Develop and test user interface concept for a dialysis machine

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Preface

The task for this Master Thesis was developed by *Gambro Lundia AB,* division *Human factors engineering.*

After careful consideration the performers choose this mission because they found the task to be both exiting and interesting. The Master Thesis fell in both field of interest; ergonomics.

A thanks is addressed to

Bengt Larsson, Human Factors Engineering R&D at *Gambro* Lundia AB

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Mia Andersson & Malin Farmansson

Abstract

This Master Thesis report contains a development process of an interface on a dialysis machine. The evaluation of different methods of design processes will first be described. When the design method has been selected the different step of this method will be explained. After a theory part the method steps will be implemented and the result of the tasks will be demonstrated. The design development steps will generate a prototype which will be implemented and tested by test users. The test will be described and the result of the test will be evaluated. The test result leads to modifications of the prototype and a final concept will be described. A concept called *MiMa* was generated by this process. A discussion will describe how the result turned out and the conclusions and further recommendations can be read at the end of the document.

Keywords:

User interface, dialysis machine, design development process, Usability test

Sammanfattning

Målet med detta examensarbete var att ta fram ett nytt koncept för ett användargränssnitt för en dialysmaskin. Detta användargränssnitt ska kunna användas internationellt och av personer med olika utbildningsnivåer.

Efter en utvärdering valdes en designutvecklingmetod att arbeta efter som har lärts ut på LTH:s industridesignavdelning. Metoden började med att studera dialys i teorin, därefter utfördes en systemanalys där parametrarna som påverkade systemet jämfördes med de utgående parametrarna. En *brief* utfördes där målet för produkten förklarades, här definierades huvuduppgiften för det nya användargränssnittet; att kommunicera med personer med olika bakgrund och kultur. Utifrån denna analys utfördes en funktionsanalys, där adjektiv och verb sattes samman för att beskriva produkten, detta låg även som underlag för senare utvärdering.

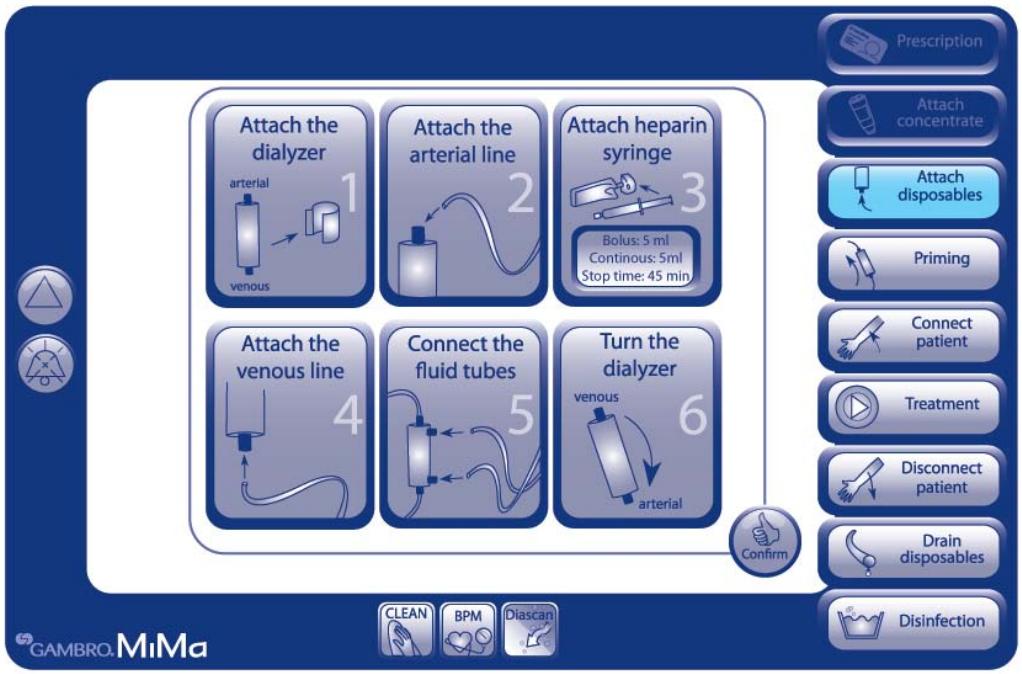
Marknadsundersökning utfördes genom att göra studiebesök på Heleneholms dialys i Malmö. Här sågs det nuvarande användargränssnittet i sin verkliga kontext. Det fanns även utrymme för intervjuer under besöket för att få en ökad förståelse. Konkurrenters dialysmaskiner jämfördes med *Gambros* dialysmaskiner i ett sektor diagram. Här kunde positioneringen av det framtida konceptet bestämmas. Denna punkt utvärderades och känslor kopplades samman med hur en maskin i denna sektor skulle uttryckas. Dessa känslor blev: *säker, pålitlig, ordningsam, strukturerad, välträngad, genuin, stabil, vackert att titta på och användarvänligt.* Dessa känslor uttryckets med hjälp av *mood boards* för att få en uppfattning hur olika människor uppfattar samma ord och sätta ord i bilder och former. Andra *mood boards* utfördes också men med fokus på andra världsdelar och hur man uttrycker sig grafiskt i dessa, samt hur en dialys kan se ut i ett annat land.

Brainstorming gav sedan utlopp för all underliggande kreativitet som skapats under de första metodstegen. Här var det olika saker som skissades; helhetskonceptet med hur en användare kan interagera med en dialysmaskin men även olika funktioner var för sig. Efter utvärdering baserad på de uppsatta målen beslutades att en pekskärm skulle användas. Utifrån vetskapen om en pekskärm skissades olika förslag upp i Adobe Illustrator på datorn. Förslagen begränsades till åtta stycken som i sin tur utvärderades efter de uppsatta målen. Efter överläggning beslutades att blanda några av förslagen för att komma fram till ett koncept. Detta koncept vidareutvecklades med långa diskussioner både internt på *Gambro* men även med de tre olika handledarna på LTH. En prototyp togs fram i Adobe Flash för att kunna användas i tester. En testplan skrevs, där målet med testet togs upp. Detta mål bygger på en heuristisk utvärdering där effektivitet, verkningsgrad, säkerhet, användbarhet, inlärningsförmåga och igenkänning ingår.

Ett användartest utfördes i *Gambros* lokaler, där testet filmades och utfördes av en testledare och observerare. Efter testet intervjuades testpersonerna som bestod av två användare med mindre erfarenhet av dialys, två sjuksköterskor som arbetar med dialys och tre sjuksköterskor från *Gambro* som arbetar med att lära ut *Gambros* olika maskiner. Dessa tester gav nyttig information och delar av konceptet ändrades. Testpersonerna var överlag mycket nöjda med användargränssnittet så endast mindre funktioner och grafiska moment behövde ändras, dock krävdes en del tid för att ta fram det slutliga konceptet. Här bestämdes alla funktioner in i minsta detalj så långt som det är möjligt. Det sattes även upp rekommendationer för framtiden och hur en vidare utveckling skulle kunna se ut. Det nya konceptet döptes till *MiMa* och kommer i framtiden benämnas som det.

MiMa är ett lättöverskådligt användargränssnitt som bygger på nio steg, se figur 1. Dessa nio steg ska guida användaren genom en dialysbehandling. De nio stegen är; ordination, fäst koncentrat, fäst engångsartiklar, skölja maskinen, koppla patient, behandling, bortkoppla patient, töm engångsartiklar och desinficering. Under dessa stegen finns olika guideboxar, i dessa boxar finns tillvägagångssättet beskrivet för varje steg. Om användaren behöver hjälp med något av dessa stegen kan denne bara trycka på boxen och ett hjälpfönster kommer upp. Om ett tillbud dyker upp kommer ett alarm visas på skärmen. I detta larmfönster kommer alla parametrar som rör alarmet finnas tillgängliga. Det ska vara möjligt att lösa alarmet direkt i alarmfönstret.

Stegen i *MiMa* kommer att bekräftas med hjälp av en bekräftelseknapp, detta för att öka säkerheten i användaregränssnittet och bidra till tydligare återkoppling.



Figur 1-1. Ett av stegen i användargränssnittet *MiMa.*

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1 Gambro

Gambro is a global medically company that develop, produce and distribute products and treatments for kidney and liver dialysis(1).

The company was founded in 1964 by Holger Crafoord who started to develop an invention by Nils Alwall concerning artificial kidneys, see Figure 1.1. In 1967 they started their production for artificial kidneys and in the 70th *Gambro* started to grow outside Sweden.

Figure 1-1. *Gambros* founder Holger Crafoord and professor Nils Alwall(1).

Today *Gambro* is divided into three separate companies; *Gambro* who focus on extra corporeal treatments, *Cardigan BCT* who focus on blood component technology and *Diaverum* who was the operator of *Gambro* dialysis clinics earlier and is now sold to investment company *Bridgepoint*. The company of *Gambro* has 8000 employees, production facilities in nine countries and is selling products in more than 100 different countries.

At *Gambro Lundia* in Lund Sweden, the dialysis machines are manufactured, water purification facilities and dry concentrate that's in use during a dialysis treatment. The research- and development departments of *Gambro* are located in Lund and that's where this Master Thesis has been developed.

2 Project description

In this chapter the project is described by means of problem description, the objective, limitation and focus.

2.1 Problem formulation

Gambro wants to keep up with other dialysis companies in terms of development, and due to that *Gambro* decided to search for new solutions by having students doing their Master Thesis on interaction design in the *Human Factors Engineering* department at *Gambro*, in Lund.

The dialysis machine *AK 96™* had a suitable complexity for the Master Thesis and felt outdated, something that *Gambro* wanted to improve.

2.2 Objective

The purpose of this work is to compile and develop a user interface concept for a dialysis machine legitimate for multicultural use, to the four corners of the earth. The user interface must support the dialysis machine users with different backgrounds and education levels.

The aim is to:
• Develop and produce a prototype for an user interface concept.
• Develop a style guide that describes the design of various objects in the concept
• Document and explain the dynamics of the concept
• Evaluate the prototype of an intended user who practice the latest techniques.

2.3 Limitations and focus

Gambro has from the beginning of this project put up focus points;

- *Gambro* users shall be able to see the *Gambro* brand in the machine
- The user interface shall follow European standards
- The user interface shall be suitable for people with different education level.
- The users to the dialysis machine *Artis™*, *see in Artis™*, shall be comfortable using the new interface
- The interface shall be suitable for people over the whole world

Throughout their education the performers have learned that it doesn't make sense to suit all people of all kinds. It's better to focus on a specific target group to reach

success of a product and have the world under your feet. There was also a lack of focus on user interface. Therefore they have set up extra limitations from their side to get a more clear focus and a better product over discussions with *Gambro*. The added limitations are;

- *To be consistent throughout the design*

  It has been proved that a consistent design goes hand in hand with user friendly design.

- *To have a good overview*

  To have a good overview could make the interface more user-friendly.

- *To have a lot of illustrations*

  This is due to the fact that a picture is worth more than a thousand words, but also that they in both China and Brazil are used to and are comfortable with a lot of illustrations according to *Gustaf von Friesendorff, Gambro Business Intelligence.*

- *To put simplicity before complex technical design*

  This is so that the user friendliness always is put on focus.

There are a lot of factors to include in interaction design, see Figure 2.1. The performers don't have all this knowledge and experience, which result in some more limitations. The performers will focus on parts of the three sections; *Academic disciplines, Design Practices* and *Interdisciplinary fields*(2). In academic disciplines the students has knowledge and experience of ergonomics and engineering, there will be limitations in psychology/ cognitive science, informatics, computer science / software engineering and social sciences. In the machine design practices field the performers have knowledge and experience of graphic design, product design and industrial design, there will not be any focus in artist-design and film industry. In the interdisciplinary fields the students will get knowledge about human factors, human-computer interaction, cognitive ergonomics and cognitive engineering, but there will be limitations in computer-supported cooperative work and information systems.

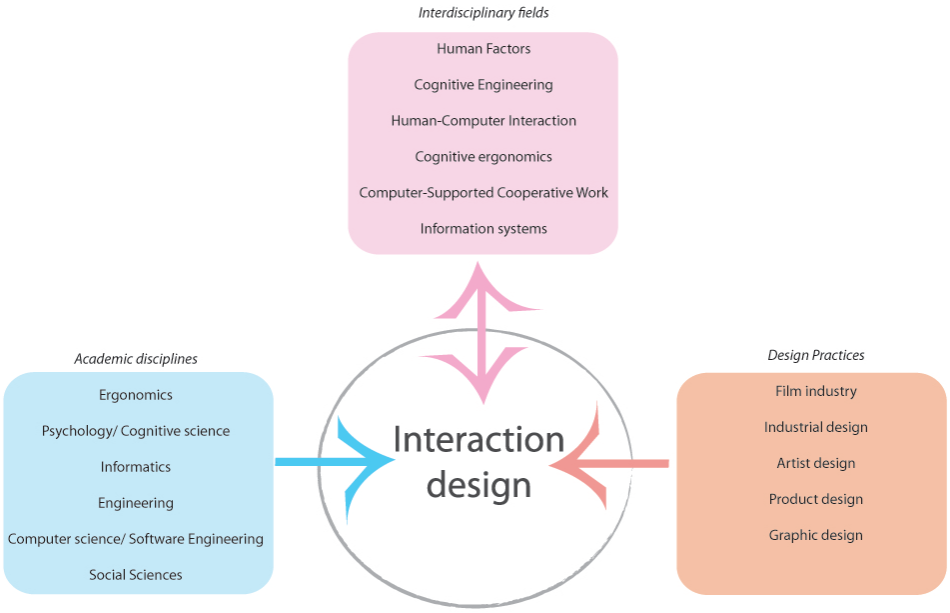

Figure 2-1. Different parts involving interaction design(2).

3 Method

There are different methodologies to use when carrying out a scientific report. Some common scientific approach is exploratory, descriptive, and normative explanative. This report will consider both the explanative, explanatory approach but also in some aspects the normative approach. The aim of the report is to describe and explain the interaction between humans and design.

The purpose of this work, as described in chapter 2, is to compile and develop a user interface concept for a dialysis machine legitimate for multicultural use. The user interface must support the dialysis machine users with different backgrounds and education levels. To be able to come up with this concept literature studies will be performed. This provides an introduction to the dialysis machine and its environment. Literature studies should be conducted around the user interface and interaction between man and machine. Conversations and interviews with the lecturers on cognitive design will be performed. This gives a broader knowledge of the subject and the interviews help to get a true picture of the topic.

Observations, interviews and surveys will be conducted to create an understanding of the dialysis machine and its operator interface. Since the purpose of this work is to create a concept that is adapted for different cultures and people from different backgrounds and education levels data will be collected from as broad audience as possible. However, it's difficult to observe and interview people in other countries and other places than in Lund. Surveys can be sent out internationally if Gambro's previous studies not are sufficient.

To reach out to different levels of education data will be collected from users with different education level and it should also be made observations at a dialysis centre. Data will also be retrieved from internal employees.

3.1 Selection of method

Selection of method was based on three different methodologies, *Design methodology by Per Liljeqvist,* see further in the text, *Ulrich & Eppingers- and Matt Cooke's methodology,* see Appendix A, Appendix B and Figure 3.1 (3),(4) and (5).Below follows an analysis and reasons for choice of method.

The design methodology by Liljeqvist focuses on the creative process, there's numbers of elements that improve the creativity, for example the brief should be as free as possible so that no solutions can be made prematurely. This method promotes innovative solutions and wants the performers to "think outside the box".

The method has been taught to students by lector Per Liljeqvist at the *Industrial Design Department* at *Lund University*, the performers have used the methodology in various courses. This method promotes creative solutions, which can be seen very risky when solutions can be exceptionally innovative. Innovative solutions can have both positive and negative impact on the market, sometimes the market need a revolutionary product, and sometimes the market is calling for "just" an improvement of a previous product. This method wants to free the performer from such habits and thoughts of a product. This means that the performer doesn't want to see the end from the start of the project, the final concept will emerge and this requires a reliance on that the method will work. The method can be difficult to use in negotiation situations, it may be difficult to convince a boss that this is the optimal method to use just because of the fact that a glimpse of the results can't be given in advance

Ulrich & Eppingers methodology is a basic methodology that works well for collaboration between the industrial designer and the engineer designer. The method is systematically divided into various steps that are easy to follow, the description is detailed and performers can follow a template. However, this can inhibit creativity if the developer gets stuck in a template.

In this method the creative process is in the phase of generate ideas. This method could knock-back the creativity due to the fact that there is no preparation considering creativities methods. Therefore there's a risk that the performer already has clear solutions from the beginning and thereby inhibit other solutions to arise.

Ulrich & Eppinger's method has also been taught to students at the Faculty of Engineering, but this course wasn't directed only to industrial design students, but also to product developers in machine construction. The method works well in collaboration between industrial designers and engineers. Engineers often have a way to see if the solution works, to see what is possible to manufacture, to see what is sustainable and to find the exact values of such measurements. The industrial designers are great to come up with creative proposals and to open up a habitual pattern. The method favours cooperation between the parties.

Matt Cooke is a graphic designer from San Francisco that has developed a design methodology that focuses on weaving the user more into the process. In many of the method steps, the industrial designer check with the user if and what they understand and what they like, the user is always in focus.

The method is systematic, creative and innovative. Cooke put a lot of effort into identifying problems, needs and users. This is a new methodology that's interesting, the methodology has not been taught to students at the Faculty of Engineering and therefore they have no experience. To have a regular contact with users is a clear competitive advantage; however, it's time consuming and has a high financial cost. In many projects it can be hard to find users and take their time.

The old panel on *AK 96*^{TM}, see Chapter 5, gives an outdated impression and *Gambro* wants inspiration for a new concept. *Gambro* has also opted to bring in outside help in the form of students at the faculty of engineering, this is an indication that *Gambro* is looking for "new imputes" and an innovative interface. Since both the Liljeqvist's

methodology and Matt Cooke's methodology actually encourages creativity and creating an innovative product, these methods are a good choice. According to the project description, *Gambro* will focus on industrial design and not production; this reinforces the choice to choose a method that favours creativity.

Matt Cooke's methodology is based on a large focus on the user. Due to time constraints and financial constraints, this will not be possible and, therefore, this very creative process isn't chosen. There is also very positive experience from the Per Liljeqvist methodology from both performers and they are confident in the methodology.

The work will culminate in a new interface that is innovative, easy to understand and expresses *Gambro*, in order to achieve this objective Liljeqvist methodology is considered to be the most advantageous method.

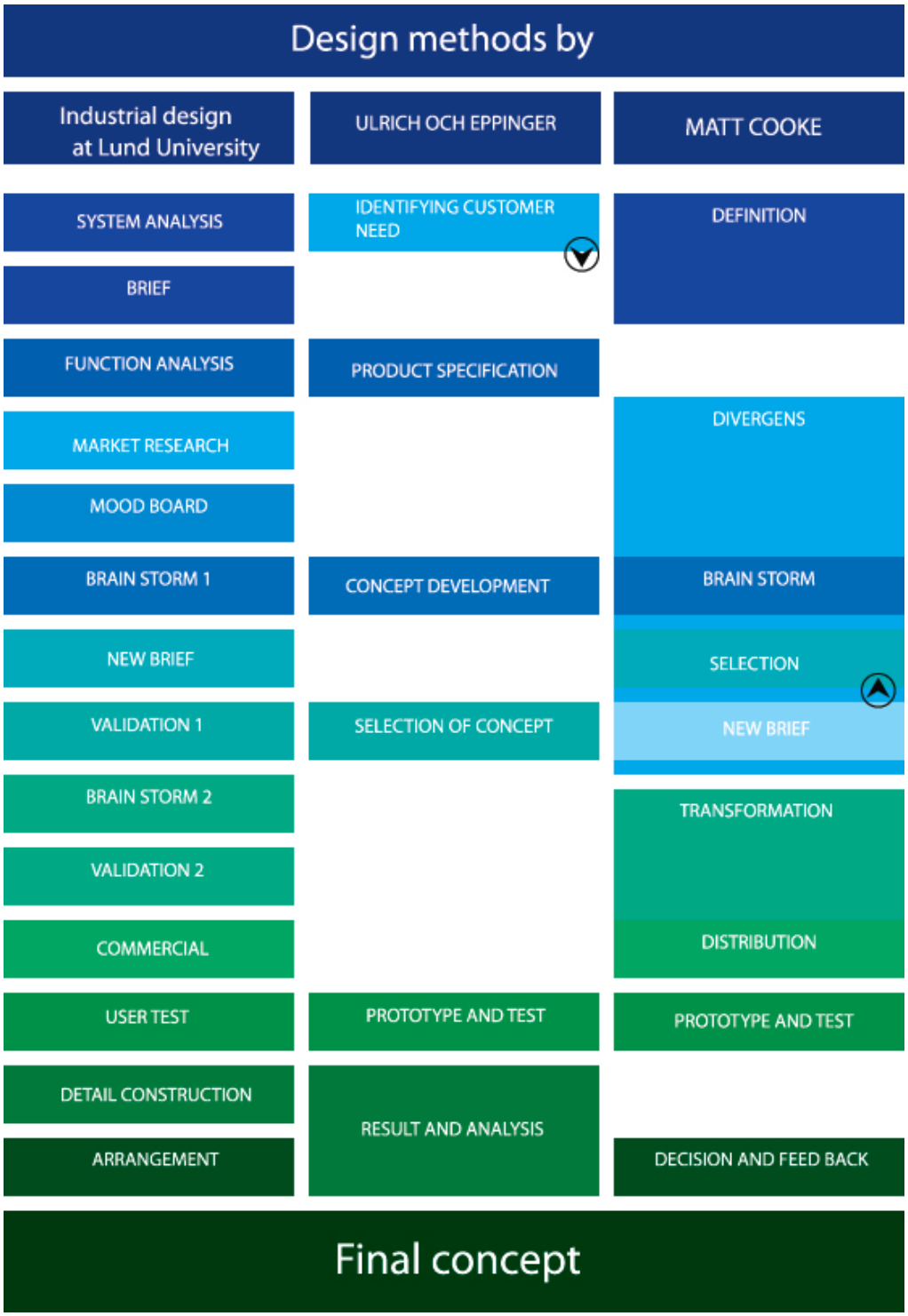

Figure 3-1. Disposition of different design methodologies.(3),(4) and (5)

3.2 Design methodology by Per Liljeqvist

This design process is a method that's taught at Lund University, *LTH*, department of Industrial Design(3). The following describes the process step by step.

3.2.1 Research, Review and Background

In the first phase is information gathered and knowledge of product, for example, literary studies considering the product's function researched. This is performed to obtain a better understanding of the product. Surveys and observations can also be conducted to examine the gaps and needs of the product. This is done to ensure the value of a future product

A common method for systematic data collection is to perform interviews. This is one of the easiest ways to get information about how a person perceives or feels about a phenomenon that is interesting or known before. A well-conducted interview provides facts that meet the specific requirements of usability. In scientific contexts the requirements usually can be a summary of; reliability, validity and make it possible for outsiders to review the results.

3.2.2 System analysis

System analysis determines and identifies what the product needs in order to function and what the result is, that is what goes in and comes out of the product. A systems analysis answers questions such as: *What's the purpose of the product? What do the customers get out of the product? What does the product get from a service provider?*

3.2.3 Brief

A brief is a terse summary of the product, audience and market. It should, for example, answer to questions like; *Why does the product exist? Who is the user and who is the buyer? Where can the product be sold?*

This is summarized into a few lines to clearly see the objectives of the design development. The brief is meant to keep focus on the original target and process view; the process designer can go back and see if the brief objectives are satisfied. A brief can be developed and updated during the process but it should always undergo a carefully weighing before it's changed.

3.2.4 Function analysis

In the functional analysis the designer reflects on why the product exists, it's an analysis and summary of product information, activity and characteristics. A product may be a service, an environment or a system. The purpose of a functional analysis is to reflect on the product and finding a consensus between the parties. This is done based on the product features and how they are valued and to provide a greater insight into the product, this is so that it will be possible to find the needle in the haystack and develop great things.

In a functional analysis the main objective is specified. Functions relating to any properties or requirements that the product has been and can be briefly described using a verb and nouns, for example, “radiate security". Functional analysis may also include a so-called performance limit, for example, to be short (1-2 mm). Here is, 1-2 mm, a so-called *performance limits*. Below are some features that can be included in the functional analysis

- *Main Function*-The *main function* is what the function of the product is primarily intended to do. This property is unrestricted.
- *Sub function*-Sub function is a function that together with other features creates an overall function.
- *Support function*- A support function is a function that ensures the quality of the product and raises the standard of the product.
- *Essential function*-Essential function is a function whose property is necessary for the product. This can also be called as a requirement.
- *Desired function*-A desired function is a feature that it built on the capacity of the desired character. The function is desired but not required.

3.2.5 Market research

Market research is carried out to identify market needs, namely a study to estimate the demand and the options available in order to sell a product. Here the tables are turned and the products designers has to listen to the market instead of just develop what they think is necessary. This investigation is aimed at consumers and users to determine trends and how those users will get the knowledge about the business, the brand and the products.

Market research can be done at different levels of quality and quantity. There’s market research studying people as well as studies that ask questions to the consumers. However, studies that are based on responses to questions should always be taking under consideration. It has been shown through studies that people do not always say what they think when they get asked.

3.2.5.1 *Field observations*

A field observation gives you an idea about what users do when you observe them and talk to them in a real setting i.e. in the context and environment in which they usually live and work. Field observations consist of collecting data in the field by observations, interviews and apprenticeship. The main advantage of this method is the direct observation or, in case of apprenticeship, the experience of user’s difficulties in a given task or the task flow It’s in the early stages of a design process field observations are particularly useful, because it’s in this stage the user thought about improvements really can contribute to the design process. Thus, an explorative and contextual approach is essential.

3.2.5.2 *Mood Board*

Mood boards are a collection of pictures and graphics to convey an impression. There are many ways to create a mood board. Whichever way is chosen depends on time, creativity and what the mood board wants to represent.

3.2.5.3 *Collage*

A loose collage is a mood board that is quickly put together with various images that convey the main impression of the forthcoming product. Around this collage developer is gathered to delete or add photos so that everyone agrees on the feeling. It takes no allowance of details, such as fonts and small areas of colouring in the images, therefore this is the easiest way to create a mood board.

3.2.5.4 *Refined standard*

If clients are not so familiar with a design development process or want a more structured approach, a refined flat can be a more suitable alternative. This method is a more formal development of a mood board and here the colours, and graphic pattern is describes by themselves. The font can be defined for specific keys and user modes.

From these different mood boards an adjective can be defined as representing the various proposals, such as black, classic, elegant and so on. If the other areas need to be defined a mood board can be done around this as well.

3.2.6 Sector Chart and Positioning

Positioning is about determining how a product will be perceived in the market, which direction the product should strive to. It's about being first to transmit an idea to the customer, the product must be the product that first comes to mind. It’s about finding a gap in the market and fill it. The customer will quickly understand the benefits of its product and also what differentiates its product from the competitors. To find market gaps a sector chart can be used. The sector chart is drawn up as an assortment of the market products that will be used. These products are placed into the sector chart according to different measurements on the axis. The factors used to evaluate the market’s products are up to the performer to decide.

3.2.7 Initial brainstorming session

An initial brainstorming session is conducted to generate ideas on product concepts, which can be done every time a new product is to be produced or when problems occur and a solution of the so-called, *Gordian knot*, needed to be untied.

In a brainstorming session, subject to various ideas are pitched on the table. Here the quantity is more important than quality. The mind-set is based on the more the merrier and more suggestions at a later stage lead to quality. Everyone in the group should shout out ideas from the top of one’s lungs to get ideas from a different angle and a new point of view. You can’t be criticized during the session. Spontaneity is encouraged and a feeling that will form the session is that all ideas are good ideas. An idea that seemingly seems bad can always develop into a fantastic and innovative

product. It’s important that all participants in a session will be involved in developing each other's ideas. During brainstorming, various kinds of methods can be used.

3.2.8 A new briefing

After functional analysis, market research, brainstorming and mood board, new definitions and requirements might come up and the brief need an update. It’s therefore the same steps as previously in *Brief* that should be done again.

3.2.9 Initial Evaluation

The ideas that came up during the initial brain storming are assessed according to the mood board, the new brief and other characteristics that are considered important. A grade system is built up to make it easier to rate the various proposals. Here the best options are objectively selected. This step is based on producing the best proposal and based on this work a product idea can grow. There’s an option not to choose the proposal with the highest score but you need a reason to justify it.

3.2.10 Second Brainstorming session

After having selected the product to be developed further, a new round of brain storming is in order. This is because new ideas may become available, the product will be improved and old ideas can be developed. More knowledge and thoughts about the product may have emerged which can provide better ideas. Here brain storming is done on individual functions or even on an entire system.

3.2.11 Second Evaluation

The ideas are evaluated again. Since the end of the process is now heading towards an actual product, new valuation factors get to play their role. Again, as in *Initial evaluation*, the rankings are based on a grade system determined by the brief and functional analysis.

3.2.12 Usability tests

Usability testing is performed to investigate the success of the concept. Here it’s important to remember that it’s the users who shall understand the product. A sense of understanding can never be questioned. Usability testing plays a central role in a process concerning usability. There are several different methods for usability testing.

3.2.12.1 *Single room set*

In a single-room set the test persons get to be in a room where the product is placed. In the room some cameras is rigged to easily analyze the tests afterwards. A test leader is included in the room to be a support to the test persons. However, it’s important that this test manager do not help people to the point that the test results is deteriorate. Observers can be placed behind a special glass wall that is translucent in one direction, this so that observers are able to see the test persons, but not vice versa. Observers may also sit in the test room, but then recommended that they do not have any interaction with test participants during the test.

3.2.12.2 *Think out loud method*

Think out loud method mean that test persons without any test leader in attendance will try to use the product. This is recorded using video surveillance and individuals are invited to express the full review why they do as they do, what they do and if anything is different from what they had expected. This is a good and relatively inexpensive method that provides a fairly effective value of what happens in reality. A drawback of the method is that the product isn't in its normal environment and that this may affect the test subjects.

