been any comments from operators about functions in the user interface that the operator finds unnecessary or difficult? If so, which one?

____

Have there been any comments from operators about functions (i.e. shortcuts or navigational tools) that should be added in the user interface in order to improve it? If so, which functions should be added?

____

Have there been any comments from operators about changing or restructuring the user interface in any way? If so, in what way?

____

Do you have any further comments concerning the operator profile or this questionnaire?

____

____

____

Thank you for your participation!

D. Interviews with the operators.

Female, 23 years.

- Employed for 6 months.
- Higher education, three years in collage, management.
- No technical- or computer oriented education.
- Received both practical and theoretical education when she started at the plant. In total during a period of four weeks.
- She thought it was very easy to learn how to handle, and to use, the Tetra PlantMaster. (1 in a 1 trough 5 scale, where 1 is very easy)

- Three applications should be added

    1. Indicators that tell the level of products in all the tanks, including the tanks between the different process units.
    2. Level of progress when washing the system.
    3. Proportional size on the tanks in the interface.

- Two applications should be restructured.

    1. The alarm handling.
    2. The plant overview.

- She could not find any applications that she found to be unnecessary.

Male 59 years

- Employed for 43 years.
- No higher education.
- No technical- or computer oriented education.
- Receive ongoing education when it is needed. Received an education on the Tetra PlantMaster when it was put into use.
- He thought it neither hard nor easy to learn how to use the system (3 in a 1 trough 5 scale, where 1 is very easy)
- Once he had learned to use the system it was easy to use.
- He thought that there was too much information on the screen and that some of the information could be removed. He could not say what part of the information that should be removed.
- Two applications should be restructured.

    1. The alarm handling.
    2. The plant overview.

- No applications should be added.

Male 40 -50 years (The participant did not want to say the exact age)

- Employed for 26 years.
- No higher education.
- No Technical- or computer oriented education.
- Received an education on the Tetra PlantMaster when it was put into use.
- He thought it neither hard nor easy to learn how to use the system
  (3 in a 1 trough 5 scale, where 1 is very easy)
- Whether it is easy to use is a matter of which application that is being used. He could not name any specific applications that are hard to use but he says that they are hard to use due to the lack of overview.
- He could not find any applications that were unnecessary in the interface.
- One application should be restructured.

    1. The plant overview.

- No applications should be added.

Remarks: None of the operators read the alarm text when a new alarm showed up on the screen. And there were a vast number of alarms during the interview.