3.2.12.3 *Interview*

To obtain a test result different forms of interview techniques can be conducted. Two types are structured interview and its opposite unstructured interview. They differ such as in the structured interview, questions are already predetermined, while unstructured interviews are based on more non-specific issues that could lead to discussion. It's for these usability tests deciding whether the product is worthy to be launched or whether any step in the process must be repeated.

3.2.13 Final concept

In the detailed design specifies all product details and dimensions are specified. Here are the exact color codes and standards determine. Detail design is the last drawing before the product goes to manufacturing therefore it's essential that the drawing is carefully conducted and reviewed. When a product is developed, the process ends with the presentation of the final concept.

4 Dialysis

The Master Thesis is about develop a new interface for the Gambro machine AK 96™ due to the fact that this machine has a suitable level of complexity. To be able to understand the discussions and upcoming questions regarding the development of a new interface a chapter about dialysis is provided. The dialysis chapter is about how the treatment can be performed, how the dialysis machine work and about different dialysis units.

4.1 Treatment

This part is about the most common method for treatments; Hemodialysis, *HD*,(6). There will be explained how a treatment is prepared and how to complete it. It will also be information about acute complications during a treatment.

4.1.1 Hemodialysis

The aim with dialysis is to replace the exudation of the kidneys when their function is knocked-down. On an artificial way unwanted substance and superabundance fluid is ablated.

The kidney is a vital organ for the excretion of waste products from the body, but the kidney also regulates the composition of the body fluids. The kidneys excretory functions are to remove waste products, remove excess fluid, and regulate blood pressure, red blood cell production and to regulate calcium uptake.

Hemodialysis is the most common method of treatments that involves depurative of blood when the functions of the kidneys are knocked-down. In *HD* the blood is purified outside the body by an artificial kidney, the blood flows on one side through a thin membrane to the other side where the waste products migrate into a fluid stream. Hemodialysis is typically performed 3-5 times per week.

The blood is depurated from superabundance fluid and unwanted substance through a treatment that pump the blood from the patient through a dialysis filter where the depuration is made, and then back to the patient again.

The dialyzer, “the artificial kidney”, contains two artificial ducts that are separated with a membrane. One of the ducts contains the blood that jets from the patient and the other duct contains the dialysis fluid. The membrane is semi permeable, which

means that one of the ducts leads liquid and loses substance up to a certain molecule size.

Superabundance fluid in the blood is ablating through the pressure differences in relation to the dialysis liquid. This is called ultra filtration. Waste products are removed by the differences in concentration between blood and dialysis liquid.

The differences in concentration makes the mixture wanting to reach equilibrium and dilute the concentration, which means that molecules from the blood gets to the dialysis liquid through the membrane. This is called diffusion. When the diffusion is done the superabundance fluid in the blood and all the rest products has been removed.

The transmembrane pressure, *TMP*, is the pressure differences between the dialysis fluid and the blood from the patient.

The osmotic pressure is the pressure that is enquired to stop the diffusion of liquid from the blood through the membrane to the dialysis fluid. The oncotic pressure on the other hand is that osmotic pressure that is made by the plasma protein.

The rate to reduce fluid is controlled by differences in pressure over the membrane and the capacity of the dialysis. The rate to reduce substance is depending on the blood flow rate and the dialysis fluid flow rate, concentration gradient between blood and dialysis fluid, the capacity of the dialyser, the type of membrane, size and surface.

The function of the dialysis fluid is to correct the chemically construction of the uremic blood, by that means the state of urea and other nitrogenous products that are in the blood. This is due to that the dialysis fluid has the same composition as normal plasma without plasma proteins.

In order to maintain the pH value in the body, by that means how acidic or alkaline solution the body is, the patient should have the right buffering level. Bicarbonate is usually used for this purpose.

At haemodialysis some of the loose particles are going with the blood to the dialysis fluid, this is due to the convection, by that means the transport of loose particles together with a fluid rate. The velocity that loose particles are transporting with through convection depends on ultra filtration rate and the membrane permeability.

Clearance for the dialysis machine describes the purification capacity. Clearance is a dimension on the blood volume that the kidney per unit time cleans completely from one subject, typically in ml / min.

An anticoagulant, for example heparin, is needed to prevent blood coagulating in the extracorporeal circuit. This is given intravenously during treatment but can also be given before a treatment. The coagulating time is extended about 50-100 % during a treatment, but should have returned to normal by the end.

Heparin can be doses single, *bolus injection*, doses sporadically, *intermittent administration*, or doses continuously, *continuously administration.* If a too small

dose is added the blood can coagulate in the dialyzer and there can be a loss of blood. If instead too much heparin is added the patient can get long-term side effects, such as acute internal bleeding or osteoporosis.

4.1.2 Preparations for a dialysis treatment

In a dialysis centre the nurses prepare the dialysis machines at the patient's arrival. They use the patient's journal to pre-program the dialysis machine according to the patient needs. The machine is usually in standby mode after being disinfected. The first step is therefore to start the machine and plug in the dialysis concentrates. A concentrate is connected, usually *BiCart*® [1] which is a solution made of sodium bicarbonate. *BiCart*® is combined with a acid dialysis concentrate that is a composite component. It's an option to plug in acetate also known as etha.

The dialysis fluid will then flow through the system until the correct temperature and conductivity has been achieved and stabilized. Now, the blood lines and the dialyzer can be connected to the machine. The blood line's arterial end is connected to the bag of NaCl solutions. The NaCl saline is mounted on a drop gantry along with an empty bag. This bag is connected to the venous end of the dialysis line.

The next step is called to "prime" the machine. In this step, the blood lines and the dialyzer are filled and rinsed with NaCl solutions. The fluid circuit is also connected so that a back pressure can be created. During the priming, the lines are filled up with NaCl solution, and after that additional 1000-1500 ml to remove air bubbles and etceteras decay products. If air bubbles are obtained during treatment the blood can solidify, which means coagulation in the lines. Air bubbles can also cause blockage in the dialyzer blood path and cause a decrease of the membrane surface. This can be harmful to the patient.

When the preparations are complete, the machine is unused until the patient arrives, but the blood circuit shall be rinsed a final time just before use.

4.1.2.1 *Parameter settings*

Before every treatment the patient has to be weighed. The volume of fluid that will be removed is calculated from the weight increase since the last treatment with an addition of the ingested fluid during the treatment plus the infused fluid. The patient shall not increase their body weight too much between visits, this can burden the cardiovascular system and occur high blood pressure, *hypertension*. A recommendation is to not increase the weight more than 3% of their natural body weight. This is usually equivalent to about 0.5 decilitres a day. From this volume, the machine can adjust the required treatment time, usually between three and a half to five hours.

4.1.2.2 *Acute complications*

Symptomatic hypotension, i.e. a sudden drop of blood pressure and fainting in the worst scenario, is the most common complication during hemodialysis treatment. The patient may also feel sick and have to vomit. The complication usually occurs in the

end of a treatment and infusion of NaCl solution may help to improve the condition. At these complications, the ultrafiltration, *UF*, rate should always be reduced. The slower the *UF* rate is set to the less risk for hypertension.

4.1.3 Complete the treatment

To be able to complete the treatment the arterial needle is removed and the line system is rinsed with saline in order to push back as much blood as possible into the patient's body. Then the second needle is pulled out and the puncture sites are plastered. Two things should be satisfied in an adequate dialysis treatment; enough of removed unwanted solutes and excess fluid.

4.2 The dialyzer

The dialyzer is in other words the artificial kidney(6). Blood and dialysis fluid is flowing through the dialyzer and are separated by a semi permeable membrane. There are two kinds of dialyzers: *the plate* and the *hollow fibre*. It's important that the dialyzer is of a good vigour, that is, how effectively it cleans the blood, and compatibility, which communicates how well it interacts with the body. The plate is very rare.

The hollow fibre is the most common dialyzer. It has four external ports, two for the blood, in- and outflows, and two of dialysis fluid. The blood in the hollow fibre dialyzer is flowing through small, thin capillaries which are surrounded by membranes. Around these capillaries is dialysis fluid flowing.

Ultrafiltration, *UF*, is a value on the dialysis machine that describes the water transport rate through the membrane at a given difference in pressure. UF can be seen as a measure of the hydraulic permeability.

4.3 Dialysis machine

The dialysis machine contains a lot of functions to be able to preceieve a safe dialysis(6). In this chapter important function on a dialysis machine is described. The functions of a dialysis machine can be divided into three features: basic, safety and optional functions.

4.3.1 Basic functions

The basic function takes care of the circulation of blood and dialysis fluid trough the dialyzer. It's important with the correct composition of temperature, flow rate and pressure.

4.3.1.1 *Blood circulation*

The blood flows from the vascular access of the patient through the arterial blood line to the dialyzer, after which it's returned to the patient via the venous blood line.

4.3.1.2 *Initial fluid preparation*

The dialysis fluid line is prepared inside the machine. During a treatment, the dialysis fluid is mixed, heated and deareated. The dialysis fluid is heated to 36 - 40 degrees Celsius, depending on the patients needs. The dialysis fluid is produced from an A- and B -concentrate by continuous dilution with purified water. The incoming water contains air which has to be removed.

4.3.1.3 *Second preparation*

The dialysis fluid is a mixture of pure water and concentrated electrolyte solution. It's important to get the right concentration, this is controlled by measuring the solution's conductivity, which is how well the solution leads electrical current. Different concentrates can be used in the dialysis fluid: acetic dialysis and bicarbonate dialysis. When bicarbonate is used, a two-step proportioning is needed to avoid precipitation of calcium carbonate, $CaCO_3$. This insoluble salt is formed if there are high amounts of bicarbonate and calcium ions in the same solution. For this reason, two concentrates are used, A and B concentrate. A concentrate contain all the electrolytes except for bicarbonate. To resist $CaCO_3$ acetic acid is used. The B concentrate contain bicarbonate.

4.3.1.4 *Ultrafiltration*

In hemodialysis a certain fluid is removed from a patient through a difference in the hydrostatic pressure, TMP. This is controlled by two pumps, a *flow pump* that pressure the fluid in to the dialyzer and a *suction pump* that is located after the dialyzer. The suction pump is adjusting the pressure and the outflow is always faster than the inflow. The differences in flow rate correspond to UF. There are two ways to control the amount of removed fluid, either through TMP or through the volume control. The machine calculates, with the UF rate, the amount of fluid that will be removed. To ensure the UF rate, that means the difference between the inflow and outflow from the dialyzer, volume control is used. This can for example involve sensors to measure liquid flow.

4.3.2 Safety functions

The safety functions monitor and control all processes to provide a safe treatment for the patient. When the alarm limits exceeds the alarm disengage and the patient is disconnected from the system. A clamp is available in the first and last device, it can for example be used to quickly stop the blood flow and disconnect the patient from the system. Pressure monitoring ensures that the pressure is ok, for example no blockage in the blood lines, it's also used as a measurement for venous pressure. A drip chamber is placed after the dialyzer to carry out air. Air bubbles can be very dangerous if they block a blood vessel, which can cause embolism and be fatal. An air detector is also located at the end of the drip chamber.

There are various functions in a dialysis machine in order to protect the patient. The sensors controls the temperature and conductivity before the liquid enters the dialysis machine. If something is wrong the liquid is lead around the dialyzer by the bypass

and the audio and light alarm is trigged. During this time the diffusion is stopped and no solutes is removed.

The blood lead detector controls the leakage from the blood line to the dialysis fluid. This can be trigged if the membrane breaks during the treatment. The detector is placed in the fluid circuit after the dialyzer. Infra-red light detects small amounts of red pigments. A large value start the sound and light alarm, then the dialysis fluid transfers trough the bypass function, the blood pump stops, the blood tubes are squeezed and the patient is disconnected. A PH-meter can be placed on the dialysis machine to verify that the correct concentrate is used.

4.3.2.1 *Alarm Handling*

Modern dialysis machines have a complex network of monitoring and control equipment. It's important to have an easily understandable and user-friendly interface, partly because the machine should be easy to use, but also for safety. In emergencies, it must be easy for medical personnel to quickly locate the information that they need in order to take action. Key features, such as to stop the ultrafiltration, should be activated with a well-defined action in one step, for example by just pressing on one button.

4.3.2.2 *Disinfection*

To prevent bacterial growth in the system, the fluid lines have to be disinfected after treatment. This is done either by heating the equipment to 90-95ºC or using chemicals such as peracetic acid, hypchloride or formaldehyde. The recommended method is heating after each treatment and chemical disinfection once a week. When the dialysis fluid with bicarbonate is used, a certain amount of calcium carbonate precipitates. The equipment must therefore be regulary descaled with citric acid. The fluid lines also must have a regular alkaline cleaning to get rid of organic substance from the patient.

4.3.3 Optional functions

Optional functions are depending on the operators needs; it could for example be an extra pump for single-needle dialysis.

4.3.3.1 *Single-needle dialysis*

Single-needle dialysis is used if an access site is damaged or if one needle falls out. Some clinics prefer to use this routinely. When only one needle is used, the needle has to be large enough to give the right blood flow.

When the method is used routinely a double pump is often used where an arterial and a venous blood pump are working alternately. The single-needle dialysis can also be performed with only one blood pump, which use clamps that alternately closes the tube for each line.

4.4 The dialysis unit

To a dialysis unit patients who come need help to perform a dialysis treatment(6). In a typically dialysis unit, there is a doctor, a head nurse, a technician, six nurses and eighteen machines. This kind of dialysis unit accepts 72 patients with groups of eighteen people. There are usually two to three treatment-sets per day. One treatment takes about 3-5 hours and should be done three times a week, either Monday, Wednesday, Friday or Tuesday, Thursday, Saturday.

In this kind of a dialysis unit, the head nurse is first to arrive. The first task for the day is to turn on the water treatment plant; this purifies the water that is used in the dialysis machine. Then follows an intensive hour with various preparations and a meeting with colleagues and a responsible doctor to discuss the following treatments. The dialysis unit usually belongs to the renal medicine clinic at the hospital.

The doctor is medical responsible and head of the unit. The doctor follows up the clinical results and prescribes treatments. The head nurse takes care of the practical arrangements and make sure that everything is handled properly. The nurses' task is to perform the treatments. There is also a medical technician that is responsible for the service on the equipments. The patient and the nurse get to know each other very well, this is due to that the patient requiring dialysis three times a week for several years.

An acute hemodialysis treatment is sometimes performed in a dialysis center. In an acute stage, the patient is usually unstable and a move is impossible. The medical staff can then make the treatment where the patient is, for example at the intensive care.

Dialysis at home is an alternative to dialysis in a dialysis unit. This kind of treatment requires a great trust in the patient's knowledge and the patient has a large responsibility. Dialysis at home is an option when the patient wants to feel independent or live far from a dialysis unit. Limited Care, also known as satellites, is a form of treatment when patients perform many parts of their own treatment in a dialysis centre.

5 Market research

The dialysis machine AK 96™ is the machine this Master Thesis will consider due to the fact that this machine has a suitable complexity for this project. One of the requirements in this Master Thesis is that the new user interface concept will work well for people that today use Artis™, another Gambro dialysis machine. AK 96™, Artis™ and Fresenius 5008 will be described in this chapter. Fresenius is a big competitor and a world leading company in dialysis treatment and that is why Fresenius 5008 is important to research.

5.1 AK 96™ dialysis machine

AK 96™ is a standard dialysis machine(7), see Figure 5.1. The latest version was launched in 2008. The machine was developed to produce a standard dialysis machine that makes treatment easier, safer and more efficient. *AK 96*™ is available in markets all over the world except for the U.S.

The machine has a *Diascan feature* that allows clearance value scanning in real time and Kt / V measurement. Clearance value is the volume of blood from which a substance is completely cleared by the kidneys per unit time. *AK 96*™ enables parameter setting of the concentrate dosing, the function controlling values and the alarm will start at any variation. There's a *Battery back-up* to ensure that the machine works during power failure. The machine also has separate control and protective systems, this creating an independent that increase the security.

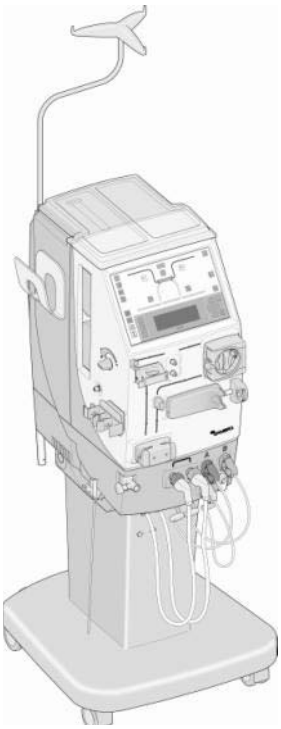

Figure 5-1. The dialysis machine *AK 96*^{TM}(7).

5.1.1 *Operator panel for* AK 96™

The operator panel on the *AK 96*™, see Figure 5.2, is constructed with a time display at the top of the panel, a flow chart in the middle, an information display at the bottom with related adjustment buttons(7). On the left side function buttons are located where user can activate, processes and get alarm information.

When the operator is handling the display, information is shown on the display and some information can also be noticed by the flashing buttons. Up lit buttons provide information about the button's associated function. A flashing button indicates the user to press the button in order to go forward in the treatment or get more information.

The mother symbol of the panel is the flow path, the function indicates when blood and dialysate is in the lines, depending on the liquids different colours on the lines is shown. When the bloodstream is showing red colour blood is detected in the venous line. Dialysis fluid is detected when the liquid path is green. A part of the fluid path is yellow when the dialysis machine is in bypass or during isolated ultrafiltration. When the operator is required to provide machine instructions, he first has to ask himself whether it’s considering the blood or fluid path. The buttons are connected to the associated lines, for example blood parameters next the blood line.

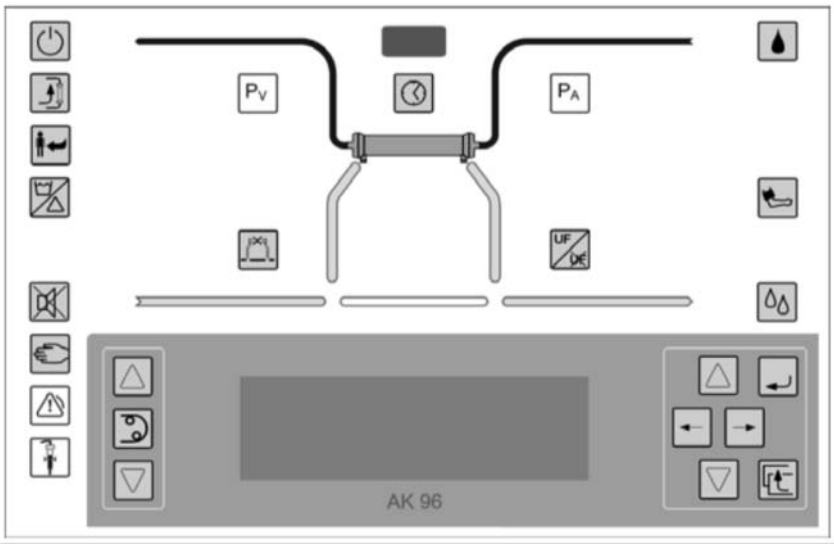

Figure 5-2. The interface on the AK 96™ dialysis machine(7).

5.2 Artis™

Artis™ is another dialysis machine made by *Gambro*(7). *Gambro* claims that *Artis*™ have an intuitive graphical user interface and that *Artis*™ is simple, logical and effective. *Artis™* uses the dialysis fluid of both high and low permeability.

Artis™ control all processes via a touch screen as the only communication path to the user. The functions that are controlled are enable- and disable functions to visualize and bring values and to accept user instructions, alarm and alert.

The mother symbol at the touch screens of *Artis*™ is the so-called "star", see Figure 5.3. From this communication symbol, the user can enter several menus. The round shape symbol in the middle of the *star* shows a dialyzer. A click on this icon leads to the home menu. The *star* is constantly placed in the lower right corner. The blood drop symbol at the left of the star indicates a menu where all the parameters concerning blood are located. Here, the user can access the configuration options and the measured values during the treatment. The green drop on the right of the star refers to the dialysis fluid, which contains dialysis data. The blue stylized man at the top of the star means patient protocols. Behind this button the user will find prescription from the doctor, and if not these values can be entered here and also the patient's identification documents. The last symbol of the star is the yellow protocol at the bottom. Here, the processing events, such as vomiting and so on, can be filed in. After the treatment is done it’s possible to go through every step of dialysis in order to see if there were any difficulties and if so, how these can be solved the next time

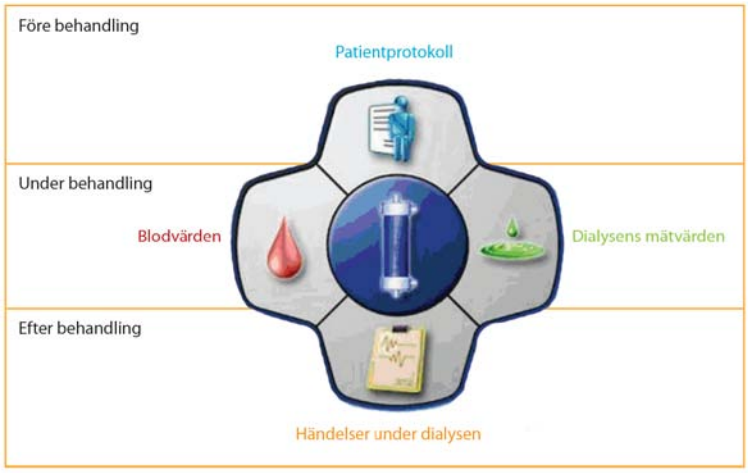

Figure 5-3. The star at the interface of *Artis*™(7).

In the upper part of the touch screen the remaining time is shown with clear figures. This impression is also confirmed by that the bar beneath the numbers constantly increases. When the dialysis fluid is filled up this is indicated with that the lines marking the dialysis fluid path turns green, so-called "green path", see Figure 5.4.

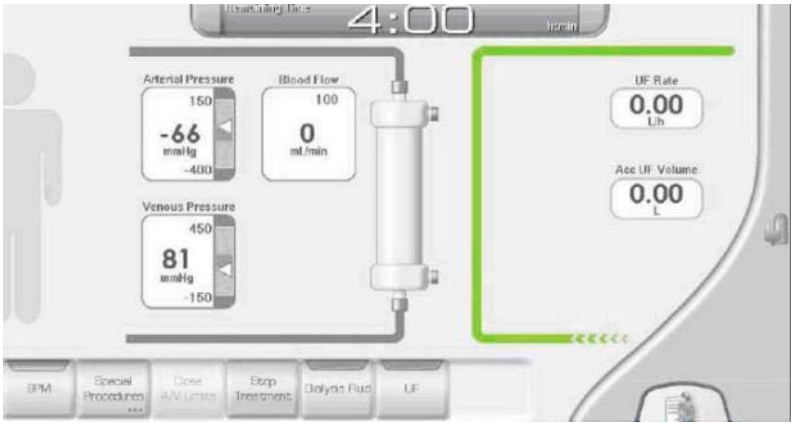

Figure 5-4. The upper part of the touch screen on *Artis*™(7).

Values that concern the dialysis fluid can be observed on the right side of the screen and they also have a green border around them to increase the understanding. The values that are visible is the UF rate and UF-volume, see Figure 5.5.

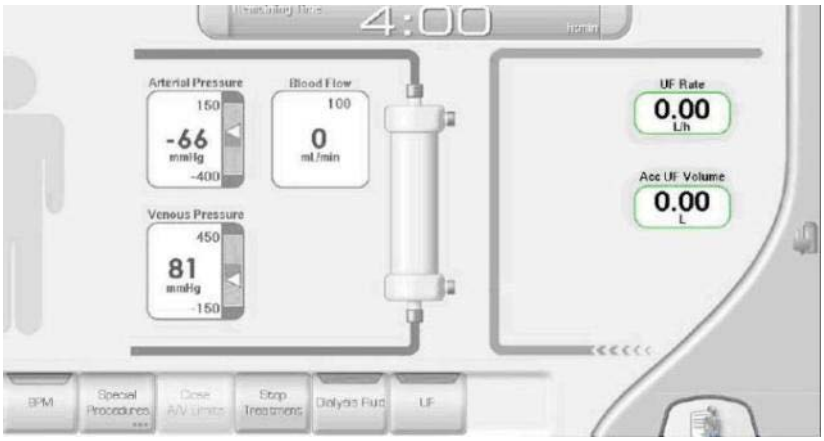

Figure 5-5. *Artis*™ with UF volume and UF rate highlighted(7).

When the patient is connected and the blood has started to go through the dialysis machine, the path on the left side is coloured red, see Figure 5.6. The hats on the dialysis ends are coloured red and blue, see Figure 5.6, this to highlight the arterial and venous blood line. Red indicating arterial, and blue venous.

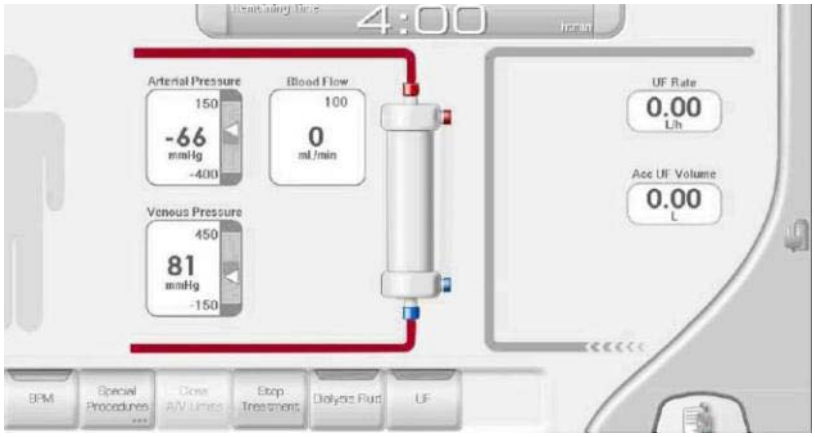

Figure 5-6. The patient is connected to the dialysis machine *Artis*™ and blood is flowing(7).

The blood values that can be read directly on the full screen are arterial pressure, blood flow and venous pressure. They are found on the left side of the blood stream, Figure 5.7.

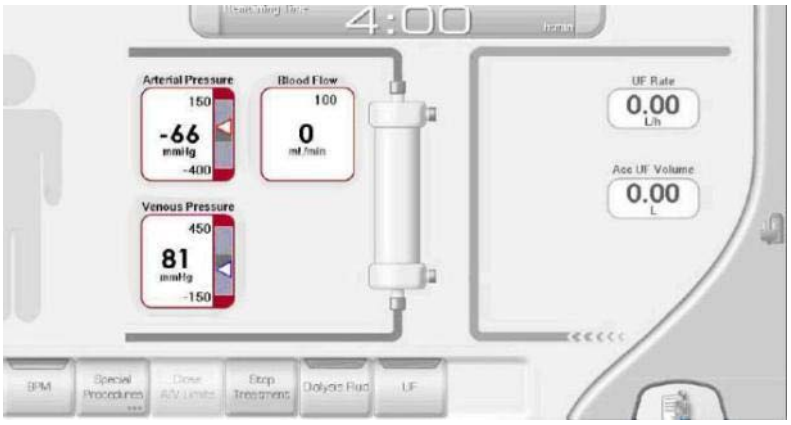

Figure 5-7. The blood values that can be read directly in full screen mode(7).

When the machine is working in a particular position this is shown by yellow-highlighted colour over a special moment, see Figure 5.8. When the task is complete the colour switches to green.

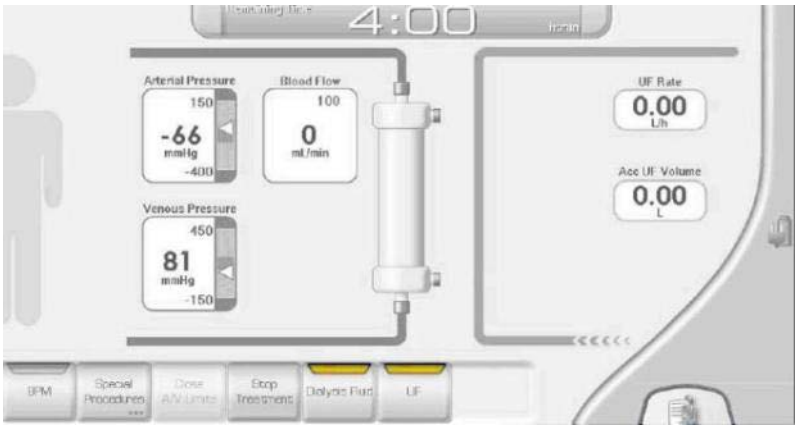

Figure 5-8. The selection of a process(7).

When an alarm occurs, the left corner switches to red, see Figure 5.9. The user can also find information about the alarms there. A number indicates which type of alarm that has been triggered.

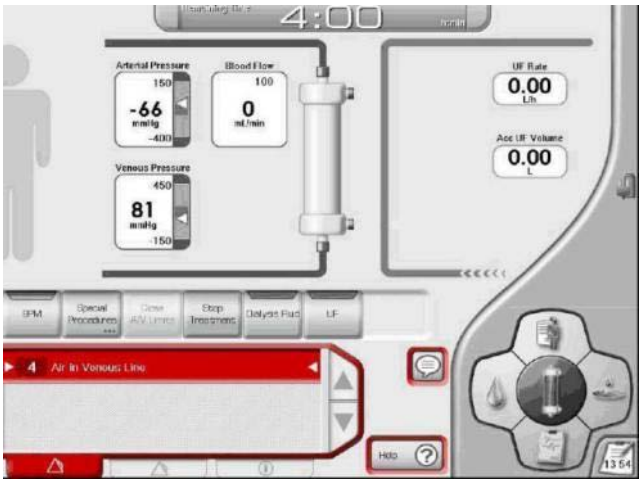

Figure 5-9. When an alarm occurs(7).

When a less acute alarm occurs, the same field instead signals a yellow-orange colour and tab two will be highlighted, see Figure 5.10.

Figure 5-10. A less acute alarm is triggered(7).

If the dialysis machine will inform about an incident or a non-urgent situation, this is shown in blue colour in the left corner, see Figure 5.11. The last tab is now opened in the information layout.

Figure 5-11. An invitation to read about an incident and non-urgent information(7).

When the machine requires the user to write in details a keyboard will appear on the screen, see Figure 5.12. This keyboard is built in the same order as a keyboard to a European computer. The user can confirm the entered details down in the right corner.

Figure 5-12. Keyboard to *Artis*™(7).

When the user selects the patients protocol in the star, a new box occurs on the screen, see Figure 5.13. This box is surrounded by a blue colour to indicate the blue menus appearance. There's a variety of properties that can be set in this menu. There is also a patient card that contains the prescription from the patient's doctor.

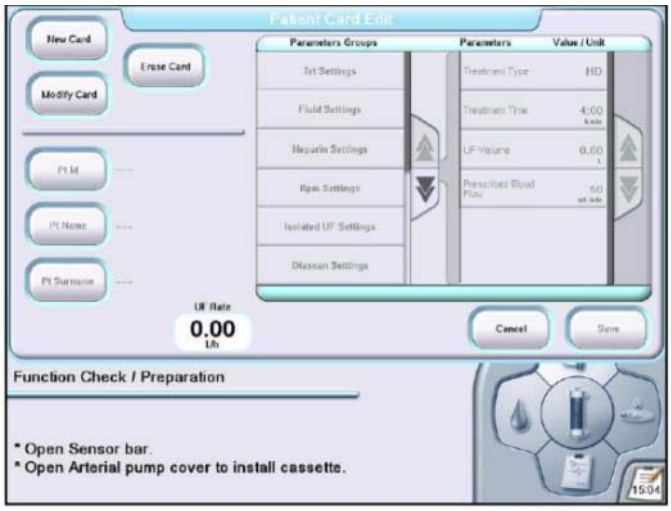

Figure 5-13. *Artis*™ patient menu(7).

The user can confirm a choice with the help of a so-called *pop-up box*, see Figure 5.14. The confirm button is recognised with a green symbol, while the cancel button is marked with red.

Figure 5-14. The *Artis*™ menu when the user has to confirm something(7).

If the incident menu is selected, a yellow frame occurs on the screen, see Figure 5.15. It's possible for the user to add information about different incidents from the treatment and how they executed it.

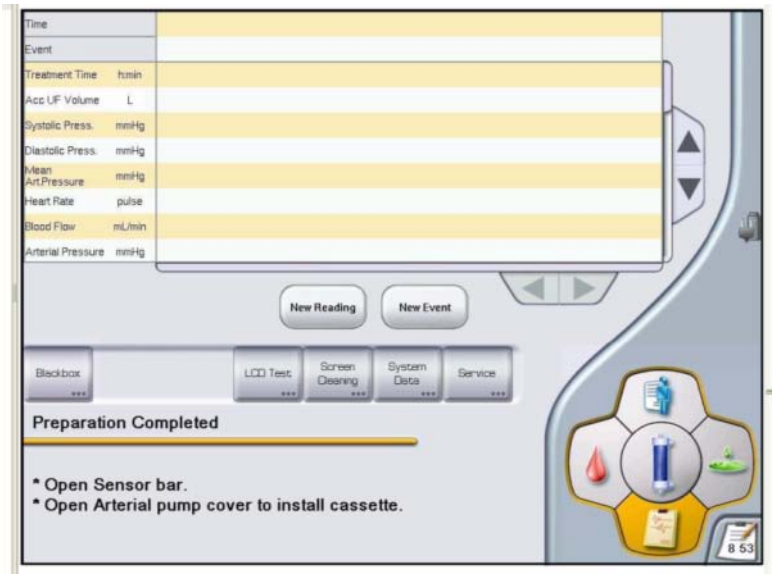

Figure 5-15. The incident menu(7).

5.3 An insight in Fresenius machine user interface

Fresenius is a big competitor to *Gambro* and a world leading company in dialysis treatments. That is why it's important to research the dialysis machine *Fresenius 5008*, see Figure 5.16. During a test on *Fresenius 5008* there were some thoughts concerning the machine that came up:

- Fresenius has a good work flow and the user gets a good overview of the whole treatment.
- The interface has a lot of text in relations to figures
- The treatment time is well defined and the user can see when the treatment is finished in real time.
- The on/off button is strange and confusing.

- It’s hard reading the text on grey buttons when the contrast is low.
- When the machine finishing a step in the treatment, there’s a sound that emphasis this.
- Fresenius has colour code for buttons that are active, inactive and electable. There’s a lot of grey colour in the user interface, blue is for electable buttons and green is to view in which step the treatment is in. Red and yellow colour is also used in small portions.
- Fresenius has a screensaver during treatment viewing arterial and venous pressure, UF goal, UF velocity, UF volume, blood flow and treatment time.

Figure 5-16. Fresenius 5008 dialysis machine(8).

6 User interface

This chapter contains information about interaction design, useful usability goals, principles of design and how to evaluate a user interface.

6.1 Interaction design

Interaction design means designing products to support the way people communicate and interact in their everyday and working lives, this includes a lot of areas; users, technologies, and interactions between them, how people act and react to events, how people communicate with each other, how emotions work, aesthetics, desirability, understanding the business-, technical-, manufacturing- and market side. A lot of different people with different backgrounds have to be included to create a good user interface. In this Master Thesis it will not be possible to consider all aspects in interaction design, find more facts about this in the Chapter 2.

In the book *Interaction design, beyond human-computer interaction* they explain the process of interaction design and this involves four basic activities which are similar to the chosen methodology(2):

1. Identifying needs and establishing requirements for the user interface.
2. Develop alternative designs that meet those requirements.
3. Building interactive versions of the designs so that they can be communicated and assessed.
4. Evaluating what's being built throughout the process and the user experience it offers. For example by observing users, talking to them, interviewing them, testing them, modelling their performance, asking them to fill in questionnaires, asking them to be co-designers.

A primary goal is to understand the user so that it's possible to develop an interactive product for them. There are some general goals about user interaction that can be good to know about, these goals are divided in two parts; *Usability goals* and *User experience goals*.
The usability goals include:

- *Effectiveness* is about how good a product is at doing what it's supposed to do.
- *Efficiency* is about how good a product is to support the user to carrying out the tasks.
- *Safety* is about to protect the user from dangerous conditions and undesirable situations.
- *Utility* is about which extent a product contains the right kind of functionality so the users can do what they need and want to do.

- *Learn ability* is about how easy a system is to learn to use.
- *Memory ability* is about how easy a product is to remember how to use, when the user has learnt it. Users shouldn't have to keep relearning how to carry out tasks.

User experience goals include how a user experiences a system. It can be hard to understand how a user feels for a system, the *User experience goals* is a tool to provide this. For example with questions like; *What is the user's immediate response to the interface appearance? Is it one of mockery, dismay or enjoyment? Do they smile, laugh, or scoff?*(2)

6.2 Psychopathology and principles of design

To get an interface to work well the key is to have a good conceptual model and a clear vision about the design audience(9). Human factors are important in the design development phase. To get a great interface there are certain facts you should check so that the interface doesn't fail.

- Functionality /mental model – what are the functions this object can perform? And will it work the way the designers want?
- State - What mode is the interface in?
- Control- How do I do to control the interface?
- Feedback- How do I know what I did? And if it did what I thought it would do?

The fact is that we as humans have a lousy memory, we don't see what's really there, we don't say what people really mean, we get confused, we get tired, we don't pay attention and we're easy to distract and designers have to take this into account. That's why human errors and "machine misuses" are so called errors in design. That's why designers have to understand the range of users and their physiological limitations. Designers have to make sure that the interface communicates functionality, a good model about how something work, provide feedback and foresee possible contexts of use.

It's important to separate usable and useful. With usability means the ability to actually use the system while useful is due to if the system actually does what you need it to do. Another important thing to think about is cultural idioms. For example the trash can symbol Apple uses looks like a metal trashcan in the US, see Figure 6.1. This trash can symbol works well in the US but in for example Malaysia where a trash can looks different this symbol doesn't work at all. Another example is due to the urban living because this is about a symbol for post. The letterbox, see Figure 6.2, on one hand looks like a typically American mailbox, but for people with urban living that never have been outside cities this symbol doesn't work well because they have never seen this type of mailbox, see Figure 6.2.

Figure 6-1. Trash can from iPhone.

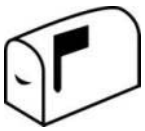

Figure 6-2. Symbol for a typically American mailbox.(10)

6.3 Valuation

Ten Usability Heuristics is a popular method to use in valuation of a user interface(11). The method helps to identify problems and critical areas in the user interface and is one of the most used in the field of interface design. *Gambro's* department of *Human Factors* is also using the method in the valuation of new concepts. You can find the ten Usability Heuristics in Appendix *C*

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7 Identification of customer need

A research in usability test reports has been made in order to find information about customer need. Persons at Gambro that have important knowledge regarding the project have been interviewed and a summary on the interviews has been made.

7.1 A summary of the three usability test reports

Gambro has three usability test reports of the *AK 96*™ that concerns this Master Thesis(12),(13) and(14). In one of the reports the user test was conducted in Lund (Argus laboratory) and in Borås with Danish and Swedish medical nurses. The Danish nurses had experience from *AK 96*™ and *AK 95*™, while the Swedish nurses had only worked with the *AK 96*™. The test was set up in the beginning of 2009.

In the second report were user tests done by *Gambro* in Lund with thirteen dialysis nurses. They had experience from several dialysis machines, among others *AK 95*™, and *AK 200*™. The tests were done in June 2007.

In the third report were user tests made by Gambro in San Jose with 24 nurses. The test persons didn't have any experience from *AK 95*™ and *AK 96*™. The tests were performed in June and July 2009. Here follows a summary of the reports;

- The screen has to be improved with better contrast and quicker respond, the interface gives a messy and confusing impression. Several users thought the display were missing an overview.
- Lighted buttons need to be clearer why they're lighted. Function buttons shouldn't be able to be lightening if it's impossible that the function is active. They also need to have a good contrast so that it could be seen in bright rooms.
- There should be a consistent user language on the buttons with on/off functions, compared the *UF* button start and stop function with the *bypass* button.
- The guidance on *AK 96*™ is appreciated, but the support isn't consistent. A help button is requested where the user can find a short description of the function. This is usefully in situations when the operators get lost or get in touch with unknown functions, colour-coding could be good.

- The icons are difficult to understand by inexperienced users, they weren't logical to understand.
- Some users didn't like that they couldn't confirm a reset parameter.
- Time display and time parameters don't show the same value. This creates confusion for the operator if he/she wants to change the time during the treatment.
- A better workflow to the new *Diascan* feature was requested.
- Trans membrane pressure, *TMP*, is a complex parameter that requires a lot of training for the user.
- It seems to be unnecessary to have a confirmation button when connecting the concentrate.

7.2 Target group specifications

There are several different people who interact with a dialysis machine(6). These people all have different aims and goals of the interaction. Common to all is an education required before use.

7.2.1 Doctors

All dialysis treatments are made following a prescription from a doctor. These doctors are able to interact with the dialysis machine but do this infrequently in the treatment of patients

7.2.2 Registered nurse

A registered nurse is the person who uses a dialysis machine and is also the main user of the machine. The nurse is the one doing the processing of patient and set all the values in the machine that the prescription provides from a doctor. Usually a nurse takes care of about three or four patients at a time. The nurse should be able to use the machine in any stage of the process and are expected to have an adequate knowledge about kidney disorders.

7.2.3 Dialysis assistant

In many countries there's a group called dialysis assistant. These persons take care of all things concerning a dialysis machine and its treatment. This person is not in charge of medicines. Typically, these dialysis assistants are trained by the medical department and have no formal medical training.

7.2.4 Tech aid

Tech Aid is in some countries a person who has no formal medical training but have tasks that concerns retrieving materials in warehouses, clean the dialysis machine and get things for the patients. These people are not involved in the treatment of a patient.

7.2.5 Service technician

Gambro train service technicians and provide them a certificate that they're service technician for *Gambro* machines. In order to log in to the technical settings on a dialysis machine a provided password is needed. No other user group has access to these settings on the *AK 96*™. The technician is responsible for all the configurations on the machine so that it can be used for a specific department or hospital. The service technician is also responsible for the repairs of the machinery. This person will not use the machines during a treatment.

7.3 User environment

AK 96™ is meant to be used in the treatment of patients with chronic kidney disease(13). Time is set to take between three to five hours per treatment and has a maximum of ten hours. The intended environment for the *AK 96™* is a clinician or so-called *satellites, see chapter 4*. Different environment have different procedures for cleaning and processing. It also differs in practice between different countries but common is that all countries have rules written by an authority.

The treatments that are done in clinics often have all dialysis machines in a large room. It can be placed up to 30 machines at frequent intervals along the walls, this so that the staff can have an overview from the middle of the room. The dialysis machine and the dialysis chair form a dialysis unit. In the dialysis unit there's usually also a TV available for the patient. The patients bring personal things, such as magazines, MP3 players and so on to the dialysis to get the time going.

During start-up, the noise in the room can be relatively high and then be rather low for the rest of the treatment, except during an emergency. To enhance the tranquility of the room they usually put out the light after the last patient in the patient round is connected to the dialysis machine.

7.4 Facts from interviews with Gambro experts

Interviews with experts from *Gambro* have been done. The interviews are about branding, marketing and international users.

7.4.1 Interview with the scientist Thomas Hertz

From a interview with the senior scientist Thomas Hertz there're some new parameters to have in mind for the interface concept(15).

- Touch screen can be difficult to use for users with shaky hands.
- Knobs can cause ergonomic injuries among users.
- Some users seem to learn the dialysis machine by heart, without really understanding the function.
- The dialysis machine can be noisy.
- Approximately 90% of the nurses that work on the hospital are women.
- The nurses have an age between 22-65 years.
- It's usual to have other nursing experience before starting to work at a dialysis clinic.

- The nurses tend to change sections within the hospital to get a variety in their working life which leads to that there's often new nurses that need to learn about dialysis treatment and the machines.
- The nurses tend to like *AK 96*^{TM} but they think it looks a bit old fashion.

7.4.2 Interview with the Director of branding globally; Anki Davidsson

From an interview with the *Director of branding globally;* Anki Davidsson there're some new parameters to have in mind for the interface concept(16).

- *Gambro* wants to be more brand oriented. Branding, positioning and marketing are the new focus areas. The products today have a variety of functions and products names. Now, *Gambro* wants to be clearer in what the machine shall symbolise and create a better thread between the machines.
- Blue and orange is the colours for the whole company and it was globally lunched 2010.
- Your home of innovation- You inspire, we innovate. This is the motto of *Gambro,* something *Gambro* should also focus on inside the company.
- The patient should always be in focus.
- *Gambro* has to live the brand but they also need to get the brand alive.

7.4.3 Interview with Mgr Business Intelligence; Gustaf von Friesendorff

From an interview with the *Mgr Business Intelligence;* Gustaf von Friesendorff there're some new parameters to have in mind for the interface concept(17).

- *Gambro's* strength is the logical and well thought through machines. *Gambro* is also proud of their good technical support.
- *Gambro* in Lund sees a trend and a good potential in touch screens with large screens.
- The dialysis interfaces are different over the world, for example Japanese has interfaces with more icons, symbols, and animations on the machines.

7.4.4 Interview with the Senior Clinical Adviser; Gunilla Andersson

From an interview with *the Senior Clinical Adviser* Gunilla Andersson there're some new facts to have in mind for the interface concept(18).

- In countries around the world it's common not to have dialysis nurses, they hired dialysis assistants, which get trained at the clinic to control the treatment. In countries with inexperienced staff it's important to have a machine that's safe, simple to use and not too flexible.
- Andersson thinks a smart dialysis machine should be more individualized. With different access to the machine, it can work in the whole world.

- Andersson wants a user interface in portions to create an individualized user interface. A technician or other person could be able to remove “portions” or functions that are unnecessary.
- The user interface may be generally improved. User interface technology has gained significant attention lately. There’s great potential in this field. Larger displays and touch sensitive screens enables enhanced usability.
- There’re a lot of colour-blind users.
- The language must be on the countries language, even if people say they can English it’s not always true.
- It’s important with both text and symbols.
- Andersson believes in touch screen.

8 Process

This chapter is about the process that has been used throughout this Master Thesis.

8.1 Brief

In order to focus on the original goal of the work and follow it throughout the process, a brief was designed.

The product's main function is to communicate with people with different education level. The aim is that users from all over the world with different backgrounds and cultures shall be able to communicate with the product.

The product wants to be intuitive and explanatory. The user should easily understand how the product works. The product should be perceived as safe, stable and clinical. It will radiate quality and the *Gambro* brand, it will also prompt the user to use it. The product is a part of the user's welfare.

8.2 Scenario

A scenario has been written to get an idea of who the user is and to be able to impersonate him / her. Below is a *personas* described.

Agda Gren is a happy 72 year old lady from Krageholm, see Figure 8.1, which is located north of Ystad in Sweden. Since 15 years back, Agda have been a dialysis patient. Dialysis controls a big part of her life, but Agda still thinks that it has provided more than it has taken from her life. She considers it as a second chance to life.

Everyone is so nice at the "lyze" she says. We've kind of become like a gang there, "the lyze gang". Me and Gunnel usually solves crossword puzzles together and scratch "Triss". Yes, we like to bet on horses too, and of course we are looking at "Postkodsmiljonären".

Agda comes to Ystad dialysis clinic, see Figure 8.2, three times a week with the help of Region Skåne's transportation service.

- It can be tuff to go sometimes, says Agda. Yes, I have the crutch and everything and I'm not in my 20's anymore.

When inside the clinic their jackets are undressed and they get weighed. Her 62 kg is printed on a ticket.

- Oboy, up four kilo since last time, wonder how much water I can drink before I burst, said Agda laughing and flash the eye.

Nurse Annika meets Agda at dialysis unit 7. A dialysis unit consists of; one dialysis bed, one dialysis machine of the type AK 96™ and one TV hanging from the ceiling. At Ystad dialysis clinic, all patients received a personal plastic box with pillows, blankets and other personal belongings that can be stored, both to reduce the load capacity for the clinic but also to avoid having to bring things back and forth to the patients' home.

- I brought your box, said Annika.
- Yes thanks, said Agda with a cheerful mood. Is my I-pod there? I think I forgot it here the last time.
- Yes, answers Annika. What's on it now days?
- It's an audio book by Bjorn Ranelid but I don't know if I think it's good.
- If it's read by Ranelid I understand it, said Annika laughing. Now you can lie down so that I can connect you.

Agda lies down in the patient's chair and exposes her left forearm for Annika. Her coarse fistula is clearly visible under the skin.

- It looks nice, said Annika while she was cleaning the arm. Then I puncture.
- Even though I'm doing this three times a week it's always a very unpleasant thing, says Agda a bit bothered.
- Yes, but Agda is always good, Annie says. So now it's done. Good girl!

While Annika set all the parameters on the dialysis machine and check the blood sugar Agda gets ready with the I-pod. She usually listens to half an hour on the audio book before her friend Gunnel come to the dialysis. Agda pulls the blanket over herself. She has the habit of freezing during dialysis so she has her own leopard-colored blanket in her box.

Half an hour later, Gunnel shows up at the dialysis. While her friend is connected to a dialysis machine, device 8, i.e. the unit next to Agda the two friends talk and laugh. Having the beds next to each other was something they requested so that they would be able to talk to each other and get time going. The time on the dialysis goes on as usual, and Agda and Gunnel are occupied with eating breakfast, and solve a new crossword puzzle and take a look at Oprah on the TV. Gunnel also has a project going on and that is to knit mittens for her grandchildren Nova. During the treatment, Annika comes to control values and record these. After about four hours Agdas treatment draws to an end.

- It's time to disconnect you, said Annika.
- Okay, says Agda. It will be nice to move around a bit.
- Well, now the blood is inside you again, let's try to get the needles out.

Annika pulls out the needles and keep pressure bandage on to reduce that Agda loose too much blood. Annika presses for a while until the pressure has subsided after which she bandage the wound and Agda will stand up. Annika ensures that Agda feel good and not feel any dizziness. Then Agda get to go and get her coat. Agda thanks

for today's treatment and hugs Gunnel which is still during treatment, then she goes out into the yard where the transportation service is waiting to take her home.

Figure 8-1. The fictional lady Agda in the scenario(19).

Figure 8-2. A dialysis centre (20).

8.3 Function analysis

The function analysis reflects on why the user interface exists, it’s an analysis and summary of user interface information, activity and characteristics, see Figure 8.3 and Figure 8.4. The main function is to communicate with the dialysis machine.

Figure 8-3. Function analysis for dialysis interface.

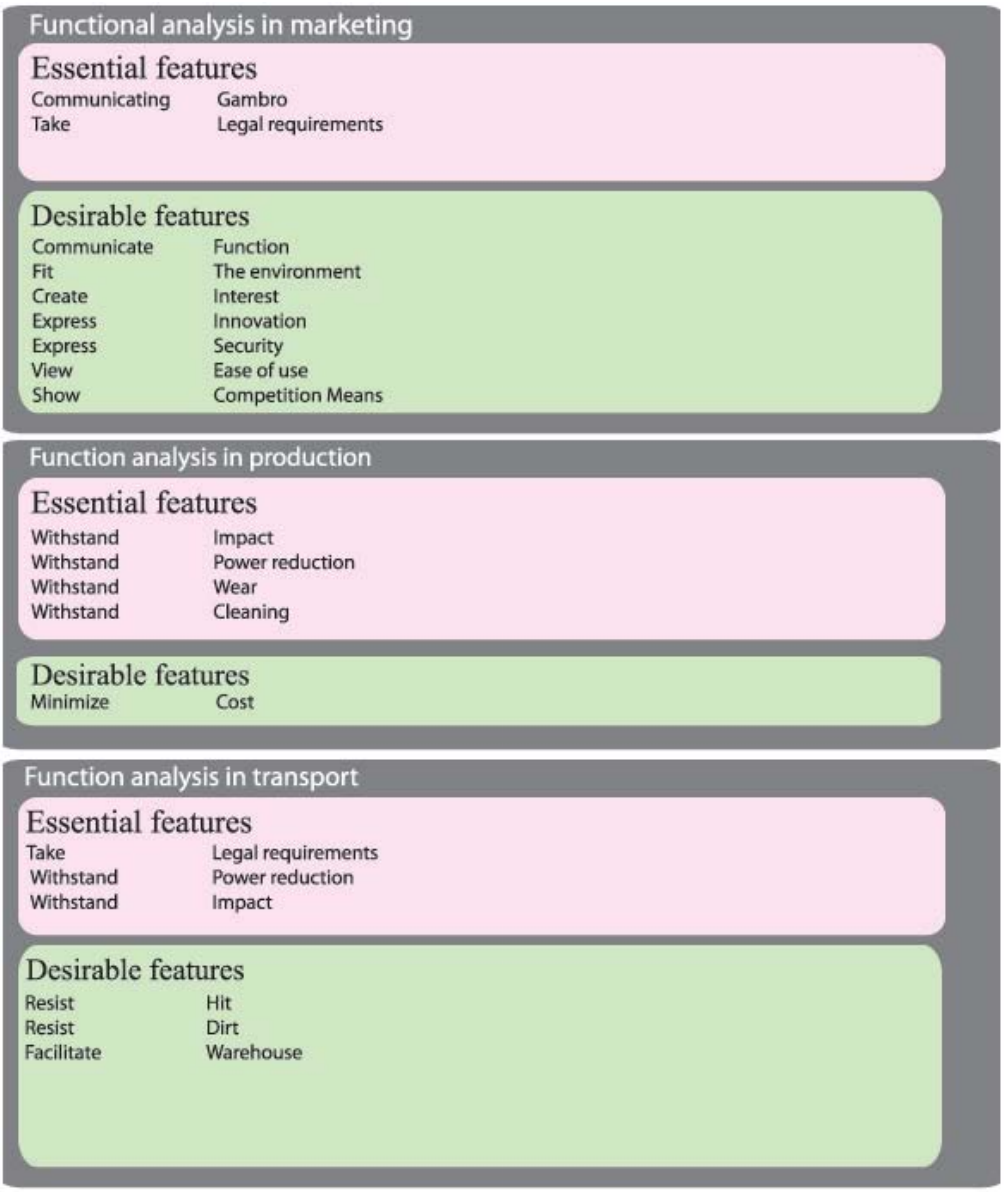

Figure 8-4. Second function analysis.

8.4 Sector chart

Positioning is about determining how a product will be perceived on the market, which direction the product should strive to reach the most customers. Sector charts are done to find market gaps. The sector charts are based on different dialysis machines and not only the user interface.

8.4.1 First sector chart

In the first graph *Soft* vs. *Hard* was placed on the y-axis and *Machine construction* vs. *Industrial design* was placed on the x-axis, see Figure 8.5. This was performed to get an idea of how these factors can be seen in a dialysis machine, and what conclusions that can be drawn, from our perspective, about these feelings.

Conclusions from the first sector chart were that the dialysis machines follow a diagonal line, see Figure 8.5. In the third quadrant, that is, *Machine design- Hard*, many machines are gathered but also in quadrant one, that is, *Soft-Industrial design*, a few are placed. Space was found in quadrant two and four, that is, S*oft - Machine design* and *Hard - Industrial design*.

In quadrant three, *Machine design* vs. *Hard*, heavy and large machines are seen. The machines are essentially more detailed and give a complex impression. They also have a rectangular and squared shape.

In quadrant one, *Soft - Industrial design*, the machines are less complex according to impression, they're smaller in size and rounder in shapes.

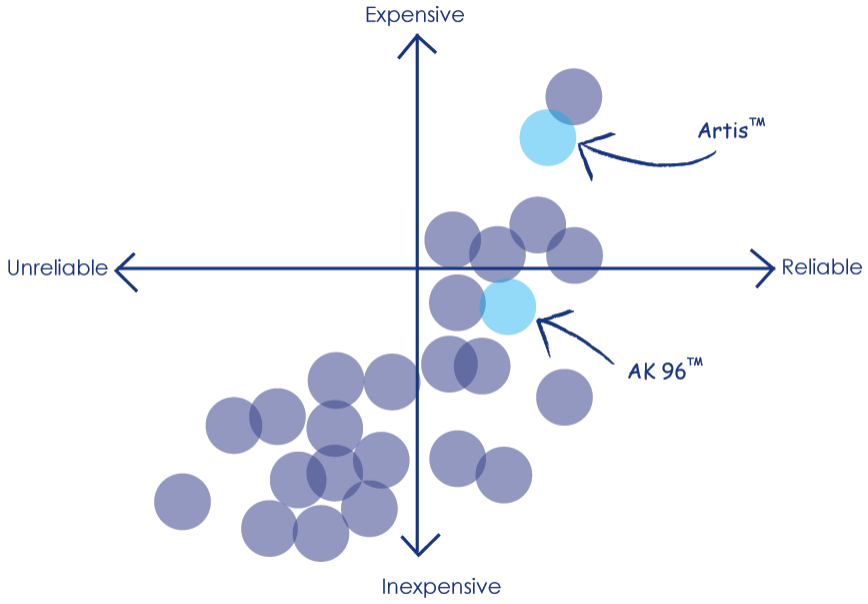

Figure 8-5. Illustration of the first sector chart.

8.4.2 Second sector chart

In the second sector chart the adjectives that were used were *Reliable vs. Unreliable*, and *Inexpensive vs. Expensive*. The conclusion was that for the more expensive locking machine the impression is more reliable and vice versa.

If *AK 96*™ was compared with *AK 95*™ you could see that *AK 96*™ looked more expensive, but they had the same degree of reliability. When the *AK 96*™ was compared with *Artis*™ and *Prismaflex*® the last ones gave a more expensive and reliable impression.

In quadrant one, *Expensive – Reliable*, all machines had a low high. Structured machines gave a more reliable impression, while outdated machines looked more unreliable.

8.4.3 Third sector chart

The third sector chart was carried out with axes *Junior vs. Senior* and *Simple/ Easy to use vs. Complicated*/D*ifficult*.

The machines got a personal identity to easier rely to them. Among *Gambro* machines were personalities such as; *Ove,* a 43 years old engineer that's bit difficult to work with, *John,*a 29 years old lawyer who is cocky, *Kathy, a* 23 years old weather girl who is good looking, user friendly and sensual. *Rebecca, a* 25 years old police officer was the personality of *Artis*^{TM}. *Rebecca* was the machine that was ranked the highest.

The things that emerged from this discussion were that a dialysis machine should feel like a secure police, who is dependable, organized, pleasant, effective and stable. Rebecca is represented by the *Gambro* dialysis machine *Artis*™ who fall just over the border to the direction of the axes for easy to use. The machine should be easy to work with, but it shouldn't be so simple that important features are removed. Sometimes the machine require selection of different features to give the patient the best possible treatment, the machine will also be able to speak up when things go wrong.

8.5 Mood board

Based on the third sector chart, a number of mood boards were created. The feelings that appeared in connection with the fictitious person Rebecca, *Artis*™ was; safe, reliable, orderly, structured, physical fit, effective, stable, pleasing to the eye and user friendly. Around every feeling one mood board was done by the performers without interference from each other to obtain such a personal thought about the feeling as possible without being influenced by each other.

8.5.1 Safe

The first feeling that was reflected in a mood board was *safe,* see Figure 8.6. The things that were depicted as safe in the images were mainly family, friends and loved ones. The forces of order and security were also part of the first mood board. Several

pictures showed a warmth feeling and to feel snug. Children were clearly depicted throughout the images, both in Sweden and abroad.

Figure 8-6. Mood boards made about the feeling safe.

8.5.2 Reliable

Being reliable was reflected very differently between the performers. On one hand there were a lot of people in uniform while on the other hand it was reflected as the trust of people as parents and counsellors. To trust ones diaper, condom or partner was also shown, see Figure 8.7.

Figure 8-7. Mood boards made about the feeling reliable.

8.5.3 Orderly

Orderly were depicted and chores like to bake, cook, wash the car and iron was shown, see Figure 8.8. Being orderly was also shown by images of people using bicycle helmets and to have order in the office. The Swedish royal family was considered to be orderly but also folk dancers and the perfect gentleman. Famous Swedes who were orderly was Blossom Tainton, a personal trainer and artist, and Tina Nordstrom, a chef.

Figure 8-8. Two mood boards made about the feeling orderly.

8.5.4 Structured

To be structured was shown in images with a lot of office supplies, see Figure 8.9. In quantities of office supplies post-its, highlighters and binders was shown. Flow charts and diagrams were also shown as structured.

Having the order was considered to be structured, which was depicted with the help of a well-structured wardrobe and a conveyor belt system. Photo album and having a well-designed notice-board was at a premium when structured was assessed.

Figure 8-9. Two mood boards made about the feeling structured.

8.5.5 Physical fit

The feeling physical fit was reflected, not surprisingly, by the athletes who exercise some form of sport, see Figure 8.10. There were a variety of sports from dance and cycling to skiing and swimming. It was mixed, both men and woman, but the average age was narrowly down to between 25- and 35 years.

Figure 8-10. Two mood boards made about the feeling physical fit.

8.5.6 Genuine

Genuine were shown by chairs made of wood, rubber boots, but also the classics; the phone *Cobra* and the *BRIO* basset, see Figure 8.11. Pancakes were considered to be genuine and also the author Astrid Lindgren. Post office and a bakery felt pure and genuine just like the movie, based on the musical, *Mamma Mia*.

Figure 8-11. Two mood boards made about the feeling genuine

8.5.7 Stable

Stability was reflected in different ways, see Figure 8.12, with everything from a stable family to the Egyptian pyramids. A sumo wrestler was considered to be stable but also a heart rate. On one hand, it was heavy items that were shown to reflect stability, like things to stand on, while on the other hand it were reflected by being stable in order to stand on a pair of stilts

Figure 8-12. Two mood boards made about the feeling stable.

8.5.8 Pleasing to the eye

Things that are pleasant to look at were in both cases clearly limited to nature, see Figure 8.13. The two proposals have been almost exclusive to show natural. However, it did reflect different types of landscapes, both above and below the water surface, but water are often involved the pictures. The turquoise colour seems to come back among the images.

Figure 8-13. Two mood boards made about the feeling pleasing to the eye.

8.5.9 User friendly

User friendly was described solely on products, see Figure 8.14. Practical products such as; a cheese slicer and a *Wc-duck* was shown but also beauty products such as the swedish lable *Blåkläder* and the *Crocks* slippers. *iPhone* is shown and also an easy-to-use phone designed for the older generation. User friendly is depicted through basic functions such as a soap dispenser, door handles, coffee cup, a bell and a water tap. The shoes in the lower right corner symbolizes that velcro is seen as a user-friendly product.

Figure 8-14. Two mood boards made about the feeling user friendly.

8.5.10 Mood boards regarding South America and Asia

To see if there were any differences in dialysis treatment around the world compare to Swedish two mood boards with pictures from dialysis in South America and Asia were created, see Figure 8.15-8.16. It's hard to pinpoint the differences though it seems to be pretty alike, but a realisation that can help further on as well. In Asia it seems like the dialysis hospitals are more crowded than the Swedish ones. The folders for dialysis in Asia seem to use more colours then the ones in Sweden as well, but the colours are the same as in Sweden with the arterial side red and the venous blue.

Figure 8-15. Dialysis clinics in South America.

Figure 8-16. Dialysis clinics in China.

8.6 Initial brainstorming

An initial brainstorming session was made to sketch all ideas from the preparing work. Ideas of concepts and specific functions were drawn. In the session quantity was more important than quality. After the session some proposals were chosen in order to decide how the user will communicate with the dialysis machine. The chosen concepts were: *Touch screen, Remote control, Sensor, Manual keys, SMS, Blow on, Laser and Odor,* see Figure 8.17 - 8.24. For evaluation see Appendix F.

With a *Touch screen* the user have to communicate with a finger, while the *Remote control* makes it possible to communicate from a distance. With a *Sensor* the user will communicate through movements, the sensor that's connected on the user will have a receiver on the machine. If the user for example jumps the receiver will convert this movement to start the blood pump. If the interface have *Manual keys* the user's fingers are needed in order to communicate with the dialysis machine while concept that communicate through a mobile phone and send messages to the machine doesn't need the user to be close to the machine. With the concept *Blow on* the user will communicate with air from the user. With *Laser* the user can communicate from distance with a laser pointer. The last concept is *Odor,* in this concept the user will communicate with sending different odors to the machine.

To evaluate the eight concepts six criteria were posted. These criteria are taken from the brief, see Chapter 8, objections and the Master Thesis focus areas, see Chapter 2. The chosen criteria were: *Radiate future Gambro, Limiting unnecessary units, Work international/cultural, Carrying structure, Please the user* and *Resist abrasion*. *Touch screen* got the highest score.

Touch screen is together with *Manual keys* the best concept in order to radiate future *Gambro*. *Touch screen* is without dough the best concept in order to limiting unnecessary units. The concept makes it easy to make changes between languages. In this reason is the chosen concept also good to work internationally and thereby also culturally. *Touch screen* is pleasant to the user and the belief is that all countries are familiar with a *Touch screen* and if not, *Touch screen* is easy to learn. Touch screen

did also get the highest scored in resist abrasion, it’s easy to clean when blood doesn’t stick to buttons or other elevations.

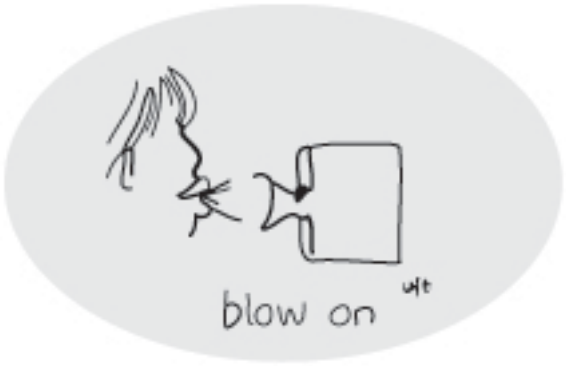

Figure 8-17. Blow on.

Figure 8-18. Manual keys.

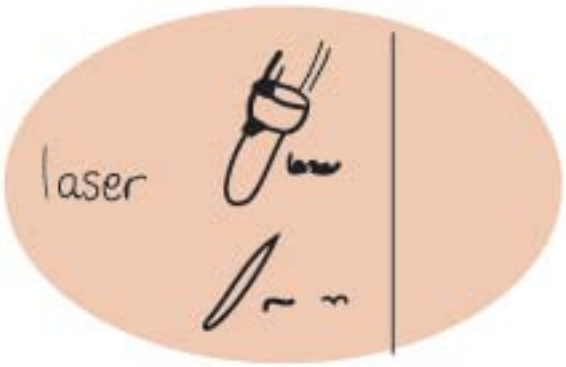

Figure 8-19. Laser.

Figure 8-20. Odor.

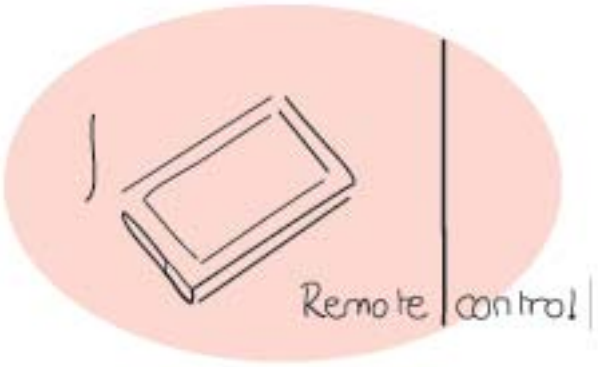

Figure 8-21. Remote control.

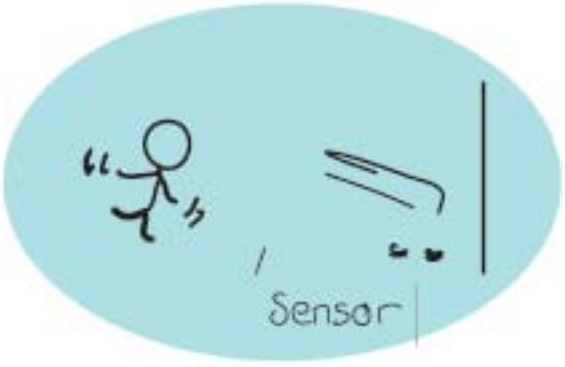

Figure 8-22. Sensor.

Figure 8-23. SMS.

Figure 8-24. Touch screen.

9 Concept Generation and Selection

Eight concepts considering touch screen were made with inspiration and information from brief, interviews, the current user interface, background, mood board and other research. The concepts were done in the computer visualisation program Adobe Illustrator. First are all concepts presented and in the end of this chapter an evaluation will be provided.

9.1 Concept 1

Concept 1 has the *Gambro* brand style with blue- and white gradient in the background. To clarify the brand even more, the logotype is placed in the lower, left corner, see Figure 9.1. A dark blue frame is placed in the background to make a uniform impression. The left circle is a working flow. This plate doesn't care if the user read from left to right or the opposite, only that the user can work clockwise, this will work around the world.

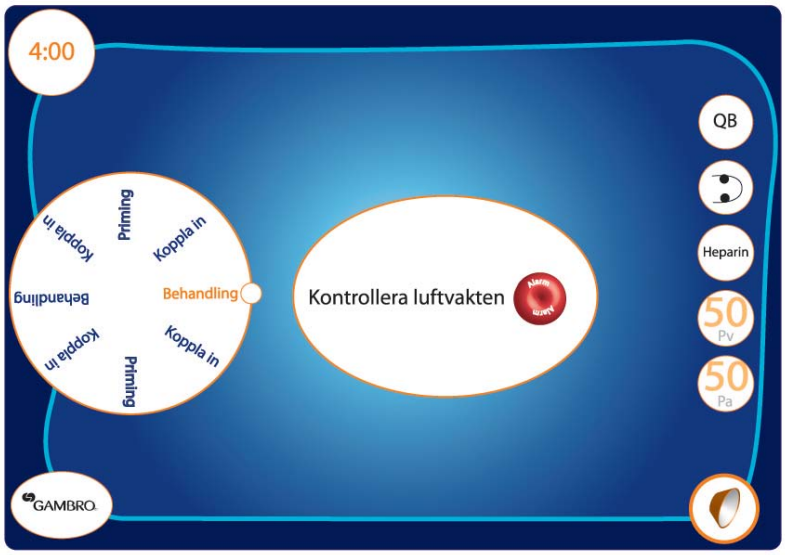

Figure 9-1. Concept 1.

9.2 Concept 2

Concept 2 is a simple and clean concept, the user only need to press the button to set the limit for the arterial pressure, or the function the user need to set in this step, *see* Figure 9.2. The user has an overview on the left side of the screen, which explain where the user is right now and what the user has done and what to do next. The big

buttons in the middle of the screen gives information on what to do in this step. There is also a clock which shows the treatment time.

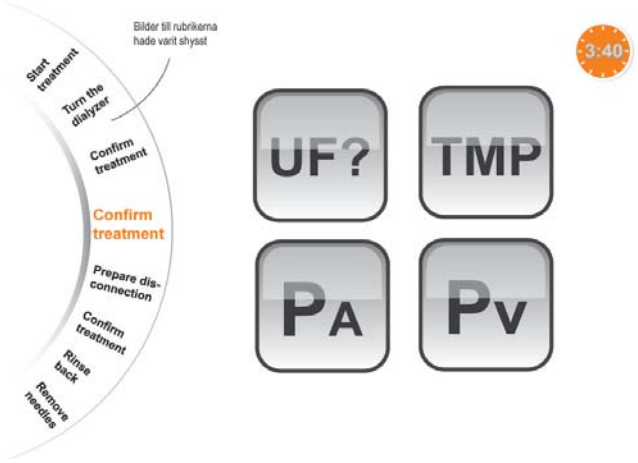

Figure 9-2. Concept 2.

9.3 Concept 3

Concept 3 has a dialogue box on the left side, a treatment window on the right side and alarm buttons and a clock in the lower left corner, see Figure 9.3. The dialogue box gives information about what to do in order to go further, here will also the alarm appear when needed. When the user is done with one step, this has to be confirmed with the *done* button, if the user needs help it's only to click on the *help* button. The treatment window gives information about important parameters. Before the dialyzer is connected to the machine the dialysis symbol is suppressed, and when the dialyzer is connected the symbols lines are lit up. This helps the user to see what is done and what needs to be connected to the machine before the treatment starts.

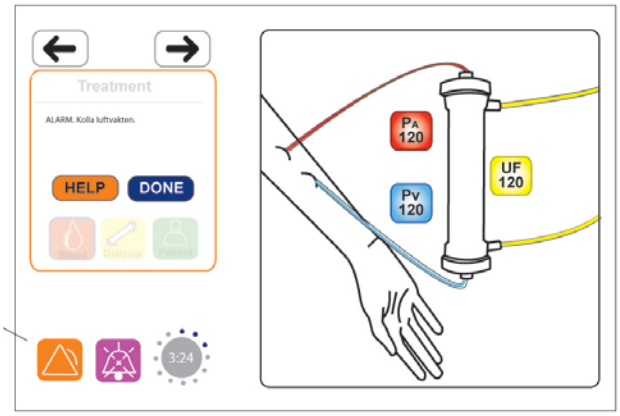

Figure 9-3. Concept 3.

9.4 Concept 4

The idea behind concept 4 is the overview. The treatment has a division in three parts; *Preparation*, *During treatment* and *Completion*, see Figure 9.4. In each part some step are included, for example the user need to through *Identity*, *Connect patient* and start *Treatment* in part two; *During treatment*. The illustration in the middle of the interface gives information during treatment. In the right column of the interface are the alarm buttons placed. The user can also see the remaining treatment time and go back to the previous window with the arrow button.

Figure 9-4. Concept 4.

9.5 Concept 5

Concept 5 is created for the Asian market, see Figure 9.5. The Asian people like illustrations, see Chapter 7, and in the centre of the screen an Asian patient is illustrated. This view gives information about important parameters during treatment. In the frame function buttons are placed. The orange colour is retrieved from *Gambro* branding. The concept has an information window in the lower part of the screen which informs the user what to do and is also working as an alarm window.

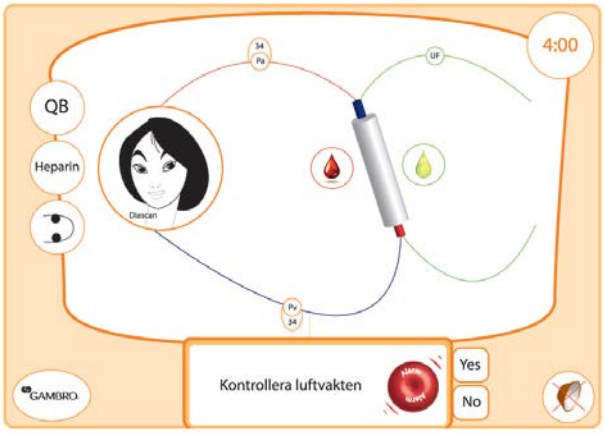

Figure 9-5. Concept 5.

9.6 Concept 6

Concept 6 shows a very clear graphic view of how to set parameters, see Figure 9.6. On the left side the “working window” is placed where the user can change the limits. If the user needs to set the “Artärtryck”, it’s just to press on respective square and the “Artärtryck” will be viewed in the “working window”. The top of the window inform the user where in the process the user is right now and in which phase. The blue and the orange colour are chosen to get the *Gambro* look. There’s also a clock showing the remaining treatment time.

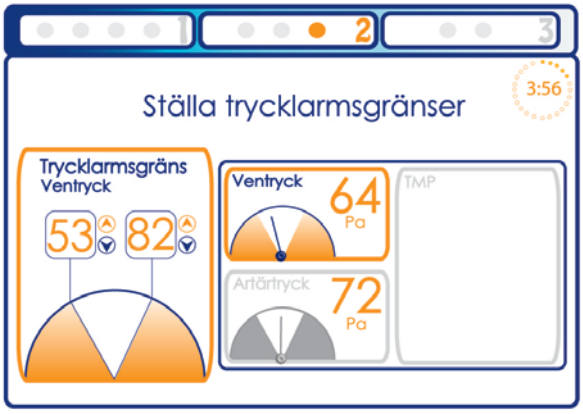

Figure 9-6. Concept 6.

9.7 Concept 7

Concept 7 is focusing on the overview of the whole process, see Figure 9.7. In the left side of the screen the user can see all treatment steps that they have to done before the whole treatment is finished. In every step there’s some more information about what to do in order to full fill the process. The concept also has a clear frame with the *Gambro* colours; blue and orange, the frame gives a comfortable, calm and uniform impression. The window views an illustration over the treatment and important parameters.

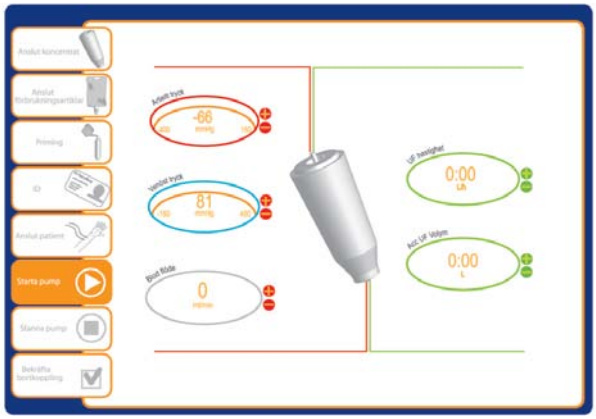

Figure 9-7. Concept 7.

9.8 Concept 8

Concept 8 has been inspired from the dialysis machine *Artis* ™, see Figure 9.8. The concept has the *star* in the lower right corner in order to navigate different functions. There's also an information window that views important information and alarms. The grey buttons have different functions that the user can use. The difference from *Artis* ™ is the smoother impression with rounded buttons and some symbols are changed.

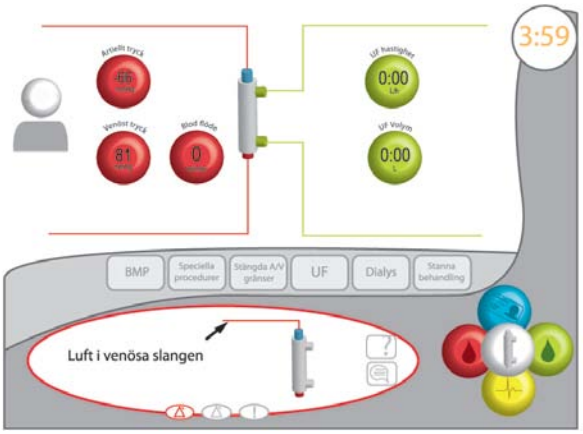

Figure 9-8. Concept 8.

9.9 Evaluation

The criteria in the valuation are collected from the Objective, Limitations and focus and the Brief and contain all requirements about the concept. The criteria that were the base for the evaluation was; safe, stable, work cultural, limiting unnecessary units, eminate future *Gambro*,work for *Artis*™ users, good overview, intuitive, carrying structure, explanatory and easy to learn, see Appendix G.

Concept 7 got the highest score in the valuation and concept 2 got the second highest score. Both concepts have an overview, concept 7 have a better overview, mostly because of a clear view of where the treatment starts and ends. They were also limiting unnecessary units. Both concepts are built on an overview where the user only sees necessary function in this step they are in at the moment and not functions that are needed in the next step. Concept 7 seems to radiate future *Gambro* and work better for *Artis*™ users more than concept 2, mainly because of the treatment view with the dialyzer and the blood lines, which is similar to *Artis*™. Concept 2 seems to be more intuitive and explanatory easily to understand. Concept 7 has a better structure and feels more safe and stable.

A combination of these concepts seems to be a good decision. Concept 7 has a really good overview and the frame gives a uniform and calm impression which gives the user a feeling of structure and control, which also gives the user the confidence to use the interface right away. Concept 2's strength is the intuitive mindset, that it's explanatory and easy to understand. This concept gives the user a clean view of which

choice the user has and what the user need to do in this very moment. Concept 7 seems to radiate future *Gambro* more than concept 2, this is mainly because of the colours; orange and blue.

Here follows a summary of what could be a well- perceived interface for this project:

- Large and clear buttons is good
- An overview of the whole treatment is good, the user shall see all steps and also locate where they are right now
- Figures and additional text give a clear view
- Colour combination gives a clear view over what function that's linked to what.
- An interface with frame gives a safe and well thought through impression
- Differences in tones and sober colours gives a pleasant impression
- There should be more branding in the user interface
- Important information shouldn't be placed in the lower left corner due to that the air guard is concealing
- The inter face should suit the whole world
- Application buttons gives a removable impression, this is good to suit users with different backgrounds and education level.

10 The concept MiMa – prototyp

This chapter is about the result of the design process i.e. the MiMa-concept.

10.1 The MiMa background

The concept *MiMa* was not bolt from the blue. A lot of considerations have been made and the hope is that with this concept *Gambro* can break new ground and after a launch, *MiMa* will immediately bear fruit.

With the background as mechanical engineering and industrial design students the goal is to meet *Gambro's* thoughts and expectations with a new view point and in a brand new way to put the best of both worlds together. Everyone have to pull one's weight in order to contribute to *MiMa* and the belief is that even if the concept is just in its start of phase it can contribute to the future of *Gambro* and a discussion about a further interface among the employers of *Gambro*. Nothing ventured, nothing gained.

After a brainstorming session and evaluation the touch screen was chosen as a start of point for this project. An interview with Gustav von Friesendorrf tells that the market today is already there, and the belief is that the *AK 96*^{TM} should have a touch screen as well, though it's better late than never. The touch screen is also good in case of the economics, it's easier to make end meets with a touch screen due to that it's changeable from country to country and there by language to language without any big recourses. This also fulfilled the goals to make *MiMa* internationally usable and the belief is that a touch screen represents future *Gambro*, see Chapter 2. Other goals were that *MiMa* should limit unnecessary units, which can be fulfilled on a touch screen where it's possible to personalize one's own *MiMa*.

MiMa should carry structure and be pleasant for the user which can be fulfilled on a touch screen. One disadvantage with touch screen is that it's cleaner due to that dirt and blood rest doesn't stick beneath a button. Another problem is due to the sun light and the glare of the screen, this will hopefully be solved with a sensor that adjusts the lighting of the screen through the sunlight it can register, or with a matt screen.

The concept is built on the fact that every person is different. Every person has its own personal needs and requirement. After an interview with Ann-Katrin Davidsson the *Gambro* future became clearer. The branding and marketing department on *Gambro* is proud of the *IQD*^{TM} program; which means to deliver *Individualized Quality-assured Dialysis*. This means to improve the life for a dialysis patient. The branding people already see the *Gambro* products to fill in to this program, but now the hope is that they will see *MiMa* take the *IQD*^{TM} to another level. The *IQD*^{TM} focus on the four corner stone's values of *Gambro* (21);

- Your home of innovation – You inspire, We innovate
- Freedom of choice – You choose, We provide
- Moving forward in partnership – You know, We understand
- Success in patient care- You care, We support

With these four corner stones as a focus point *MiMa* have become a more patient friendly product with more individualized solutions for different users. *MiMa* contains a platform that has a good overview of the process. Other problems that *MiMa* solves is how to understand when a parameter has been changed and when it hasn't. This is in *MiMa* solved with a safety button called *MiMa-confirm* button. In *MiMa* the alarm processing will be handled differently inside the alarm window, *see Alarm*, this because *AK 96*^{TM} needs a more obvious alarm process. Consistency is a keyword for this project due to the lack of it in the *AK 96*^{TM}, something that has been taken very seriously. In the new concept there's a clear and consistently flow, the user shall immediately understand how the new system work. If there's anything the user doesn't understand from the beginning, the user will have a shorter learning period because of the consistency.

MiMa has a platform containing, see Figure 10.1: *MiMa-frame*, *Gambro-logotype*, *MiMa- nine steps*, *MiMa-alarm* button, *MiMa- safety* buttons, *MiMa-arrows* and the *MiMa-alarm* window.

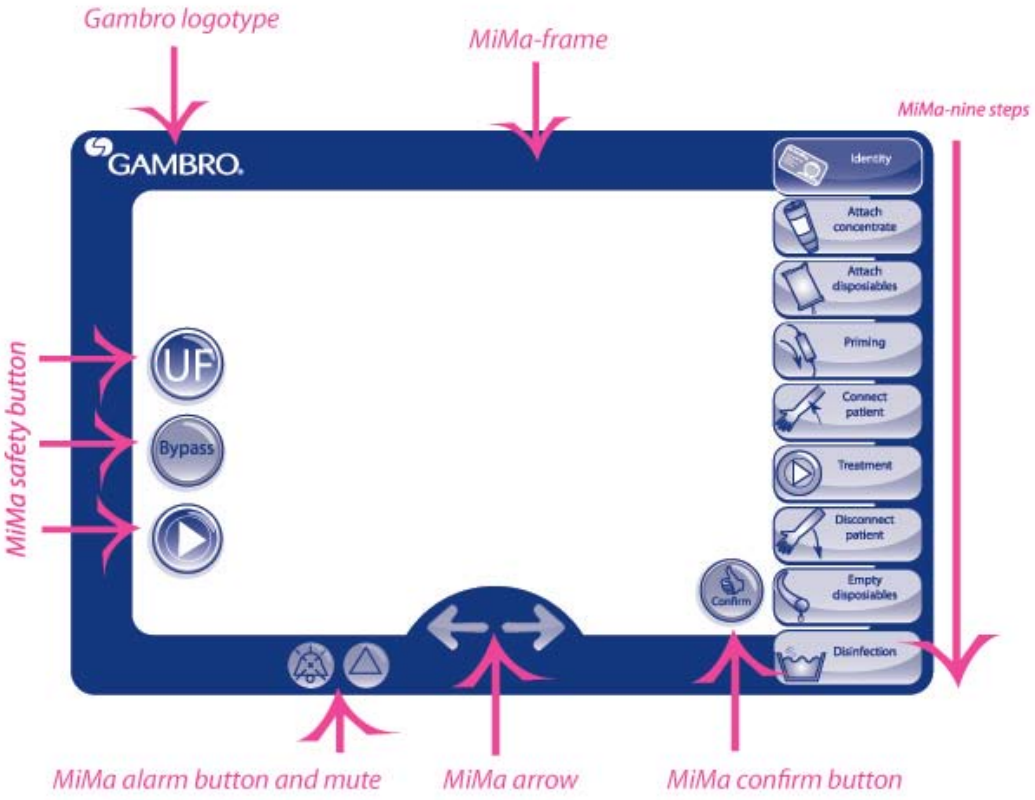

Figure 10-1. The *MiMa-platform.*

10.2 MiMa-frame

The *MiMa-frame* is design to enclose the important components of the *MiMa.* The *MiMa-frame* wants to make *MiMa* feel more secure and well structured. The functions inside the *MiMa-frame* have one meaning and the ones on it have another, something that can be read more about further on. The frame has also a purpose in mediate the *Gambro* brand. The corporate blue colour is known as *Gambro,* and the future *Gambro* machine have to look more *Gambro* in order to spread the brand to the world.

10.3 Gambro logotype

In *MiMa* the *Gambro-logotype* shall always be in the upper left corner of the platform. This could be a obvious thing for many people to have the company logotype on its product but in fact it's sometimes hard to find which company that have made the *Gambro* machines just by looking at the user interface, that's why this is an important factor on *MiMa.*

10.4 MiMa-nine steps

In the right side of the *MiMa-frame* the *MiMa-nine steps* are located. They describe what the user needs to do before the treatment is finished, all steps along the way so to speak. The flow starts in the higher right corner with *Identity* and finish at the bottom with the step *Disinfection.*The *MiMa-nine steps* contains: *Identity, Attach concentrate, Attach disposables, Priming, Connect patient, Treatment, Disconnect patient, Empty disposables* and *Disinfection,* see Figure 10.2.

The nine steps are collected from the training brochure *Training Program AK 95 S Version 1.1*. The treatment step are divided into eight steps, and after some work and discussion with *Gambro* personal one more step were applied; *Identity*. This was applied to reduce the workload and the quantity of button presses. With a memory connected to the personal identification number the patient parameters can be saved.

Figure 10-2. The *MiMa-nine steps.*

10.4.1 Identity

Identity is the first step the user meet, here the user will enter the patient's personal identity number, see Figure 10.3, a function the new *AK 96*^{TM} hopefully will be able to provide. In this ID number a variety of settings shall be able to be saved. This concerns parameters like current weight, dry weight, treatment time and blood flow. The parameters that are fixed and the one's the user can adjust can vary between users, this to get the individualized machine the user wish for.

To be able to set your personal identity number a *MiMa-keypad* will appear by pressing on the display of the numbers, see Figure 10.3. Values such as *Dry weight, Current weight, Treatment time and UF-rate* can if the functions are unlocked be changed by pressing the arrows in the *MiMa-box* to a higher or lower value, *see* Figure 10.4. If the values are fixed they will be displayed in a *MiMa-box* with no possibilities for change. There can maybe be a password or something blocking and if it's an emergency this will be able to open up.

Since there were problems with the old *AK 96*^{TM} interface with the feedback from the machine if the value was changed or not *MiMa* have the *MiMa-confirm* button. If you press on the button the values will be confirmed to the machine.

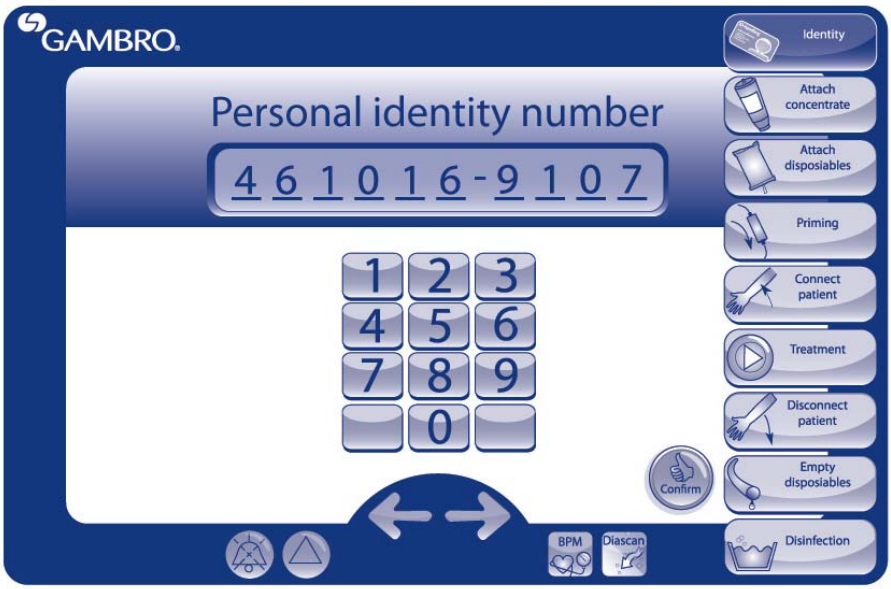

Figure 10-3. An example the *Identity-window*.

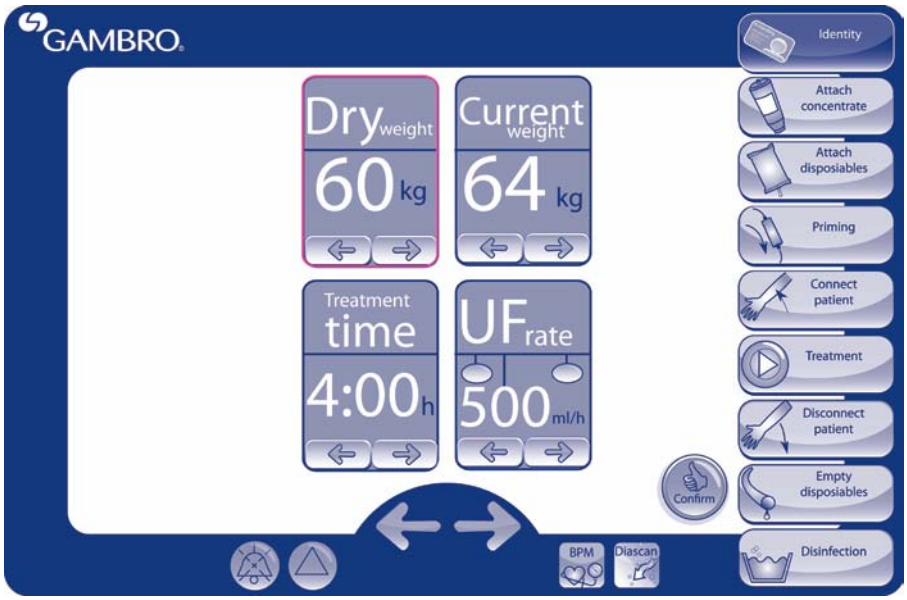

Figure 10-4. The first *MiMa-Identity window.*

10.4.2 Attach concentrate

In the step *Attach concentrate* the user will be guided to place for example the A-concentrate and the *BiCart*® if that's what they normally use, see Figure 10.5. If they for example use acetate instead of A-concentrate this will be displayed, this to meet the customer need. The concentrate that's pre-programmed will be displayed in the *MiMa-guidance box.* If the user has any problems to find where to place the

concentrate or how to do it, the user can press on the *MiMa-guidance box* that they need help with and get help with the specific task. The chosen concentrate could be confirmed by the user with *MiMa-confirm button* and in the future hopefully from the machine itself.

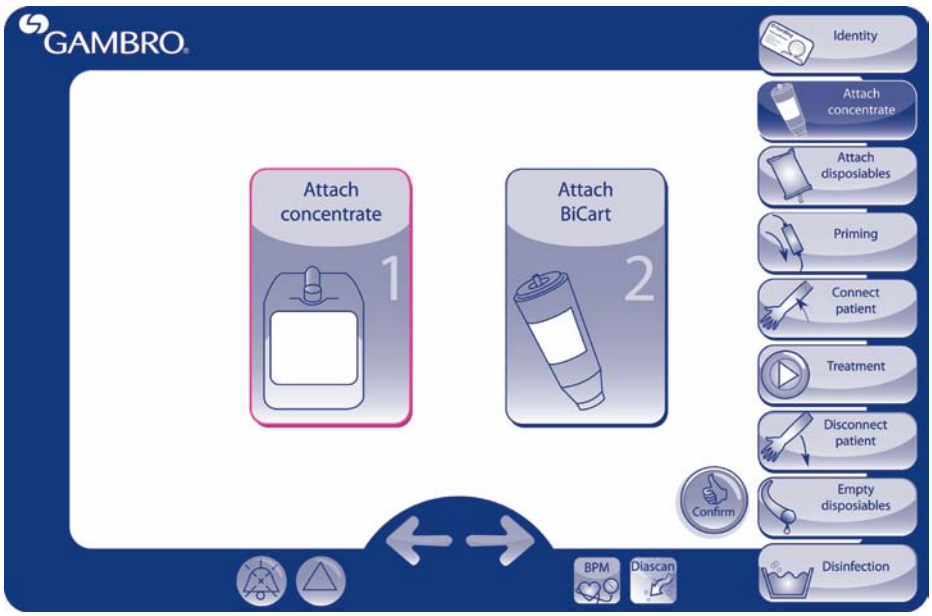

Figure 10-5. An example of the *Attach-concentrate window*.

10.4.3 Attach disposables

In the step *Attach disposables* the user will be guided to attach the disposables this would for example be; *Attach the dialyzer, Attach the arterial line, Attach heparin syringe, Attach venous line, Connect the fluid tubes* and an exhortation to *Turn the dialyzer,* see Figure 10.6. The same thing as in previous step is that if the user needs any help it's only to press the specific box they need help with and a help window will appear. To confirm that the guide boxes are done the user has to press *MiMa-confirm button.* In the future the hope is that the machine can confirm the boxes as well.

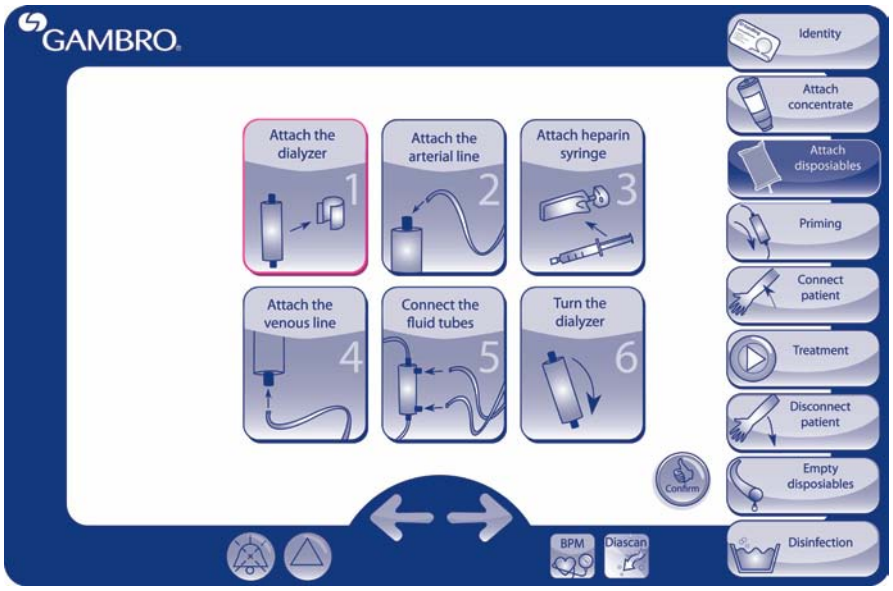

Figure 10-6. An example of the *Attach-disposables window*.

10.4.4 Priming

In the step *Priming* the user will be guided to proceed a priming this would for example be; *Start priming the blood circuit, Deairate the blood circuit, Raise the drip chamber, Activate the air detector, Turn the dialyser, Start priming the blood circuit, Priming volume achieved, Venous pressure test, Turn the dialyser* and *Connect the infusion line,* see Figure 10.7. The same thing as in previous step is that if the user needs any help it's only to press the specific box they need help with and a help window will appear.

To start the blood circuit, activate the air detector or start priming the fluid circuit the user shall press on the symbol in the box, this is a so called button in button, *MiMa-BIB.* By pressing *MiMa-BIB* the task will be activated, and to inactivate the user just have to press on it again, compare Figure 10.7 and Figure 10.8. To confirm that the guide boxes are done the user has to press *MiMa-confirm button.* In the future the hope is that the machine can confirm the boxes as well.

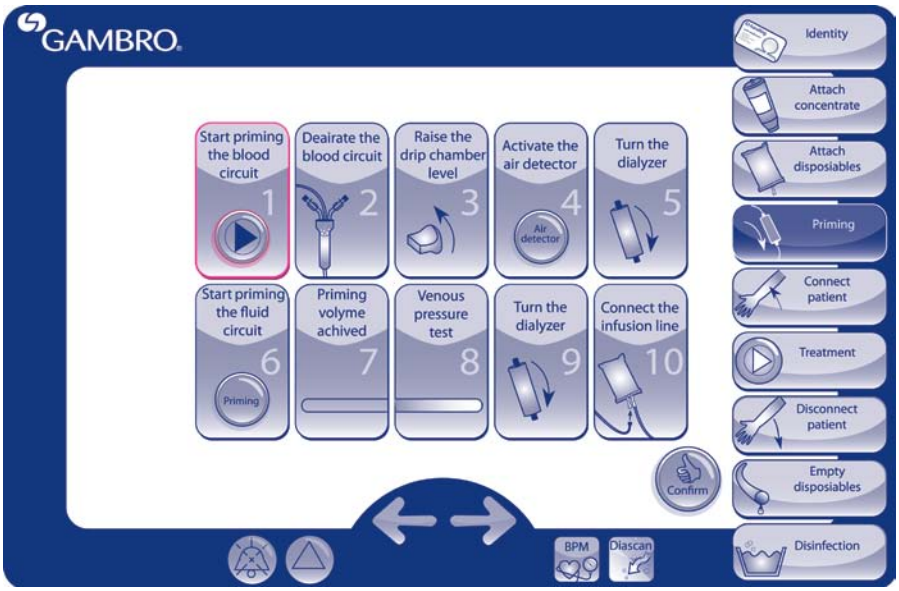

Figure 10-7. An example of how a *Priming window* can look like before the boxes are done.

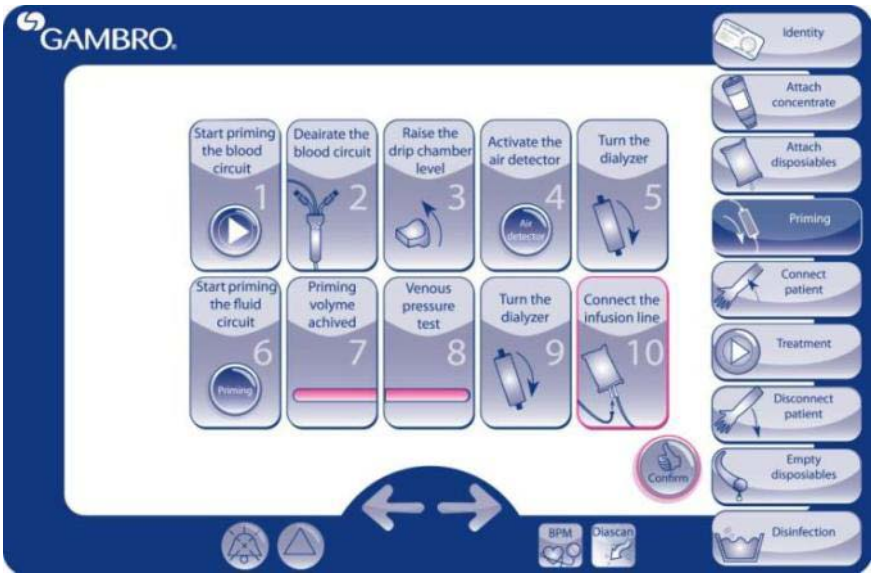

Figure 10-8. An example of how a *Priming window* can look like after the boxes are done.

10.4.5 Connect patient

In the step *Connect patient* the user will be guided to connect the patient this would for example be; *Puncture the arterial needle, Close the clamp on the saline bag, Connect the arterial line, Open the clamp on the venous line, Start the blood pump, Close the clamp from the waste bag and disconnect, Connect the venous line, Open*

the clamp on the venous needle line, Start treatment and *Turn the dialyser,* see Figure 10.9. The same thing as in previous step is that if the user needs any help it's only to press the specific box they need help with and a help window will appear. To *Start blood pump* and *Start treatment* the user shall press on the symbol in the box, the *MiMa-BIB*. By pressing *MiMa-BIB* the task will be activated, and to inactivate the user just have to press on it again, compare Figure 10.9 and Figure 10.10. To confirm that the guide boxes are done the user has to press *MiMa-confirm button.* In the future the hope is that the machine can confirm the boxes as well.

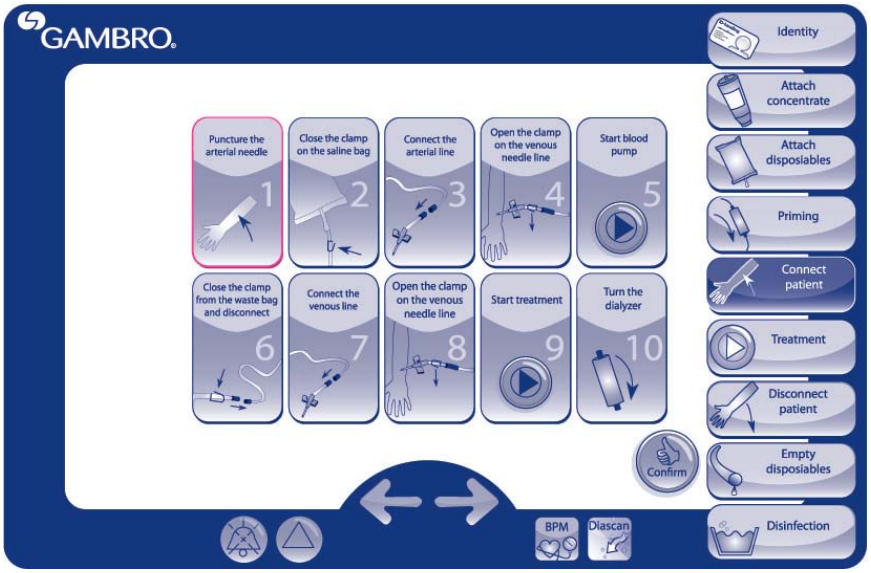

Figure 10-9. An example of the *Connect patient window* before the *MiMa-boxes* are done.

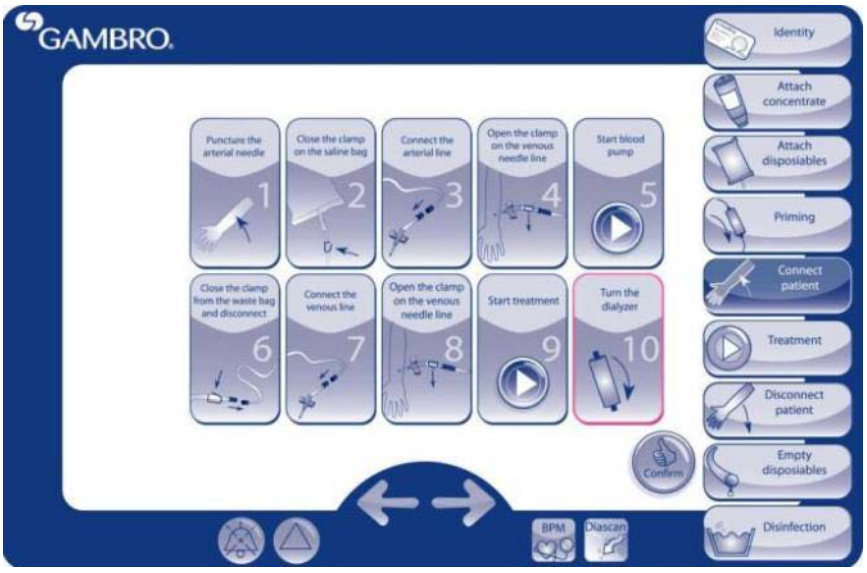

Figure 10-10. An example of the *Connect patient window* after the *MiMa-boxes* are done.

10.4.6 Treatment

In the *Treatment* step the user will have an overview of the treatment and the user will have control over different parameters for example; *Time, Blood flow, Venous pressure, Arterial pressure* and *Ultra filtration rate*. These values will be displayed in the treatment display in the top of the treatment window, see Figure 10.11. On the left side of the treatment window the user will find the *MiMa-safety buttons* which includes; *UF*, *Bypass* and *Start blood pump*. These buttons will have the same placement during the whole treatment.

To be able to set other parameters during treatment the user can chose between two options; *Blood values* and *Dialysis fluid.* If the user press on the *Blood- value button* an example of that window could consist off; *Arterial pressure, Venous pressure* and *Blood flow*, see Figure 10.12. If the user instead presses on the *Dialysis fluid button* the parameters in this window could contain; *Ultra filtration, Temperature, Transmembrane pressure, Ultra filtration, Dialysis fluid flow* and *Conductivity, see* Figure 10.13. To get back to the main treatment page the user have to press the left *MiMa-arrow*. To confirm that the adjustment boxes are changed the user has to press *MiMa-confirm button.*

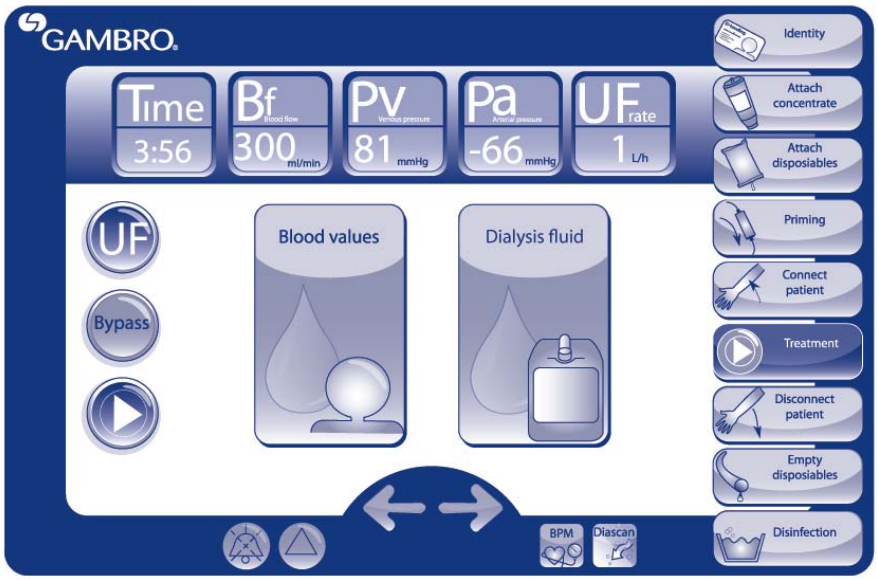

Figure 10-11. An example of the main *Treatment window.*

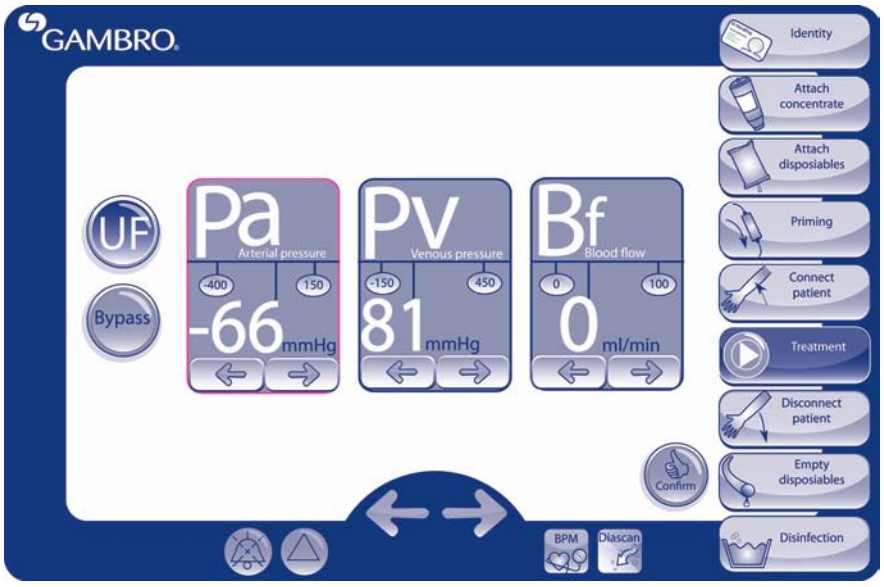

Figure 10-12. An example of the *Blood value window*.

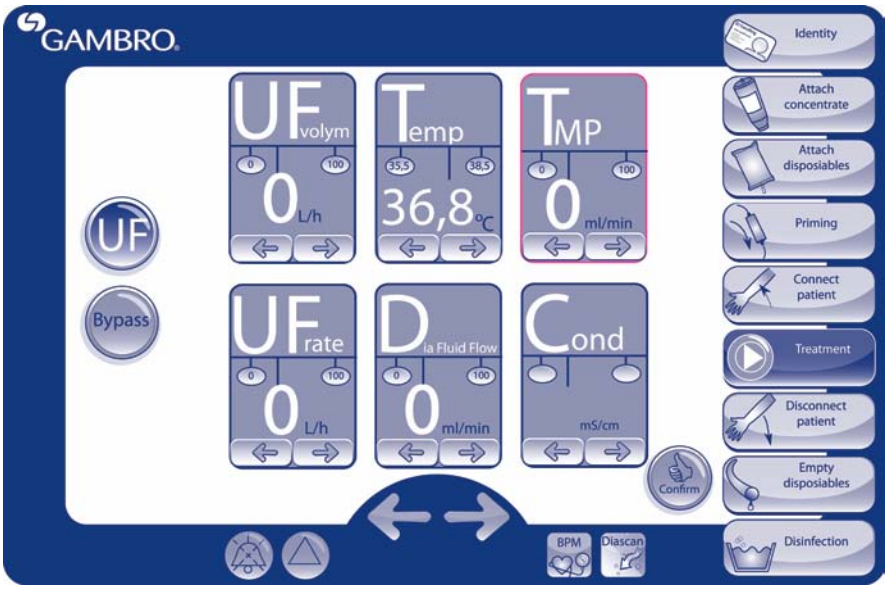

Figure 10-13. An example of the *Dialysis fluid window*.

10.4.7 Disconnect patient

When the treatment is about to finish the *disconnect patient* window opens. In the step *Disconnect patient* the user will be guided to disconnect the patient this would for example be; *Prepare for disconnection, Reset time and inactivate the pump, Disconnect the arterial line, Rinse back, Disconnect the venous line* and *Remove the needles*, see Figure 10.14. The same thing as in previous step is that if the user needs any help it's only to press the specific box they need help with and a help window

will appear. To *Reset treatment time, Start the blood pump* and *Rinse back* the user shall press on the symbol in the box, the *MiMa-BIB*. By pressing *MiMa-BIB* the task will be activated, and to inactivate the user just have to press on it again except for the reset time button, this button will not be press able after the reset. To confirm that the guide boxes are done the user has to press on the *MiMa-confirm* button. In the future the hope is that the machine can confirm the boxes as well and also that the machine will save data on a hard drive connected to the personal identity number instead of have the patient writing down the values.

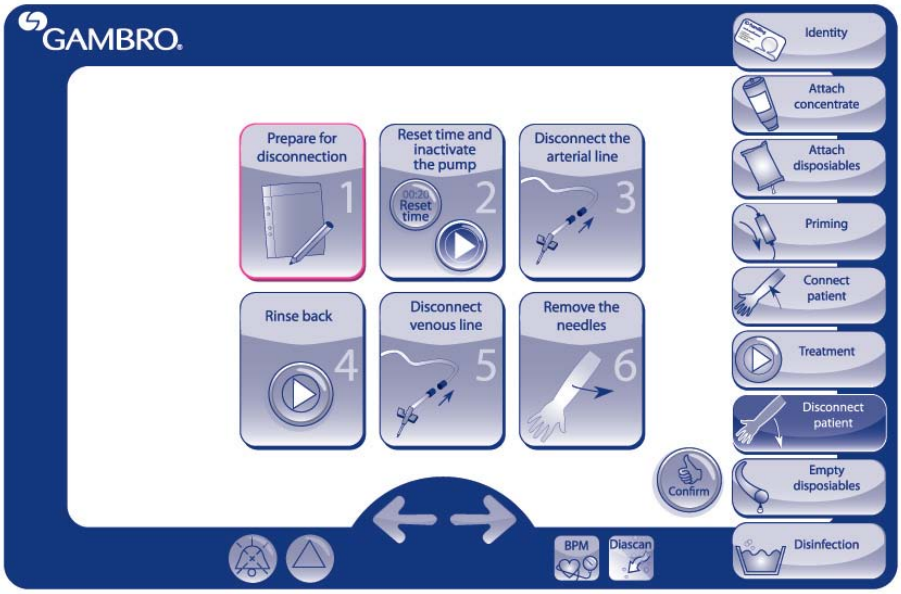

Figure 10-14. An example of the *Disconnect patient window.*

10.4.8 Empty disposables

When the patient is disconnected the disposables needs to be empty and throw it in the rubbish can. In the step *Empty disposables* the user will be guided how to empty disposables this would for example be; *Empty blood circuit, Empty dialysis fluid circuit, Empty Bicart®* and *Discard disposables*, see Figure 10.15. The same thing as in previous step is that if the user needs any help it's only to press the specific box they need help with and a help window will appear. To confirm that the guide boxes are done the user has to press *MiMa-confirm button.* In the future the hope is that the machine can confirm the boxes as well.

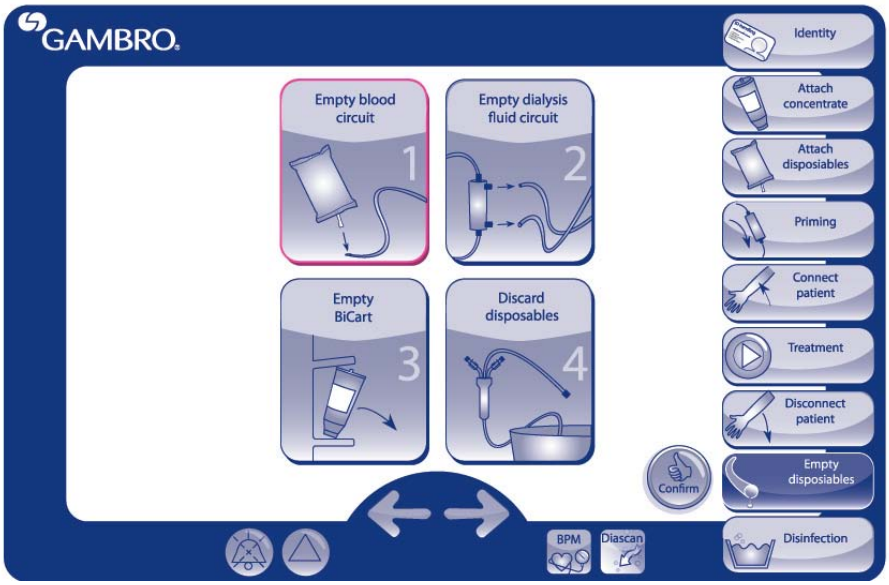

Figure 10-15. An example of the *Empty disposables window.*

10.4.9 Disinfections

The last thing to do is to clean the lines and the machine, the user can for example choose between; *CleanCart®, Heat disinfection* and *Chemical disinfection,* see Figure 10.16. These boxes are menus, just like during treatment. If you enter a menu you can choose different settings and start the disinfection.

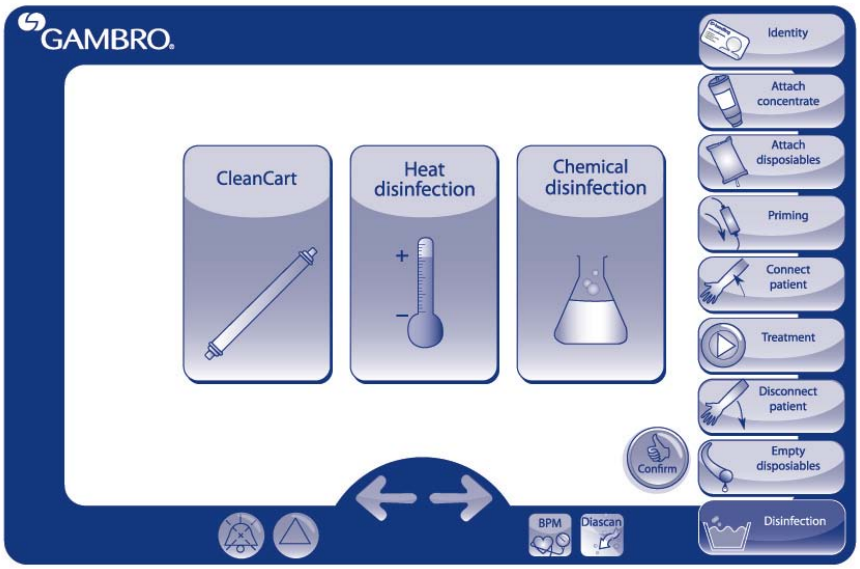

Figure 10-16. An example of the *Disinfection window.*

10.5 Extra functions

AK 96^{TM} has two extra functions: *BPM* and *Diascan*. *Diascan* is a function that shows how much blood that has been cleaned after treatment; see Chapter 5. If the user wants to measure the blood pressure they only have to press the *BPM button* in the lower right corner and a *BPM window* will be shown, see Figure 10.17. If the user wants to start *Diascan* the user just press on the *Diascan button*, see Figure 10.18, and a *Diascan menu* will show. In the future if *Gambro* decides to add more functions to the *AK 96*^{TM} they would also be placed on the *MiMa-frame*.

Figure 10-17. The *BMP button*

Figure 10-18. The *Diascan button*

10.6 Alarm

The thought about the alarm concept is that when an alarm occurs, a new window will be shown and the user can see the reason of the alarm and how to fix it. The alarms are divided in three categories; *Urgent alarm*, *Ordinary alarm* and *Attention alarm*. *Urgent alarms* have the highest priority and includes among other; *Air in the venous drip chamber*. *Ordinary alarms* have the second priority. *Attention alarms* isn't so important, the user usually just confirm that they have seen it. To distinguish the alarms, they have different colours and sounds. *Urgent alarms* are red, *Ordinary alarms* are orange and *Attention alarms* are yellow. The user can see all alarms that occur and a queue system divide the alarms with *Urgent alarms* first, then *Ordinary alarms* and last *Attention alarms*. If there's an *Urgent alarm*, the alarm button is flashing red. If no *Urgent alarms* exist but both *Ordinary alarms* and *Attention alarms* is seen, the alarm button will flash in orange. If only *Attention alarms* exist, the alarm button will flash in yellow. The mute button that is located next to the alarm button will always flash in blue, the user can pause the alarm sound for a couple of minutes, something that *Gambro* has to evaluate in a later process.

10.7 The individaute concept

This concept is created for people with different background and education level. The solution of this problem has been to configure the concept for each user. A less experienced user needs a more locked interface than an experienced one.

Before the user starts to work with the dialysis machine for the first time, there's some decision to make. This is decisions about which boxes that's necessary and pleasure for the user and which of the adjustment and guidens boxes the user is in

need of. The reason for this selection is to make the concept more suitable and pleasurable for the user. For example the expert nurse doesn't need to be reminded of when it's time to puncture the arterial line, something that the beginner could be in huge help of. Let's go back to the user who starts with the new interface for the first time. The user together with a doctor and a technician chooses boxes and functions from a function library. The doctor chooses which boxes and functions that the user needs for safety, the user choose which boxes and functions that is comfortable and pleasurable, the technician implements this.

10.8 Checkpoints

For an open interface there are some limits. The user shall not be able to start *Priming* before *Attach concentrate* and *Attach disposables* is done. The *Treatment* step shall not be able to start before the patient is connected. The treatment shall not be able to start before the *Identity* step is done. The user shall always be able to disconnect the patient, but not be able to *Empty disposables* before the patient is disconnected. Disinfection shall only be able to start if *Disconnect patient* and *Empty disposables* are done.

11 Usability test

A usability test was done to get an opinion on MiMa from the real users.

11.1 Purpose

The purpose of this test is to get the understanding of the interaction between the user and the user interface called *MiMa*.

11.2 Scope

The user test will focus on participants from Sweden, of course it had been better with international participants when that's one of the goals, but *Gambro* thinks it's difficult to find persons from other countries that will come to Sweden, because of limited time and resources. In this test there will be Swedish participants that have different education level in dialysis treatment and also test users that have worked with *Artis*^{TM}.

The test will be performed on a laptop that support a touch screen function, the *MiMa concept* was implemented in *Adobe Flash CS 3*. Together with a touch screen a user test can be done and the user can work with a finger like in the reality. There will be a dialysis machine beside the computer to get a similar environment as in a hospital. It's a limitation that the participant can't test the user interface directly on the machine.

11.3 Ethics

As a designer or developer, who wants to engage people as a source of information or evaluators of products, it's important to think of ethics(22). As a researcher you have to follow certain regulations about ethics, but the belief is that this should concern anyone working with people as a source of information. A good ethic code is achieved by:

- Treating participants with respect
- Making information and activities accessible
- Ensuring a basic level of success
- Pilot testing activities
- Informed consent

With informed consent it's meant a procedure which should be followed to make sure that the participants have the information they need in order to decide if they want to participate. In this test the participants have received a call from one of the test

leaders before the test, where the leaders have described who they are and where they work, where the test should be located, how the test is performed, the approximated time of the test, where they could call if they have any questions and what time they should arrive for the test. Before the test, the main points in the invitation are presented verbally and the test person is given the opportunity to pose questions. The following points should be controlled before the test;

- The participant is willing to participate in the specified test to try *MiMa*.
- The participant has been informed in advance.
- The participant has been informed about how the test will be performed.
- The participant has been informed about any recordings that will take place and how these are handled afterwards.
- The participant knows who to contact in case of questions.
- The participant is aware that they can, at any time, discontinue the participation without indication any reasons.
- The participants permit the recording of data on video/audio tape.

The participants will be handled a test ID. This is so that personal information like name and date of birth will be handled in a secure manner.

11.4 Test Areas and Objectives

The different test areas and objectives that will be in focus of the test are described below.

11.4.1 Test Areas

The things to evaluate in the test are primarily the flow of the user interface. Secondarily the test should concern the platform for the evaluation of the symbols, the interaction, the graphics and the different steps and functions.

11.4.2 Heuristic evaluation

Heuristic evaluation is a very informal usability testing method for user interfaces. The method is based on, but not limited to, common accepted heuristics. It's a fast method to test user interfaces in order to recognize failures with respect to intended purposes. The user test will have a list of tasks to be able to perform a heuristic evaluation:

- Create common use cases
- Create a set of heuristics
- Categorize and prioritize the heuristics
- Apply the heuristics along the use case

The specific questions and tasks will be described further down, see Test objectives.

11.4.3 Gambro Usability Objectives

In the test the tasks should also consider the *Gambro* usability goals:

- Easy to learn- The system should be easy to learn so that the user can rapidly start to use the system
- Low error rate- The system should have a low error rate, so that users make few errors when they use the system and so that the error recovery is easy.
- Pleasant to use- The system should be pleasant to use, so that the users are subjectively satisfied with it.
- Efficient to use- The system should be efficient to use, so that once users have learned it, it is possible to achieve a high level of productivity

11.4.4 Test objectives

The different test objectives that will be in focus of the test are described below as they were asked.

11.4.4.1 *Identity*

Task during the step *Identity:* We have just started the dialysis machine, and this is the first window that you will see. You are now going to get something similar to a patient journal that contains important values and parameters to this treatment. I want you to confirm and control these values with the values that the screen is showing.

11.4.4.2 *Attach concentrate, Attach disposables and Help*

Task during the step *Attach concentrate, Attach disposables* and *Help:*

- (At the step A*ttach concentrate*) If you want help with how to attach the concentrate, how would you do?
- Now I want you to prepare the machine so that *Priming* can start.

11.4.4.3 *Priming*

Task during the step *Priming:* Now the thought is that you should perform *priming* and I would like you to do this.

11.4.4.4 *Connect patient*

Task during the step *Connect patient*: Now you shall finish all preparations so that the *Treatment* can start.

11.4.4.5 *Treatment*

Task during the step *Treatment*:

- Now the treatment is started and I wonder what you can deduce from the screen?
- If you should set the parameters for the arterial pressure, how would you do?
- Now I wonder what the value is on conductivity.

11.4.4.6 *Alarm*

Task during *Alarm*:

- Oh, now you got an alarm, what has happened?
- How would you do to solve the problem?
- Finally, how many alarms do you see and what type of alarm is it?

11.4.4.7 *Discussion*

Questions during the *Discussion*:

- How do you think the test went? What went well and what didn't?
- What did you think of the stock tracking on this page? (for example; *Connect patient*)
- What did you think of the different steps under the stock tracking?
- Which symbols did you think were extra clear or less clear?
- In the treatment window, were there any parameters that you missed or want to erase?
- (BMP and Diascan): What do you think these two buttons are for?
- How did you think the alarm was working?
- Do you rather read the text or watch the pictures?
- Do you have any propositions on improvements?

11.5 User Profile

The number of users that will take part in this test is seven.

The user profiles that will take part in this test are, two nurses with experience in dialysis care (one with four years and one with 20 years), two beginners in dialysis care, the last three users are educating nurses in *Gambro* machines.

The beginners have their most training in the *Fresenius* machines, the experienced nurses have worked with a wide range of machines (*Gambro AK™ and Artis™, Fresenius, and Serena*), and the *Gambro* nurses have a long experience of different types of machines as well. All test persons are located in the south of Sweden. The age varies from 43 to 70 and two of the participants are men.

11.6 Test Environment

The test will be located in Lund, *Gambro Lundia*, test room Argus. The environment shall as far as possible be similar to the real dialysis environment. There will be an *AK 96™* machine, a dialysis chair, tubes and lines and a lap top computer with a touch-screen to test the user interface on.

11.7 Material

The material that will be used is a computer laptop with the interface *MiMa* running in *Adobe Flash CS3 Professional*. The interface is thus interaction significantly.

11.8 Data Collection

The data will be collected and notes will be taken by an observer. The test session will be video recorded as a support for the analysis work. The recording material will be deleted after the report has been finalized and approved. The following data will be collected and evaluated:

- Use errors
- Incidents, where operator intentions conflicts with handling
- Assists/prompts, where the operator gets stuck and needs some support to continue
- Test participant comments
- Subjective ratings from the participant

11.9 Resources

The participants in the test from *Gambro Lundia* will be a test leader, who will ask questions and give tasks to the test person, an assistant test leader, who will write down important observations during the test after a test template, and an observer, who will turn on the video recorder and observe the test. The observer will not be in the test room, but will be introduced before the test.

11.10 Evaluation Schedule

The user test is performed during four days, with between one to three test persons a day. The approximated total time per test is two hours.

11.11 Pilot Test

Pilot test is a trial version of the test that's going to be performed. The main reason to do this test is to catch early problems in a test run, before the real test begins. Pilot testing provides information on how long data collection can be expected to take and a preview of how difficult the tasks will be to complete. This pilot test will be performed by an in-house *Gambro* college.

11.12 Training

No training will be performed to the participant. This is to test a worst case scenario and catch the intuitive action the user makes. In a stressful situation the user might forget even the simplest instruction and do what the user thinks is correct, which is similar to the first intuitive actions the user does in this test situation.

11.13 Prerequisite Condition

The prerequisite condition that must be fulfilled, before the evaluation can take place, is that the participants have to sign a confidential agreement and be well aware about the test and how the test will proceed.

11.14 Usability Evaluation Procedure

Below the test and its procedures will be described.

11.14.1 Participant Greeting

The welcoming procedure will in short contain:

- A welcome to *Gambro*
- A presentation of the test leader, the assistant test leader and the observer
- A brief of the test

In the welcoming procedure the test leaders will make sure that all the ethic aspects have been considered, see Ethics.

11.14.2 Introduction

The introduction will in short contain:

- A questionnaire to be filled out by the test persons about basic facts regarding the test person's health.
- A welcome speech, see Appendix H, and a confidential agreement that the participants have to sign.
- A possibility to ask questions

11.14.3 Background Interview

The background questions that will be asked is regarding gender, age, occupation, education, hearing, vision and motor ability. This is done to support the test in the discussion, see Appendix I.

11.14.4 Tasks

The task will be read by the test leader to the participant during the test. The test users will get a prescription similar to reality. They will not dress a dialysis machine and they will not puncture a patient.

11.14.5 Help during the test

The participant shall solve the task sequence by her/himself without interruptions. If the test person needs help during the test the test leader will use the questions described below. The questions shall not be asked in a sequence this is due to that the first question can be enough to help the participant.

- What do you want to do?
- What did you expect?
- Can you find anything that will help you?
- If the user is still stuck, evaluate the situation and either break the task sequence or show the solution.

11.14.6 Summary Interview

At the end of the usability test procedure there will be a summary interview concerning overall impressions and feedback on the quality of the product and after completed the formal testing additional observers will be welcome to conduct follow up questions and discussions with participants.

12 Evaluation of usability test

These are ten general principles for user interface design that the performers have chosen to evaluate the usability test by(11). *Below every heading there are the problem that was found during the usability test and also proposal on improvements. To see the complete list of findings from the test see Appendix J.*

12.1 Visibility of system status

Below the solution on the findings regarding *Visibility of system status* of the system during the usability test is declared.

12.1.1 Improvements on the overall concept

- A problem with *MiMa* that was shown in the usability test was that the user didn't understand if they should confirm every *MiMa*-box or all boxes at ones i.e. confirm the steps.

  Comment/ Solution: Since every test user had problem understanding a change has been done. This was to remove the *MiMa-pink frame* in order to make the functions easier to understand which leads to that the *MiMa-arrows* feels unnecessary and is removed as well. To make it clearer that the user should confirm all boxes at ones in a step a frame around all boxes will be added.

- Every user wanted to be able to press on the *MiMa-nine steps* and not walk through the system with the *MiMa-arrows*.

  Comment/ Solution: Every button in the *MiMa-nine steps* should be press able.

- The *MiMa-arrows* was not the first buttons the users tried to use, except going backwards. This pattern was the same for all seven users.

  Comment/ Solution: The *MiMa-arrows* will in the improved concept be removed. A backward arrow will be added on pages where it's necessary, like in the *MiMa-help*.

- The users want to see more colours coded on the boxes, especially with the arterial and venous side of the dialyzer. This was something that came up during discussion from some of the users.

  Comment/ Solution: This is a reflection that has been changed in another direction. There will not be colour coded illustrations in the *MiMa-guide box*

all though it will be added text to for example put venous side up. In the *MiMa-help* on the other hand there will be a colour coded solution.

- All seven users have trouble to see if the *MiMa-BIB button* is active or just selected.

  Comment/ Solution: This will be changed with a green colour on the one that is active and make the contrast to inactive button sufficient.

- The *MiMa-BIB button* doesn't lit up when it's active according to the users.

  Comment/ Solution: Same solution as in the finding before, the active one will be lit up in a green colour.

- Five of seven test users did understand how to use the *MiMa-BIB button,* but some got confused when they didn't think it lit up.

  Comment/ Solution: The belief is that if they had understood that the button lid up the test users would have understood the function. Every test user wanted to press on the *MiMa-BIB* which makes this hypothesis significant.

- Some of the users want to see which concentrate it is when they place it on the *AK 96*^{TM} machine.

  Comment/ Solution: This will be shown in the step *Prescription,* former *Identity* see *Match between system and the world.*

- Want more clear feedback when *priming* is done.

  Comment/ Solution: The confirm button will not be press able before the priming is done; the *Priming* step will also be dimmed.

12.1.2 Improvements regarding alarm

- When an alarm is showing the users want to have access to the blood pump button.

  Comment/ Solution: There will be an emergency stop button, that will be tactile, and places somewhere visible on the machine. Further validation of *Gambro* has to be made in where to put it.

- Two of eight test users didn't see the queue alarms.

  Comment/ Solution: a comment to this is due to the fact that the screen was not possible to press on and interact with and because of that the belief is that the test users had bigger problem than necessary with this function, even though, the decision has been to let the gradient go from the other direction and increase the contrast on the symbols.

- Six of eight test users wanted to change the value of arterial pressure directly in the *MiMa-treatment display.*

  Comment/ Solution: This is something that was supposed to work, which then is a good feedback.

- To be able to see the treatment display when an alarm appears was requested from one of eight users.

  Comment/ Solution: *MiMa* is built on the hope that no unnecessary functions will be shown if the user shouldn't use them. The same thing is in the alarm handling. The parameters that are necessary in order to solve the alarm should be shown and no other. If the user wants to see other values anyway they could just press on the *treatment* step.

12.2 Match between system and the real world

Below the solution on the findings regarding *Match between system and the real world* of the system during the usability test is declared.

- One person with international background gave proposal to change Bf (blood flow) to Q_B something that's more internationally accepted.

  Comment/ Solution: The *MiMa-concept* is built on the hope for an individual treatment, therefore the belief is that every country shall have its own language and the words and shorting that fits best in their environment, not what suit the whole world best.

- Four of eight users wanted to see the *UF volume* in the treatment window.

  Comment/ Solution: *MiMa* is built on the concept that the user shall be able to choose which parameters they find most appropriate for their own treatment in a function library. Thereby ever different need could be satisfied and so also to be able to see *UF volume.*

- Two of eight test users reacted on the word *Identity*, should be *Prescription* according to them.

  Comment/ Solution: After research this seems more logical, and *Identity* has been changed to *Prescription.*

- Wants to see more parameters under *Identity,* like concentrate type, dialyze filter, and heparin dose.

  Comment/ Solution: *MiMa* is build on the concept that the user shall be able to chose which parameters they find most appropriate for their own treatment in a function library. Thereby every different need could be satisfied and so also to be able to see dialyze filter and so on under *Prescription,* former *Identity*.

- *Turn the dialyzer* where a guide in two cases where the test users thought it wasn't necessary.

  Comment/ Solution: *Turn dialyzer* will be removed in these cases but if a clinic uses the method they should be able to get it from the function library.

- One person wanted to correct *Empty disposables* to *Drain disposables.*

Comment/ Solution: After research seems this more logical, and *Empty* have been change to *Drain*

- The blood pump symbol is hard to understand.

  Comment/ Solution: Since it seems like every test user had problem with this symbol and they don't know how to illustrate blood pump in another way the decision have been made to write it in text instead.

- The *Priming* arrow should be in the other direction according to reality.

  Comment/ Solution: After research it seems more logical, and the priming arrow will switch direction which could be recognized in *AK 96*^{TM}.

12.3 User control and freedom

Below the solution on the findings regarding *User control and freedom* of the system during the usability test is declared.

- The users all find the way back to the main window with the help of the *MiMa-back arrow button.*

  Comment/ Solution: Even though the *MiMa-arrows* will be removed there will be a new arrow to make sure the user can be able to get back to the main page. Therefore this result is a good result that could give the future concept a hint of that it will work.

- All eight users want to press directly on the *MiMa-nine steps.*

  Comment/ Solution: This is something that implies that the *MiMa-nine steps* looks press able, which they are.

- Some of the users would have an increased feeling of security with a blood pump button always available.

  Comment/ Solution: There will be an emergency stop button that will be tactile, and placed somewhere visible on the machine. Further validation of *Gambro* has to be done about where to put it.

12.4 Consistency and standards

Below the solution on the findings regarding *Consistency and standards* of the system during the usability test is declared.

- The users who didn't understand the *MiMa-confirm button* at first did it after a while.

  Comment/ Solution: This indicates that *MiMa* have good consistency.

- The *MiMa-arrows* don't have the consistency in if it moves around in the boxes or on the pages.

  Comment/ Solution: The *MiMa-arrows* are removed which make this comment unusable in the new concept.

- It seems hard to know if in the *MiMa-adjustment boxes* adjust the main value or the limits.

  Comment/ Solution: The clearness in these boxes will be considered.

12.5 Error prevention

Below the solution on the findings regarding *Error prevention* of the system during the usability test is declared.

- Remove *MiMa-arrows*

  Comment/ Solution: This is a result of the usability test.

- Remove *MiMa-pink frame*

  Comment/ Solution: This is a result of the usability test.

12.6 Recognition rather than recall

Below the solution on the findings regarding *Recognition rather than recall* of the system during the usability test is declared.

- The *MiMa-guide boxes* helps the memory

  Comment/ Solution: It seems like the users get help from the *MiMa-guide boxes* which makes the user interaction easier. The belief is that this is due to recognition rather than recall.

12.7 Flexibility and efficiency of use

Below the solution on the findings regarding *Flexibility and efficiency of use* of the system during the usability test is declared.

- It seems easy for the test users to find help

  Comment/ Solution: This is good because this was a critical function that was hard to deduce before the usability test.

- Clear steps according to the test users.

  Comment/ Solution: This was one of the main goals which means that this goal is reached.

12.8 Aesthetic and minimalist design

Below the solution on the findings regarding *Aesthetic and minimalist design* of the system during the usability test is declared.

- The test users want to have *MiMa* more colour code.

  Comment/ Solution: The colour code will be found in the *MiMa-help box*. To implement more colours in the *MiMa-guide boxes* are a risk because this puts the consistency imbalance, something that was not acceptable.

- Could be nice with a screensaver.

  Comment/ Solution: A good thought for the future development of *MiMa.*

- The whole *MiMa-guide box* should be lid up.

  Comment/ Solution: There will be more obvious implementations of the feedback from the screen.

- To small text

Comment/ Solution: Recommendation for the future is 14p.

12.9 Help users recognize, diagnose, and recover from errors

Below the solution on the findings regarding *Help users recognize, diagnose, and recover from errors* of the system during the usability test is declared.

- During Alarm: The test user can solve the problem directly in the *Alarm window.*

  Comment/ Solution: This is something the test users seem pleased with.

12.10 Help and documentation

Below the solution on the findings regarding *help and documentation* of the system during the usability test is declared.

- USB-stick

  Comment/ Solution: A USB-stick to save data on could be a recommendation for the future development of *MiMa* or even better if it would be able to send data online to the doctor.

- *Diascan*

  Comment/ Solution: Diascan is a function that saves data about how good the treatment was something that could be good in a documentation purpose.

- Treatment documentation

  Comment/ Solution: In the future a treatment log would be nice to have where the machine logs all data according to the changed values during the treatment.

12.11 Other comments to consider

- Possibility to clean the screen from for example blood stains during treatment

  Comment/ Solution: This is added like an extra function.

13 Result

The evaluation of the usability test has lead to improvements of the MiMa concept, these improvements are explained in the previous chapter; see Chapter 12. In this chapter the final concept MiMa is explained. A lot of colours are explained in the text, for definition of these colours see Appendix D.

13.1 MiMa-platform

The *MiMa-platform* is built on *MiMa-nine steps*, *MiMa-extra functions* and *MiMa-alarms*, see Figure 13.1. *MiMa-nine steps* have a purpose to acquire a good overview during the whole dialysis treatment. The dialysis process is divided into nine steps and informs the user on where the user is right now, what the user has done and what the user need to do before the dialysis process is finished. The *MiMa-nine steps* are the overview of the concept. In every step follows the *MiMa-guide boxes* which present what the user is suppose to do and which functions that need to be activated in order to go further in the dialysis process. The philosophy behind this concept is that the user doesn't need to see more than necessary. The result is a clean interface that gives a well-thought impression for the user. The user shall focus on what they have to do right now and feel comfortable with *MiMa*.

MiMa has two alarm buttons on the left side of the window, see Figure 13.1. The user can always see these buttons which is important because the alarms can occur anytime during the treatment and need to be visible all the time. The lower part of the frame is dedicated to the extra functions, such as blood pressure monitor, *BPM*, *Diascan* and *Clean*, which is a function that is able to lock the screen when the user needs to clean it. These functions can be changed depending on the user that operating the machine, for example, all users dom't think that the *Diascan* function is a necessary function and should therefore not have this function available on the screen. This goes hand in hand with the philosophy; the user shouldn't see more than necessary.

The frame in the *MiMa-platform* is coloured in *Gambro blue*, this colour is taken from *Gambro Blue book*. The colour expresses *Gambro* and a dark frame highlights the functions inside the frame. The *Gambro Blue book* has three fonts; *DIN Pro*, *Arial* and *Times New Roman*. The font in the concept *MiMa* is *Myriad Pro*, the performers couldn't get the font *DIN Pro*, and this is why they have chosen *Myriad Pro* which reminds of *DIN Pro*. *Arial* and *Times New Roman* wasn't selected because the fonts are too ordinary to express *Gambro*.

One of the goals for this project is to get the *Gambro* brand more visible, this is why the logotype is positioned in the lower, left corner, see Figure 13.1.The other logo;

MiMa is placed there because this is the product name of the user interface. *MiMa* stands for *New thinking, Dare to take chances, Reliable* and *Product design*. The *M* in the logotype is from the *Gambro logotype* to get a union impression. The *a* is formed like a drop of blood that passes a membrane, which symbolize a dialyse.

Figure 13-1. The *MiMa-platform; MiMa-frame,MiMa-logo,MiMa-alarm button,MiMa-nine steps* and *MiMa-extra functions.*

13.2 Symbols

The symbols in the *MiMa concept* are created to increase the understanding of the function and also to remember a step, for example in the *MiMa guidance boxes*, the illustrations are made in purpose to remember what the user has to do in the step.

The performers' vision was to create symbols with the same grade of detail and feeling. A graphic illustration was made to clarify how detailed a *MiMa* symbol should be, see Figure 13.2. A scale is illustrated from low detailed to high detailed symbols. The performers decided to create *MiMa* symbols from the middle of this scale. This graphical illustration helped the performers to set a uniform standard. The development of the symbols is seen in Figure 13.4.

To enhance the similarity of symbols it's important to be consistent with line thickness and colours. The symbols are often filled with Gradient grey, this clarify focus in symbols, see Figure 13.3.

The alarm symbols are separate from other symbols, these symbols aren't that detailed and are standard symbols for alarms according to ISO standard, and are required according to Gambro(23).

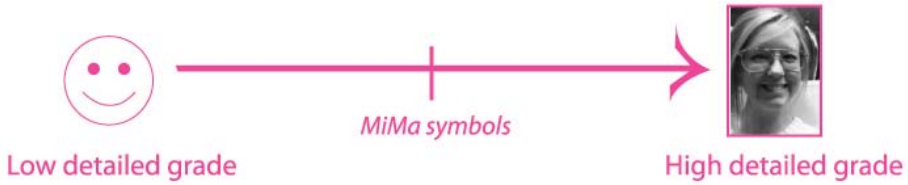

Figure 13-2. Scale of the detail level of symbols.

Figure 13-3. The gradient in the arm is to clarify focus in the symbol.

Figure 13-4. The development of the symbols from an early stage to the final concept. In the left are the early symbols seen, to the right the latest.

13.2.1 Buttons shape

The *MiMa* buttons have different shape depending on the buttons purpose. All rectangular buttons like in the *MiMa nine steps* are orientation buttons. These buttons guide the user through the dialysis treatment, nothing starts when the user press on an orientation button, only a new window will appear. The extra function buttons is formed like a square. The purpose of the function buttons is the same as the orientation buttons, nothing will start when the user press the button, only a new window will appear where the user can start the function. These extra function

buttons are a way of orientation buttons but it's not included to the *MiMa nine steps*, so to distinguish this extra function buttons they're formed as a square.

The *MiMa-alarm button, MiMa-mute button, MiMa-safety button and MiMa-confirm button* are shaped as a circle. These buttons is for safety, to make the dialysis treatment secure, *MiMa alarm and mute button* is to make sure that the patient doesn't end up in an emergency coincidence. *MiMa- safety button* is there to make the user feel safe in order to be able to always activate/inactive this functions. The *MiMa-confirm button* is there as an eye-opener for the user, to control if all steps are done, like a mental check box.

13.3 MiMa-nine steps

The *MiMa-nine steps* are the substratum of the concept and they're placed in the right side of the screen to not conceal the window with the arm, see Figure 13.5 and Figure 13.6. This thought is built on the fact that most people is right-handed.

Figure 13-5. Right-handed person conceal the screen.

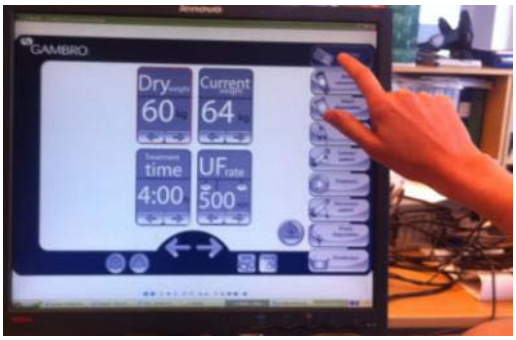

Figure 13-6. Right-handed person doesn't conceal the screen.

The buttons has a rectangular form with rounded corners to fit with both symbols and text, the rounded corners gives a smooth and attractive impression, and also a non-technical impression, which is one of the Master Thesis focus area, see Chapter 2.

The symbol in the button is placed in the left centreline and the text in the right is placed a little bit up from the centreline. The *MiMa* buttons have different forms depending on the buttons purpose. All rectangular buttons with rounded corners, i.e.

MiMa nine steps are orientation buttons, see Figure 13.7. These buttons orientate the user through the dialysis treatment, nothing starts when the user press on an orientation button, only a new window will appear.

13.3.1 MiMa-nine steps future button

The *MiMa-future button* views which step that haven't been done, see Figure 13.7. The *MiMa-future button* will in that way describe what the future will provide. The *MiMa-future button* is filled with *Gradient grey*, see Figure 13.7. This colour gives a calm and natural feeling to the user. The text are coloured in *Gambro blue* in size 14 pt. The symbol in the button is coloured with *Gradient symbol* and the lines are filled in *Gambro blue* with a thickness of 1 pt. The frame of the button is coloured in *Gradient Gambro blue*.

Figure 13-7. *MiMa-nine step future buttons.*

13.3.2 MiMa-nine steps now button

When the user has pressed on one button it switch colour to lighter blue and this is the *MiMa-now button*, see Figure 13.8. The *MiMa-now button* will in that way provide the feedback of where the user is in the interface right now. If the user drags its finger over the *MiMa-nine steps* the buttons will light up in this light blue colour but it's only when the user press on it the colour will stick to the button.

MiMa-now button is filled with *Gradient light blue*, this colour gives a lighten impression in comparison to *Gambro blue*. The text is coloured in *Gambro blue* in size 14 pt. The symbol in the button is filled with transparent colour and the lines are filled in *Gambro blue* with the thickness of 1 pt. The frame of the button is coloured in *Gradient Gambro blue*.

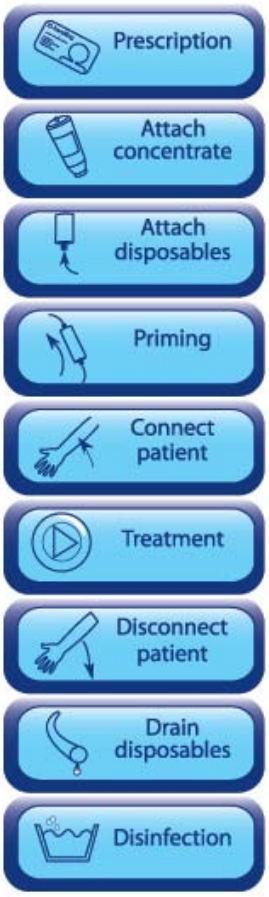

Figure 13-8. *MiMa-nine steps now buttons.*

13.3.3 MiMa-nine steps past button

If a task is done the *MiMa-active button* or the *MiMa-now button* switches to *MiMa-past button.* This is to get the feedback from the machine that the task has been made or to get the feedback that the machine has understood the tasks that the user has done manually.

MiMa-past button is filled with *Gambro blue*, see Figure 13.9. The *Gambro blue* colour melts together with the background and the button isn't in focus and looks like they're subscripted with this colour. The text is coloured in *Grey blue* in size 14 pt. The symbol in the button is filled with transparent colour and the lines are coloured in

Grey blue with a thickness of 1 pt. The frame of the button is coloured in *Gradient Gambro blue*.

Figure 13-9. *MiMa-nine steps past buttons.*

13.3.4 MiMa-nine steps active button

When the user activates a function in one of the *MiMa-nine steps* the button is turned to *MiMa-active button*. The *MiMa-active button* provides the feedback that the machine is currently working on something, for example to do *Priming.*

MiMa-active button is filled with *Gradient green*, see Figure 13.10. The green colour is chosen because it's a typical active colour and many of the test participants thought that the active button should be green. This indicates that green is an intuitive active colour for the participants. The colour is also in a good contrast according to the other colours in the *MiMa-concept*. The text is coloured in *Gambro blue* in size 14 pt. The symbol in the button is filled with transparent colour and the lines are filled in *Gambro blue* with the thickness of 1 pt. The frame of the button is coloured in *Gradient Gambro blue*.

Figure 13-10. *MiMa-nine steps active* buttons.

13.4 MiMa-back button

The *MiMa-back button* is used when a third level of the interface is used i.e. in treatment and in the help steps. With this button the user easily can find their way back to a higher level. *MiMa-back button* is filled with *Gradient grey* and the text are coloured in *Gambro blue* in size 12 pt, see Figure 13.11. The symbol in the button is filled with *Gradient grey* and the lines are filled in *Gambro blue* with the thickness of 1 pt. The frame of the button is coloured in *Gradient Gambro blue*. There is also a shadow in the upper part, to get a third dimension feeling of the button.

Figure 13-11. The *MiMa-back button*

13.5 MiMa-keypad

A *MiMa-keypad* is used if the dialysis machine has to get any information from the user that involves numbers, see Figure 13.12. *MiMa-keypad* is filled with *Gradient grey* and the text is coloured in *Gambro blue* in size 41 pt. The frame of each button is coloured in *Gradient Gambro blue* and the lines in the frame is coloured in *Gambro blue* with a thickness of 1 pt and 0,25 pt. The numbers are placed in the centre of every button, this according to graphics guidelines, that a centred number is more pleasant for the eye (24).

Figure 13-12. The *MiMa-keypad.*

13.6 MiMa-saftety button

The *MiMa-safety* buttons that will be visible are *UF*, *Bypass*, *Confirm*, *Blood pump*, *Alarm- and Mute* buttons, see Figure 13.13-13.27. These buttons are in *MiMa* to provide a safe treatment.

13.6.1 MiMa-confirm button

In almost every *MiMa-window* a *MiMa-confirm* button will be visible, see Figure 13.14. This button is aimed for the user to confirm that everything is done in the window they are in. There are three different types of confirm buttons.

- *MiMa-confirm* button, Non-press able, see Figure 13.13.
- *MiMa-confirm* button, Future, see Figure 13.14.
- *MiMa-confirm* buttons, Blue twinkle, see Figure 13.15.

The *MiMa-confirm* button non-press able it showing when the user hasn't finished the steps that the dialysis machine is able to register in the window that the confirm button is connected to. The *MiMa-confirm* button future is showing that it's possible to confirm the window the button is connected to. The *MiMa-confirm* button blue twinkle is just a twinkle the confirm button emit when pressing.
The future button is filled with *Gradient grey*, the non press able is *white* with no gradient or shades, this to express a non press able feeling, and the blue twinkle button is filled with *Gradient light blue*. The lines and the text are coloured in *Gambro blue*. The symbol is filled with *Gradient grey* in the future button and transparent in the other ones. The button has a shade in the top; this is for the future button and blue twinkle button.

Figure 13-13.*MiMa-confirm* button, non-press able.

Figure 13-14.*MiMa-confirm* button, future.

Figure 13-15.*MiMa-confirm* button, blue twinkle.

13.6.2 MiMa-UF button

The *MiMa-UF* button indicates if the ultrafiltration is running or not. If UF is active the *MiMa-UF* button active is showing, see Figure 13.16, and if not the *MiMa-UF* button inactive will be shown, see Figure 13.17. The active button is *Gradient green* and the inactive is *Gradient grey*. The text is coloured in *Gambro blue* with the size 28 pt. The button also has a shade in the top.

Figure 13-16. *MiMa-UF* button active.

Figure 13-17. *MiMa-UF* button inactive.

13.6.3 MiMa-Bypass button

The *MiMa-Bypass* button indicates if the *Bypass* function is running or not. If *Bypass* is active the *MiMa-Bypass* button active is showing, see Figure 13.18, and it's not the *MiMa-Bypass* button inactive will be shown, see Figure 13.19. The active button is

Gradient green and the inactive is *Gradient grey*. The text is coloured in *Gambro blue* with the size 14 pt. The button also has a shade in the top.

Figure 13-18. *MiMa-Bypass* button active.

Figure 13-19.*MiMa-UF* button inactive.

13.6.4 MiMa-Blood pump button

The *MiMa-Blood pump button* indicates if the blood pump function is running or not. If the blood pump is active the *MiMa-Blood pump button active* is showing, see Figure 13.20, and if not the *MiMa-Blood pumps button inactive* will be shown, see Figure 13.21. If the user isn't able to see the pump button at all time, the user seems to be unsure if they can't stop the treatment all the time, there's a request of a blood pump button that is visible during the whole process. This is solved with a tactile pump button on the side of the machine. The button's only purpose is emergency stop. The active button is *Gradient green* and the inactive is *Gradient grey*. The text are coloured in *Gambro blue* and with size 14 pt. The button also has a shade in the top.

Figure 13-20. *MiMa-Blood pump* button active.

Figure 13-21. *MiMa-Blood pumps* button inactive.

13.6.5 MiMa-alarm button

The *MiMa-alarm* button indicates if there's an active alarm or not. The alarms are divided in three categories; *Urgent alarm, Ordinary alarm and Attention alarm.*

- *Urgent alarm* is the highest priority and includes among other; air in the venous drip chamber.

- *Ordinary alarms* have the second priority.
- *Attention alarms* is not so important, the user usually just confirm that they have seen it.

These alarms lights up when an alarm appears. If there's more than one alarm, the alarm with highest priority will be shown and up lit in the alarm button. *Urgent alarm* first, *Ordinary alarm* second and *Attention* alarms last, see Figure 13.22-13.24. If there's an urgent alarm, the *MiMa-alarm button* is flashing red, if there's not an urgent alarm but both alarm and attention alarms, the alarm button will flash in orange, if only attention alarms exist, the alarm button will flash in yellow.

To separate the alarms, they have different colours and sounds. *Urgent alarm* is coloured *Gradient red*, *Ordinary alarm* is coloured *Gradient orange* and *Attention alarm* is coloured *Gradient yellow*, see Figure 13.24. The inactive alarm button is filled with *Gradient grey*, see Figure 13.25. The thicknesses of the lines in the symbols are 1 pt and the frame is coloured in *Gradient Gambro blue.* The colours are chosen to get the right feeling of how urgent the alarm is. Red is a natural colour for warning, and therefore is this placed on the most urgent alarm. Orange is also a colour for warning, but in combination with red is red seen as a more important alarm. The next colour after orange in the colour circle is yellow; this is why the *Attention alarm* has got the yellow tone. The symbols are coloured in *Gambro blue* which gives a good contrast to all colour; red, orange, yellow, grey and green. The button has also a shadow to express the press able feeling. The alarm symbols aren't that detailed like other symbols in the *MiMa concept.* These symbols are standard symbols for alarms according to ISO standard, and are required according to *Gambro*(23).

Figure 13-22. The *MiMa-urgent alarm* button.

Figure 13-23. The *MiMa-ordinary alarm* button.

Figure 13-24. The *MiMa-attention alarm* button.

Figure 13-25. The *MiMa-inactive alarm* button.

13.6.6 MiMa-mute button

The *MiMa-mute button* indicates if the alarm is muted or not. The *MiMa-mute button, active* is shown if there is an alarm, see Figure 13.26. If there's a sound the button flashes and if the user presses on the *MiMa-mute* button, active the sound is muted for a couple of minutes and the button is active but not flashing. If there's no alarm the *MiMa-mute* button, inactive is shown, see Figure 13.27.

The active button is *Gradient green* and the inactive is *Gradient grey*. The line is coloured in *Gambro blue* with a thickness of 1 pt. The frame is coloured in *Gradient Gambro blue* and the button also has a shade in the top.

Figure 13-26. The *MiMa-mute* button, active.

Figure 13-27. The *MiMa-mute* button, inactive.

13.7 MiMa-extra function

The extra functions that the user needs to have a pleasant dialysis will be placed in the bottom of the *MiMa-frame*, see Figure 13.1. If the user presses one of these functions a new window will appear with *MiMa-guide boxes* to guide the user through the extra functions. If the user needs extra help they just press on one of the guide boxes like in previous steps and a help window will appear. These extra functions can be in three different states*; Future, Now* and *Active,* see Figure 13.28-13.30. If the *MiMa-extra function, Future is* shown the button is press able and if the user presses this button a menu containing the important parameters of the function is showing. If the user has presses on the button it switches into the *MiMa-extra functions, Now* and if the function is activated the *MiMa-extra functions, Active* is the one showing. The extra functions should be eligible but *clean touch screen* and *blood pressure meter* are mandatory.

The *MiMa-future button* is filled with *Gradient grey* and the symbol is filled with *Symbol gradient.* The *MiMa-now button* is filled with *Gradient light blue* and the

symbol is coloured in transparent. The *MiMa-active button* is filled with *Gradient green* and the symbol is coloured in transparent. The symbol lines and the text in all buttons are coloured in *Gambro blue* with size 12 pt respective thickness 1 pt. The frames in the buttons are filled with *Gradient Gambro blue.*

Figure 13-28.*MiMa-extra functions*, Future.

Figure 13-29. *MiMa-extra functions*, Now.

Figure 13-30. *MiMa-extra functions*, Active.

13.7.1 Blood pressure monitor

The extra function *Blood pressure monitor is* placed as an extra function due to that the user always should be able to take the blood pressure see Figure 13.28. Blood pressure meter, *BMP*, have a symbol that resemble with a heart and a pressure meter.

13.7.2 Diascan

The extra function *Diascan*, see Figure 13.31, is placed as an extra function due to that the user always should be able to start the *Diascan*. The *Diascan* can be started at any time during the treatment. The user can also save data in this *Diascan* function.

Figure 13-31. The *MiMa-Diascan* button.

13.7.3 Clean touch screen

The extra function *clean touch screen*, see Figure 13.32, is placed as an extra function due to that the user always should be able to clean the touch screen if they get for example blood dash on it.

Figure 13-32. The *MiMa-Clean* touch screen button.

13.8 MiMa-display

MiMa concept has two kinds of displays; *MiMa-display, set parameters* and *MiMa-display, real-time parameters.*

13.8.1 MiMa-display, Set parameters

The *MiMa-display set parameters* is a showing area in the window see Figure 13.33. Here set parameters are showed. The background in *MiMa-display* and the frame of the screen are filled with *Gambro gradient*, the area behind the numbers is filled with *Grey blue*. Text and letters are coloured in *Gambro blue* with size 41 pt and 48 pt. The performers wanted to design the display to look non press able and a feeling that here is just something shown.

Figure 13-33. The *MiMa-display*, showing.

13.8.2 MiMa-dislplay, Real-time parameters

The *MiMa-display real-time parameters* is a showing area in the window to show, see Figure 13.34. Here real-time parameters are showed with the limits provided as well. The background in the *MiMa-display* and the frame of the screen are filled with *Gambro gradient*, the area behind the text is filled with *Grey blue*. The name of the box and the showing value is filled with white. The values have also a *Grey blue* border to express that the numbers changes over time. The limits and units are coloured in *Gambro blue*. The important parameters are white.

Figure 13-34. The *MiMa-display, real-time parameters.*

13.9 MiMa-guide box

In the *MiMa window* five different guide-boxes can be visible; *Set parameters, Information, Choice, Waiting line and BIB,* see Figure 13.35-13.42. These boxes are

there to guide the user through the whole dialysis process. If the user press on a *MiMa-guide box*, the box will be lid up in blue and a help window will appear with *MiMa-help boxes* available. The boxes have a rectangular form to give the illustration and text a good disposition, and also to make sure that all boxes will fit in the window and still give a good esthetical impression. The guide boxes have a background filled with *Gradient grey*. The numbers are coloured in white colour with opacity and the text is coloured in *Gambro blue*. The number is therefore the guiding through the work flow. The user shall start on number one and ends on the last number.

13.9.1 MiMa-guide box, Set parameters

The *MiMa-guide box, set parameters* contains information of the set parameter for this step, see Figure 13.35. If the user wants to change this parameter they just press on the box and the user will enter a third level of the interface where the parameters that the user can adjust will be shown. The symbols in these boxes are coloured in *Grey blue* with lines in *Dark grey blue*. The display is filled with *Gradient grey* with a frame coloured with *Gradient Gambro blue*. The letters are filled with *Gambro blue* because it's a set value. The *MiMa-guidance boxes* have *MiMa-help boxes* connected to them, the boxes are press-able and this is why they have a gradient and a frame that increases the three dimensional feeling.

Figure 13-35. *MiMa-guide* box, *Set parameters.*

13.9.2 MiMa-guide box, Information

The *MiMa-guide box, information* shows information on what to do in order to follow the pre-set way of a dialysis treatment, see Figure 13.36. The symbols in these boxes are coloured in *Gradient grey* or sometimes in *Gambro blue*, and have lines in *Gambro blue*.

Figure 13-36.*MiMa-guide* box, *Information.*

13.9.3 MiMa-guide box, Choice

The *MiMa-guide* box, *choice* is a box used when there are different ways to choose in order to go further in the treatment, see Figure 13.37. This can for example be in treatment where the user either can enter blood values or dialysis fluid to see the different parameters.

The symbols in these boxes are coloured in *Gradient grey* with lines in *Gambro blue*. Some of the figures have an added opacity in the colour.

Figure 13-37.*MiMa-guide* box, *Choice*

13.9.4 MiMa-guide box, Waiting line

The *MiMa-guide* box, *waiting line* is a guide-box where the interface gives the feedback that the dialysis machine is doing a process of some kind. If the waiting line is inactive the process hasn't started, see Figure 13.38, and if the waiting line is active the process is done, see Figure 13.39. In between these two states the process is ongoing.

The waiting line is coloured in *Gradient Gambro blue* and in *Gradient green* for the active one. The waiting line is formed as a rectangle with rounded corners. The line gives a simple feedback to the user when the machine is processing.

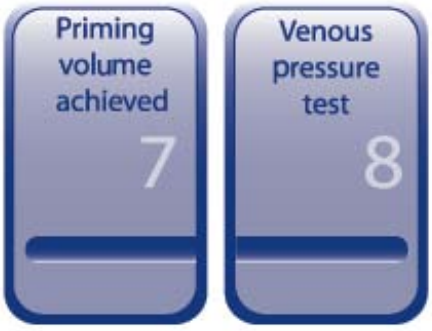

Figure 13-38. *MiMa-guide* box, waiting line inactive.

Figure 13-39. *MiMa-guide* box, waiting line active.

13.9.5 MiMa-guide box, BIB

The *MiMa-guide box, BIB* is a guide-box which contains a *BIB, button in button*. This *BIB* can be in three different states; active, inactive and non-press able see Figure 13.40-13.42. If the *BIB* is non-press able it means that the steps that have to be done before this step hasn't been register by the dialysis machine. The feedback the dialysis machine gives to the user is therefore that they shouldn't be able to go further in the dialysis until the previous step is done. If the *BIB* is inactive the machine gives the feedback to the user that the button is press able and as far as the machine can register that this should be the next step in the process. If the *BIB* is active it means that the machine has registered that the user has pressed on the *BIB* and is now processing the step.

The active button is filled with *Gradient green*, the inactive ones is filled with *Gradient grey* and the non-press able ones have a transparent colour with no gradients and shades, this buttons will express a non-press able feeling. The frames is filled with *Gradient Gambro blue* except for the non-press able button, this is coloured in transparent with lines in *Gambro blue*.

Figure 13-40. *MiMa-guide* box, BIB active.

Figure 13-41. *MiMa-guide* box, BIB inactive.

Figure 13-42. *MiMa-guide* box, non-press able.

13.10 MiMa-adjustment box

The *MiMa-adjustment box* has a purpose to register different parameter settings. There are four types of adjustment-boxes; *One parameter to adjust, Limits to adjust, All parameters to adjust* and *Alarm. MiMa adjustment boxes* don't have a window connected and the user can't press these boxes, to give the box a non-press able feeling there isn't any gradients. The box is filled with *Grey blue* and has lines in *Dark grey blue*. The frame of the display is coloured in *Gradient Gambro blue* and the display is filled with *Gradient grey blue*. The adjustable value and the name of the box are filled with *White* and the values also have lines in *Grey blue.* The value is

adjustable with the arrows, this buttons is filled with *Gradient grey* and has a frame filled with *Gradient Gambro* blue. The symbols is coloured in *Gradient-grey* and has lines in *Gambro blue*. The arrow buttons is created to express an extruded feeling, unlike from the display which wants to give a chiselled out feeling.

13.10.1 MiMa-adjustment box, one parameter to adjust

The adjustment-box with one parameter to adjust, see Figure 13.43, has the value to adjust in a display and actives arrow buttons to change the parameter with. The value in the *MiMa-adjustment* box with one parameter to adjust is shown in a big size to be easy to read, filled with *White* because it's an adjustable value. In these boxes are both limits and parameter adjustable and the arrow buttons are designed with a press-able feeling. The buttons are coloured in *Gradient grey* with a frame in *Gradient Gambro blue* the symbols are filled with *Gradient grey* and *Gambro blue* lines.

Figure 13-43. *MiMa-adjustment* box, one parameter to adjust.

13.10.2 MiMa-adjustment box, limits to adjust

The adjustment-box with limits to adjust, see Figure 13-44, have from the beginning the real-time value in the display and if the user press on one of the limits this value will turn up in the display and the non-press able button will turn to press able arrow button.

These boxes have a clear graphical view of the limits. The marked value is shown in a big size to be easy to read, filled with *Gambro blue* for non-adjustable and *White* for adjustable. In these boxes are only the limits adjustable and not the parameter and the arrow buttons designed with a non press-able feeling. The buttons are coloured in transparent with lines in *Dark grey blue*. The ovals with number in are filled with *Gradient grey* and the numbers in *Gambro blue*.

Figure 13-44. *MiMa-adjustment* box, limits to adjust.

13.10.3 MiMa-adjustment box, all parameters to adjust

The adjustment-box with all parameters to adjust, see Figure 13.45, have all parameters adjustable and the user can just press on any parameter they like and adjust it with the adjustment arrows. If an alarm occurs and this alarm could be connected to an adjustment problem an adjustment-box will turn up with the problem hedge in the colour that the current alarm has.

Figure 13-45. *MiMa-adjustment* box, all parameters to adjust.

13.10.4 MiMa-adjustment box, alarm

The *MiMa-adjustment* box with alarm has the same graphic profile like the other adjustment boxes; the small difference is the orange line, see Figure 13-46. This line is there to enhance where the limits is exceeded when an alarm appears. This line can have different colours depending on the alarm. The colours can be; *Red*, *Orange* and *Yellow*. The *MiMa-adjustment* box with alarm can have the same function as the previous adjustment boxes.

Figure 13-46. *MiMa-adjustment* box, Alarm.

13.11 MiMa-help box

MiMa-help boxes are created to help the user, see Figure 13.47. If the user press a *MiMa-guidance* box a new window will appear with further information, for example about where to place the dialyzer or how the colour coding works for the dialyzer. In these boxes adjustment parameters can also be changed, for example a change of concentrate or which parameters that will be saved in the step *Disconnect patient.* All help-boxes will be entered through a press on the *MiMa-guide* box.

The *MiMa-help* boxes have other colours to be separate from the other boxes. The user shall be clear of when a help window is viewed. The boxes are *BiCart®* filled with W*hite* and have a border in *Gambro blue*. The text is coloured in *Gambro blue* and the number is in *Grey blue*. The illustrations have the colours; *Gradient blue, Gambro blue* and *Gradient grey*. The most important in these illustrations is that the focus area is filled with *Gradient blue*.

Figure 13-47. The *MiMa-help* box.

13.12 MiMa-alarm frame

When an alarm occurs an alarm window will appear, see Figure 13.48. A frame will appear around the alarm information. This frame has different colour according to the importance of the alarm. The tag on the top of the frame indicates that there are different alarms on queue. The most urgent one is always lying on top of the others so that the user knows which order to solve the problems. The *MiMa-alarm* frame is

filled with *White* and the borders are coloured in *Red. Orange* or *Yellow* depending on the alarm status. The tabs are filled with *Gradient red*, *Gradient orange* or *Gradient yellow* also depending on alarm status. The symbols in the tabs are coloured in transparent and has lines in *Gambro blue*. The alarm frames are filled with different colours in order to be easy to read for the user. The symbol lines are filled with *Gambro blue* because this colour was giving the best contrast.

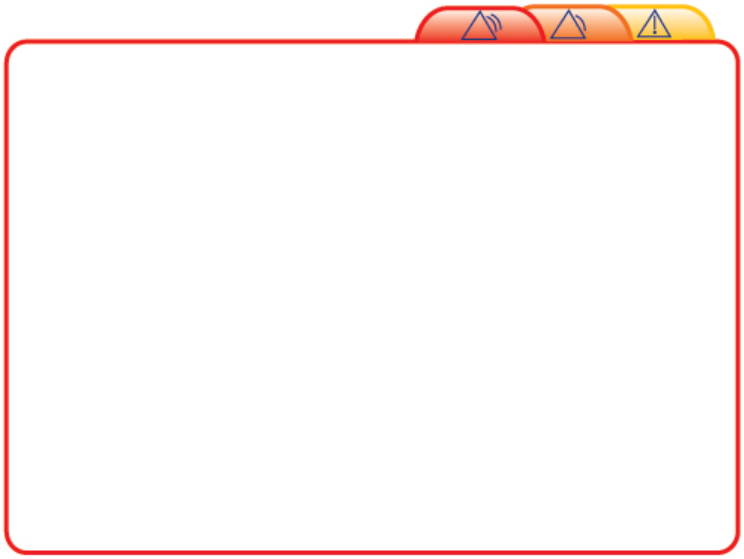

Figure 13-48. The *MiMa-alarm* frame.

14 MiMa flow

The dialysis process is divided into the MiMa-nine steps and informs the user where the user is right now, what the user has done and what the user need to do before the dialysis process is finished. Below every step follows a guidance in what the user is suppose to do and functions that need to be activated in order to go further on in the dialysis process. The dialysis treatment starts with Prescription and ends with Disinfection. Below follows a description of each step.

14.1 Prescription

Prescription is the first step the user meet. In prescription the user will meet two different windows, see Figure 14.1 and Figure 14.2. In the first one the user will enter the patient's personal identity number, a function the new *AK 96*^{TM} hopefully will be able to provide. In this ID number a variety of settings shall be able to be saved. This concerns parameters like *Current weight, Dry weight, Treatment time* and *Blood flow*. To be able to set personal identity number a *MiMa-keypad* will appear by pressing the display of the number, see Figure 14.1. When the user confirms the ID number a new window will appear.

Values such as *Dry weight*, *Current weight, treatment time* and *UF-rate* can be changed by pressing the arrows in the *MiMa-adjustment* box to a higher or lower value, see Figure 14.2. If the values are locked by for example a doctor, they will be displayed in a *MiMa* box instead with no possibilities for change. There can maybe be a password blocking and if it's an emergency this will be able to open up the interface.

Since there were problems with the old *AK 96*^{TM} interface with the feedback from the machine, if the value was changed or not, the *MiMa concept* have the *MiMa-confirm* button. If you press the *MiMa-confirm* button the values will be confirmed to the machine.

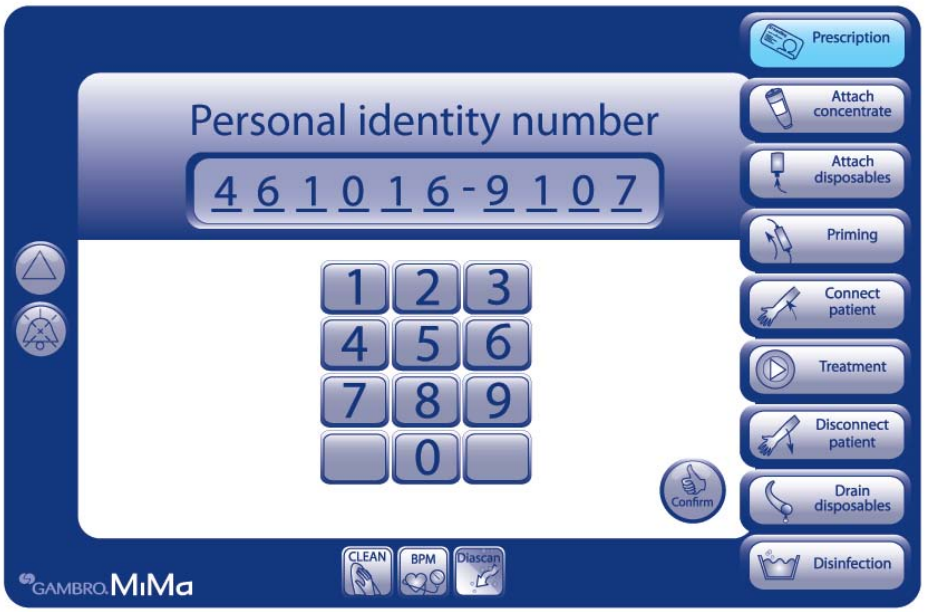

Figure 14-1. The first *MiMa-prescription* window.

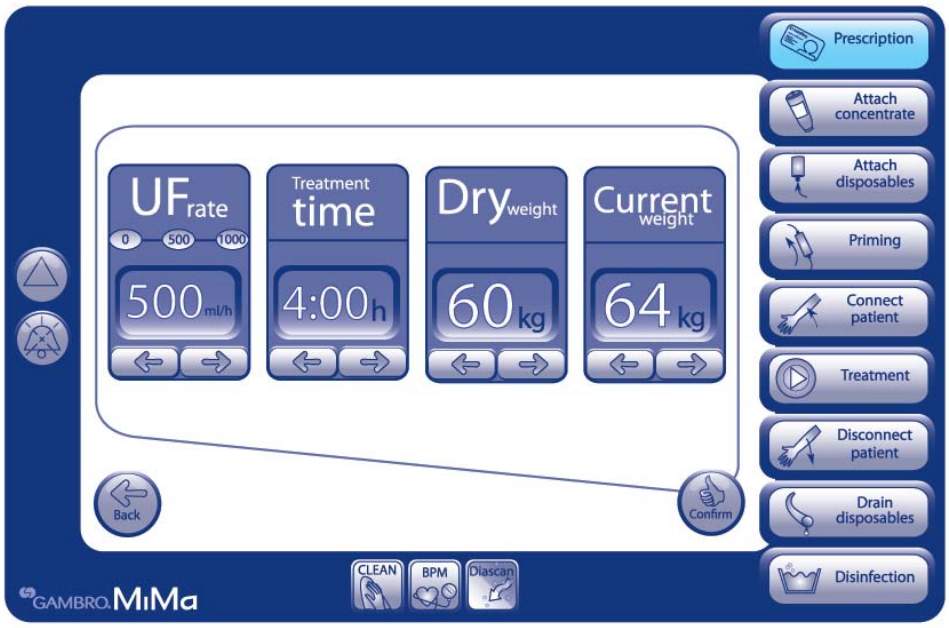

Figure 14-2. The second *MiMa-prescription* window.

14.2 Attach concentrate

In the step *Attach concentrate* the user will be guided to place for example the A-concentrate and the *BiCart*® if that is what they normally use. If they for example use acetate instead of A-concentrate this will be displayed, this to meet the customer

need. Which concentrate that is in use will be displayed in the *MiMa-guidance* box show, see Figure 14.3. If the user has any problem to find where to place the concentrate or how to do it, the user can press on the *MiMa guidance* box and get help from the *MiMa-help* box, there can for example the concentrate be changed.

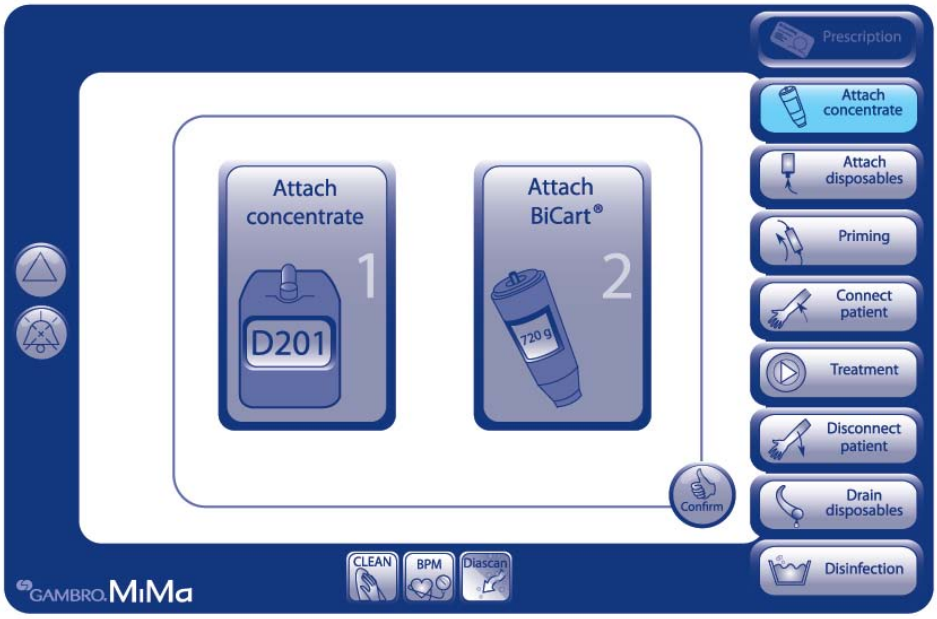

Figure 14-3. The *MiMa-attach concentrate* window.

14.3 Attach disposables

In the step *Attach disposables* the user will be guided to attach the disposables, these steps are; *Attach the dialyser, Attach the arterial line, Attach heparin syringe, Attach venous line, Connect the fluid tubes* and an exhortation to *Turn the dialyser*, see Figure 14.4. The same thing as in previous step is that if the user needs any help it's only to press the specific box they need help with and a help window will appear. In *MiMa-guide* box number 3, *Attach heparin syringe*, the heparin dose can be changed with a press on the box. A help window will appear with an opportunity to change the heparin dose. To confirm that all the *MiMa-guide* boxes are done the user has to press the *MiMa-confirm* button.

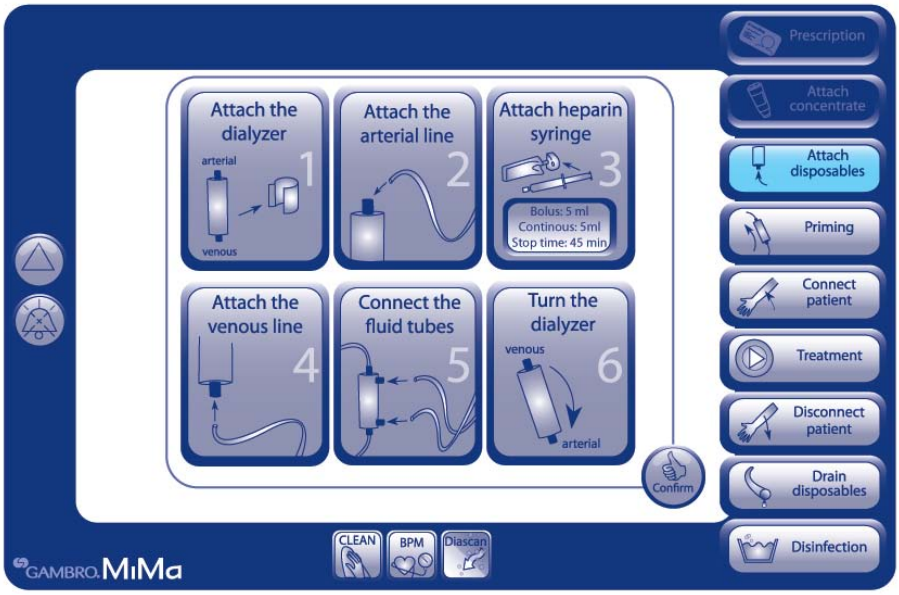

Figure 14-4. The *MiMa-attach disposables* window.

14.4 Priming

In the step *Priming* the user will be guided to proceed a priming, the steps are; *Start priming the blood circuit, Deairate the blood circuit,Rraise the drip chamber, Activate the air detector,Tturn the dialyser, Start priming the blood circuit,Priming volume achieved, Venous pressure test, Turn the dialyser* and *Connect the infusion line*, see Figure 14.5. The same thing as in previous step is that if the user needs any help it's only to press the specific box they need help with and a help window will appear. To start the *Blood circuit*, activate the *Air detector* or start *Priming the fluid circuit* the user shall press the symbol in the box, this is a so called *MiMa-button in button*, *MiMa-BIB*. By pressing *MiMa-BIB* the task will be activated and switch colour to green, to inactivate the user just have to press on it again, compare Figure 14.5 and Figure 14.6.

The *BIB-buttons* i.e. *Air detector* and *Bypass*, are non-press able until the machine has register that the *Blood pump button* has been pressed, see Figure 14.5. When the blood pump is active the *Air detector* becomes a future-button but the bypass-button is still inactive as well as the confirm-button. When the user presses the *Air detector* button the *Bypass* button becomes a *Future* button. When the *Bypass* button get pressed it turns to an *Active-button* and the *Waiting line* starts to fill up, see Figure 14.7. When the *Waiting line* is filled the *MiMa-confirm* button becomes press able, see Figure 14.8.

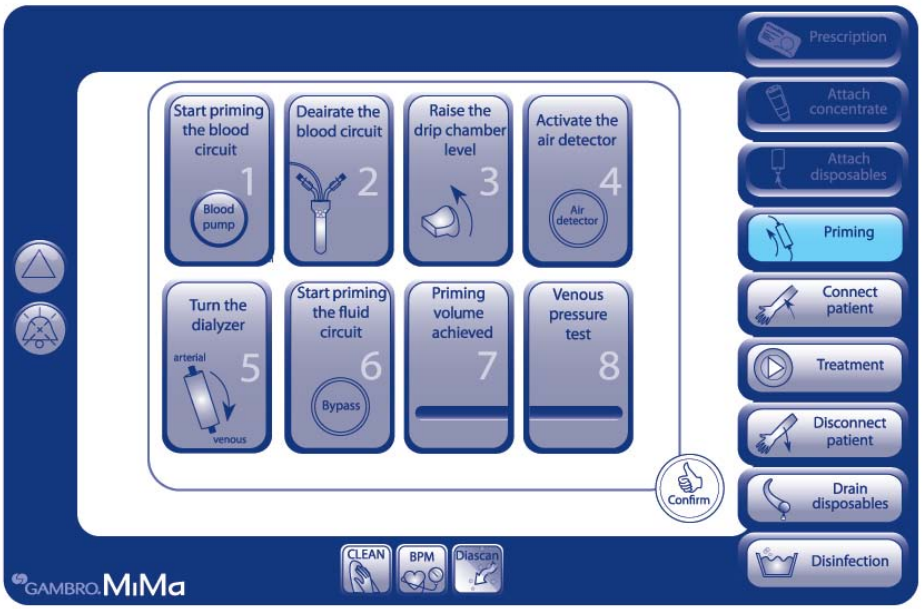

Figure 14-5. The *MiMa-priming* window when no button has been pressed.

Figure 14-6. The *MiMa-priming* window when blood pump button has been pressed, the *Air detector* button is now press able.

Figure 14-7. The *MiMa-priming* window when B*lood pump- ,Air detector- and Bypass* button has been pressed. Now the *MiMa-waiting line* has started.

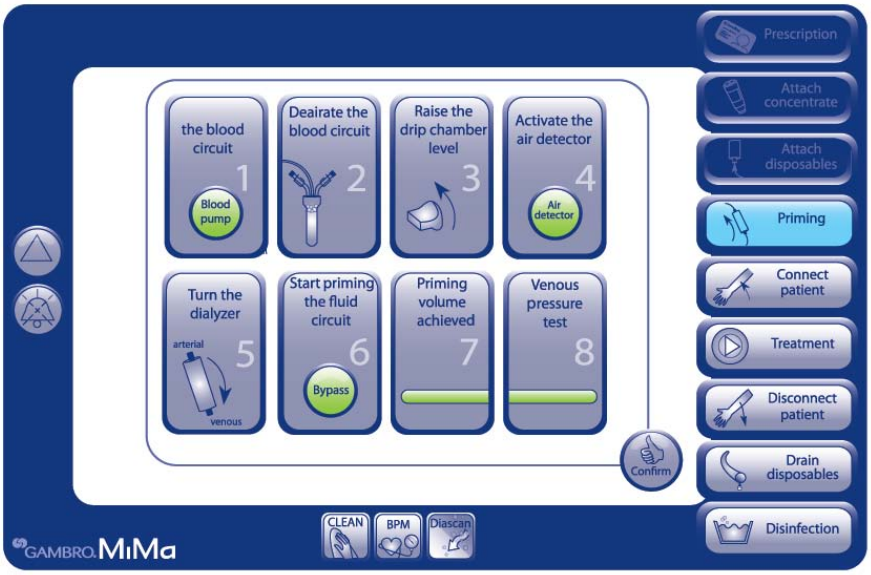

Figure 14-8. The *MiMa-priming* window when the waiting line is filled.

14.5 Connect patient

In the step *Connect patient* the user will be guided to connect the patient, the steps are; *Puncture the needles, Close the clamp on the saline bag, Connect the arterial line, Open the clamp on the arterial line, Start the blood pump, Blood volume achieved, Close the clamp from the waste bag and disconnect, Connect the venous*

line, Open the clamp on the venous needle line, and *Start treatment*, see Figure 14.9. The same thing as in previous step is that if the user needs any help it's only to press the specific box they need help with and a help window will appear. To *Start blood pump* and *Start treatment* the user shall press on the symbol in the box, the *MiMa-BIB*. By pressing *MiMa-BIB* the task will be activated and the button switches to a green colour, to inactivate the user just have to press on it again.

When the user first enters the *MiMa-connect patient* window the only press able *BIB* is the *Blood pump* button in guide 5, see Figure 14.9. When the user presses this button the blood pump starts and the waiting line in guide 6 starts to fill up, see Figure 14.10. When the waiting line is filled up the *BIB* in guide 5 will be non-press able and the *BIB* in guide 10 gets press able, see Figure 14.11. Finally when the *BIB* in guide 10 gets pressed the *MiMa-confirm* button gets press able, see Figure 14.12.

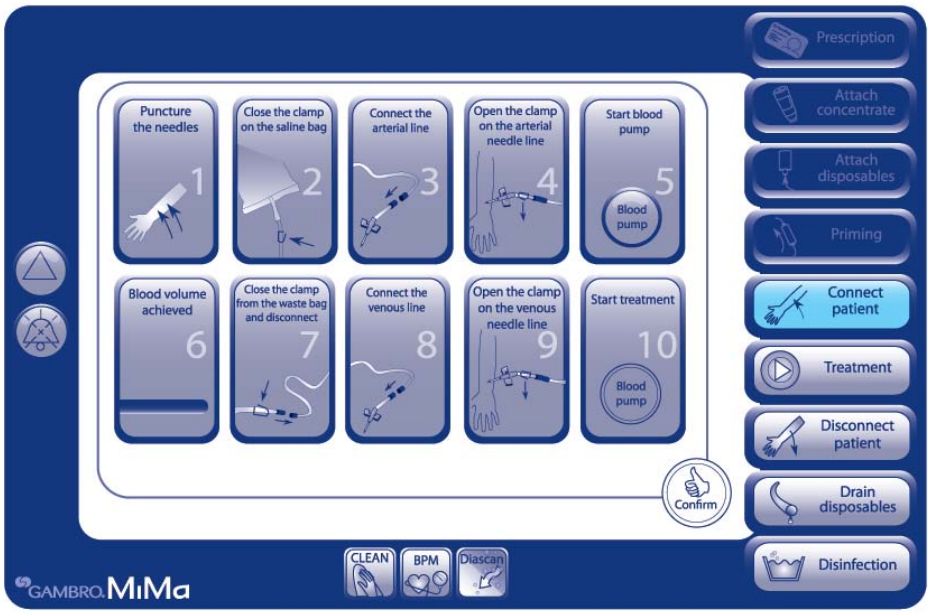

Figure 14-9. The *MiMa-connect patient* window when first entered.

Figure 14-10. The *MiMa-connect patient* window when the *BIB* blood pump is pressed in guide 5.

Figure 14-11. The *MiMa-connect patient* window when waiting line is filled up.

Figure 14-12. The *MiMa-connect patient* window when blood pump is pressed in guide 10.

14.6 Treatment

In the *Treatment* step the user will have an overview of the treatment and the user will have control over different parameters for example; *Time, Blood flow, Venous pressure, Arterial pressure* and *Ultrafiltration rate.* These values will be displayed in the treatment display in the top of the treatment window, see Figure 14.13. Since the system is built on individuality these values could be changed after what fit the user best, for example could *UF rate* be change to *UF volume* if this feels more suitable.If the user presses in the *MiMa-display* they will automatically go to the *MiMa-adjustment* box that is connected to the value. To go back to the previous window the user just has to press the *MiMa-back* button.

On the left side of the treatment window the user will find the *MiMa-safety* buttons which includes; *UF*, *Bypass* and start *Blood pump*. These buttons will have the same place during the whole treatment. If one of these buttons is activated the button has the green colour, the inactive buttons has the grey colour. To be able to set other parameters during treatment the user can chose between two options; *Blood values* and *Dialysis fluid.* If the user press on the *Blood value button* and example of that window could consist; *Arterial pressure, Venous pressure* and *Blood flow*, see Figure 14.14. If the user instead press *Dialysis fluid* the parameters in this window contains; *Ultra filtration, Temperature, Trans membrane pressure, Ultrafiltration, Dialysis fluid flow* and *Conductivity*, see Figure 14.15. To get back to the main treatment page the user have to press the *MiMa-back button.*To confirm that the values in the adjustment boxes are changed the user have to press *MiMa-confirm* button.

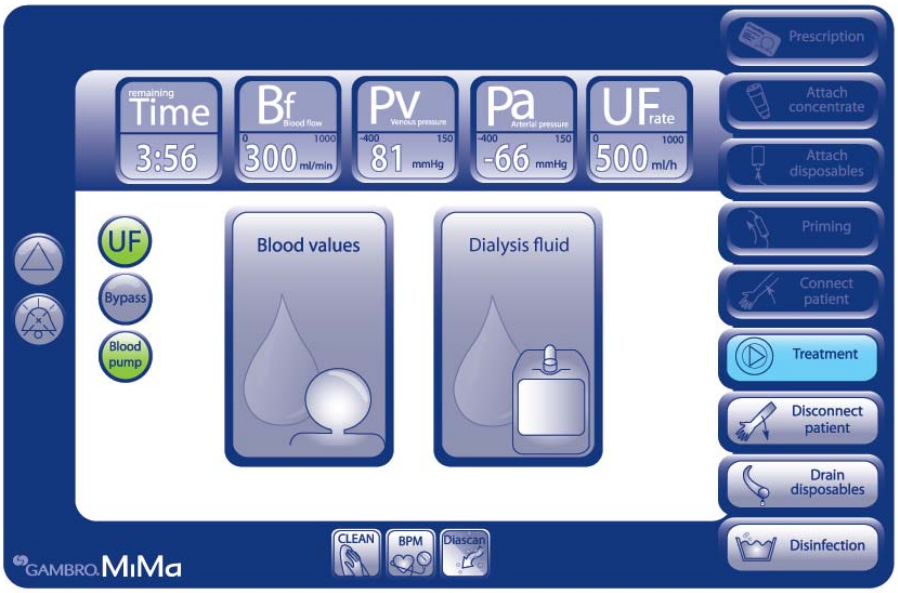

Figure 14-13. The *MiMa-treatment* window.

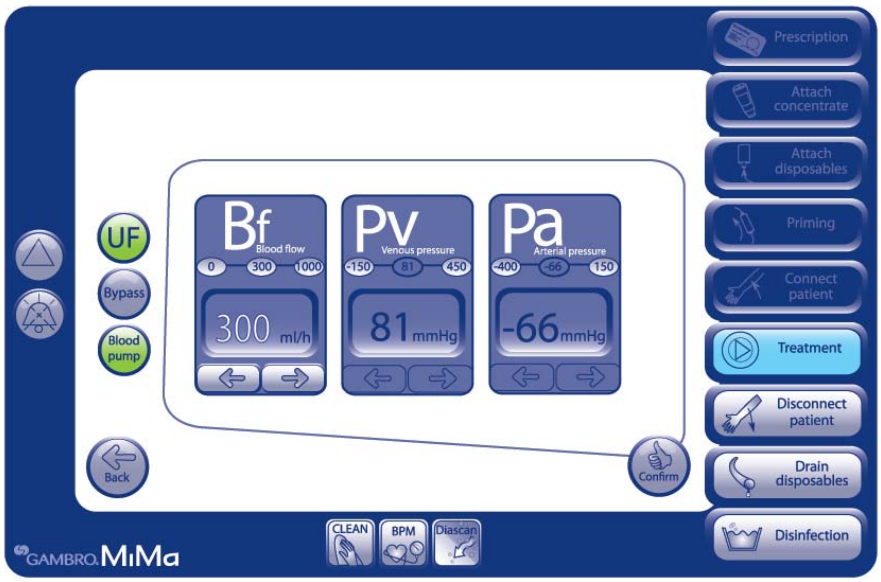

Figure 14-14. The *MiMa-blood values* window.

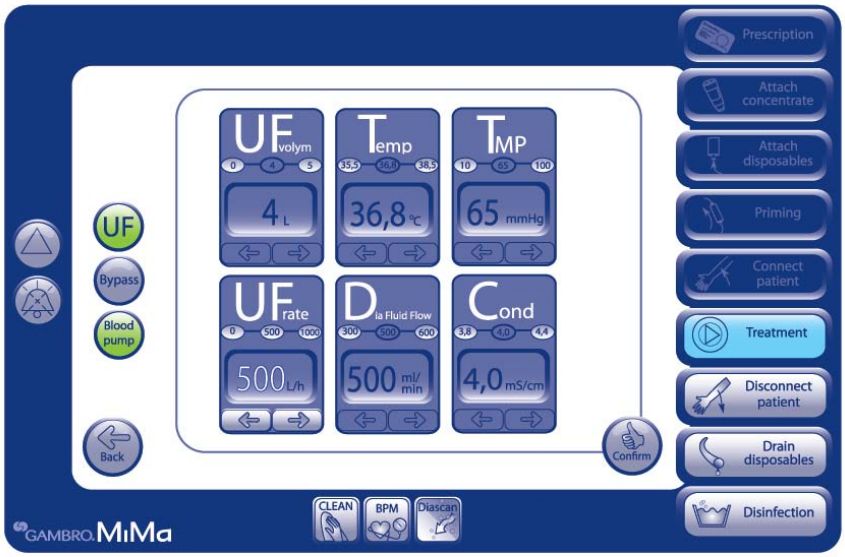

Figure 14-15. The *MiMa-dialysis fluid* window.

14.7 Disconnect patient

When the treatment is about to finish, the *Disconnect patient* window appears. In the step *Disconnect patient* the user will be guided to disconnect the patient, this would for example be; *Save parameters*, *Stop the treatment*, *Disconnect the arterial line*, *Rinse back*, *Disconnect the venous line* and *Remove the needles*, see Figure 14.16. The same thing as in previous step is that if the user need any help it's only to press the specific box they need help with and a help window will appear. If the user presses the *MiMa-BIB* in the box; *Save parameters*, the parameters are saved on a USB-stick or similar, depending on how *Gambro* wants to save patient information. The important thing is that patient parameters can be saved and be connected to the patient and not how it will be saved. To start the *Blood pump* and *Rinse back* the user shall press the symbol in the box, the *MiMa-BIB*. By pressing *MiMa-BIB* the task will be activated, and to inactivate the user just have to press on it again.

When the user first enters the *MiMa-disconnect patient* window the *BIB* in guide 1 and 2 will both be press able. The user can immediately stop the treatment before saving the parameters if necessary. The safety *BIB* is also available. When the user has stopped the treatment this button will be non-press able and the blood pump *BIB* in guide 4 will be press able. When the user has pressed this button the confirm button also will be press able so that the user can confirm that the steps has been done correctly, compare Figure 14.17 and Figure 14.18.

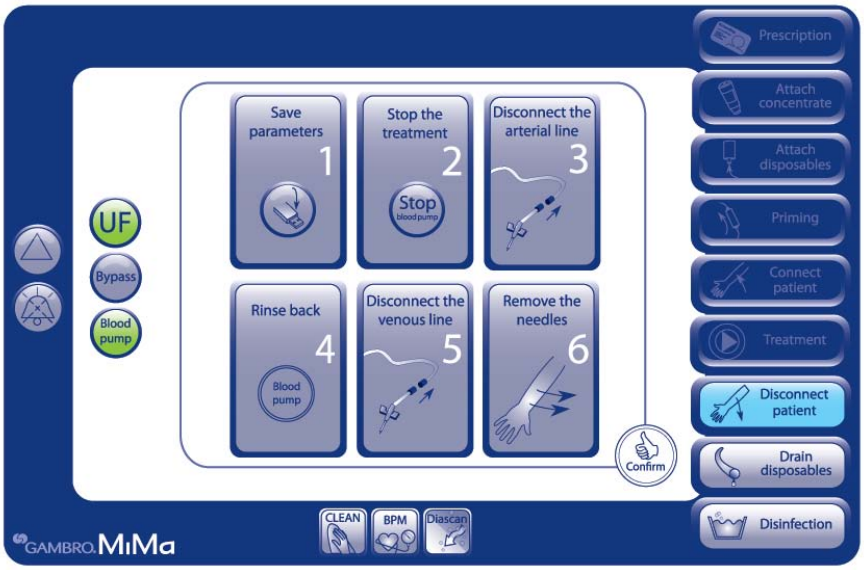

Figure 14-16. The *MiMa-disconnect patient* window when no *BIB* is pressed.

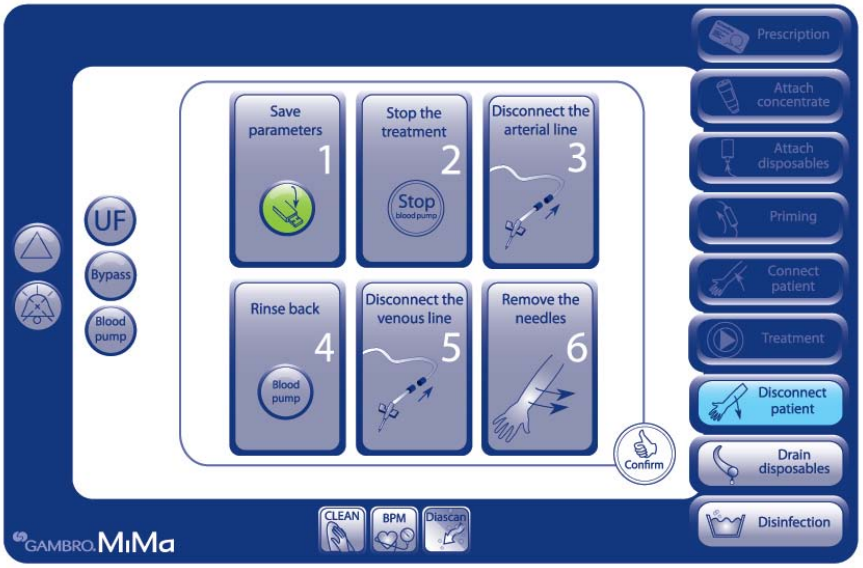

Figure 14-17. The *MiMa- disconnect patient* window when the *BIB* in guide 1 and 2 are pressed.

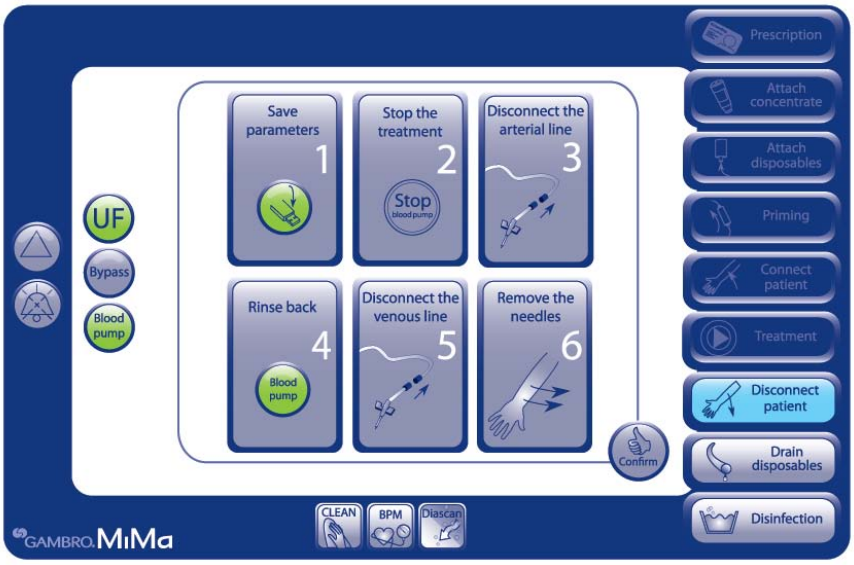

Figure 14-18. The *MiMa- disconnect patient* window when the *BIB* in guide 1,2 and 3 are pressed.

14.8 Drain disposables

When the patient is disconnected the disposables needs to be drained and put in the rubbish can. In the step *Drain disposables* the user will be guided how to drain the disposables this would for example be; *Drain blood circuit, Drain dialysis fluid circuit, Drain Bicart*® and *Discard disposables*, see Figure 14.19.

The same thing as in previous step is that if the user needs any help it's only to press the specific box they need help with and a help window will appear. To confirm that the guide boxes are done the user has to press *MiMa-confirm* button. In the future the hope is that the machine can confirm the boxes as well.

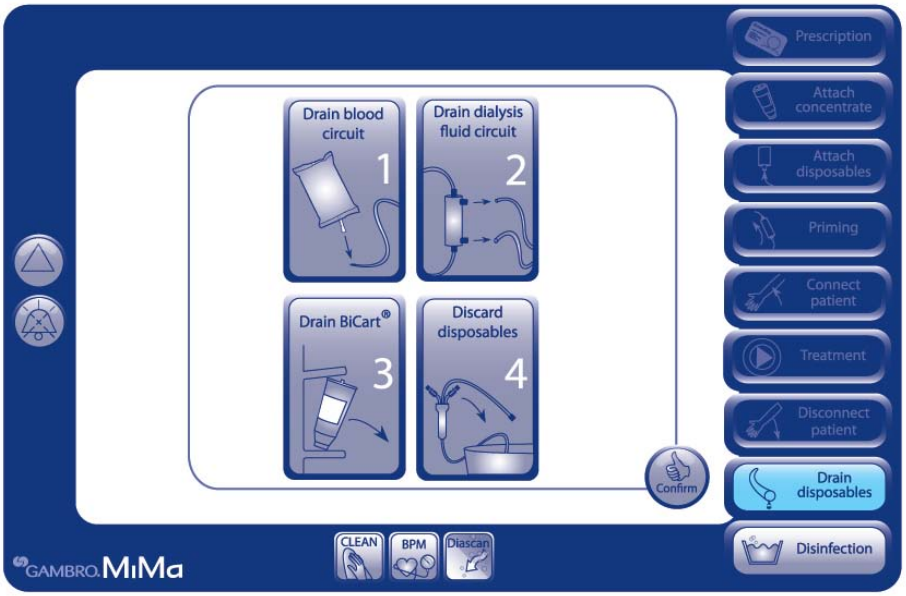

Figure 14-19. The *Drain disposables* window.

14.9 Disinfection

The last thing to do is to clean the fluid unit lines, here the user can for example choose between; *CleanCart®, Heat disinfection* and *Chemical disinfection,* see Figure 14.20. These boxes are different menus, just like during treatment. If the users enter a menu they can choose different settings and start the disinfection. If a user always has the same disinfection method the menu of this method will be shown directly in the *Disinfection* step.

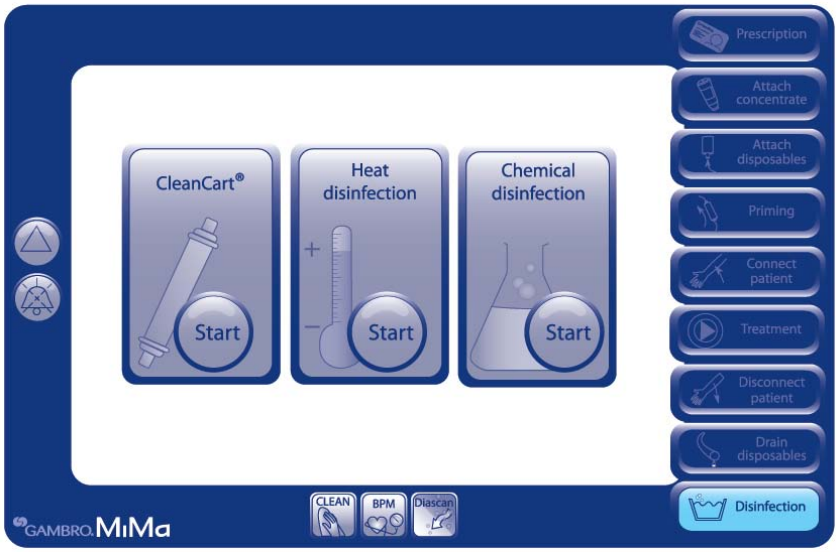

Figure 14-20. The *MiMa-disinfection* window.

14.10 Help

If the user press on *MiMa guidance* box a *MiMa-help window* will appear. In Figure 14.21 is an example of a help window for *BiCart®*. A help window is connected to every *MiMa-guidance* box and this is consistent through the whole interface. In the help window the user can find information about the specific step and in some help windows the settings are included, for example in the *Attach concentrate* button, in this help window is it possible to change the concentrate. This buttons isn't press able, this is why they don't have any gradients or shades, in this window is only information viewed. The press able button is the *MiMa-back* button, which the user needs to press in order to go back to the main window.

Figure 14-21. The *Help* window.

14.11 Alarm

If an alarm starts a *MiMa-alarm* window will appear, see Figure 14.22. In this window the user can see the reason of the alarm and how to fix it. The alarms are divided in three categories; *Urgent alarm, Ordinary alarm and Attention alarm*, see MiMa-alarm button.

In the *MiMa-alarm* window is information viewed about which kind of alarm that has occurred, information if something is inactive or active, for example if *Bypass* is active, and information about possible action to solve the alarm. This action is viewed in boxes, see Figure 14.22. The idea is that alarms shall be solved in the alarm window, the user doesn't need to go somewhere else in the interface. For the safety the *MiMa-nine steps* aren't closed, it's possible for the user to go to other places if

they want. When an alarm is solved the alarm frame will disappear automatically and the user can handle the next alarm if there's any in the line.

When there isn't any active alarm, an alarm history will appear if the user presses the inactive *MiMa-alarm* button. This alarm history will include; time, name of the alarm, category with colour-code and a function that will save the alarm history in a memory.

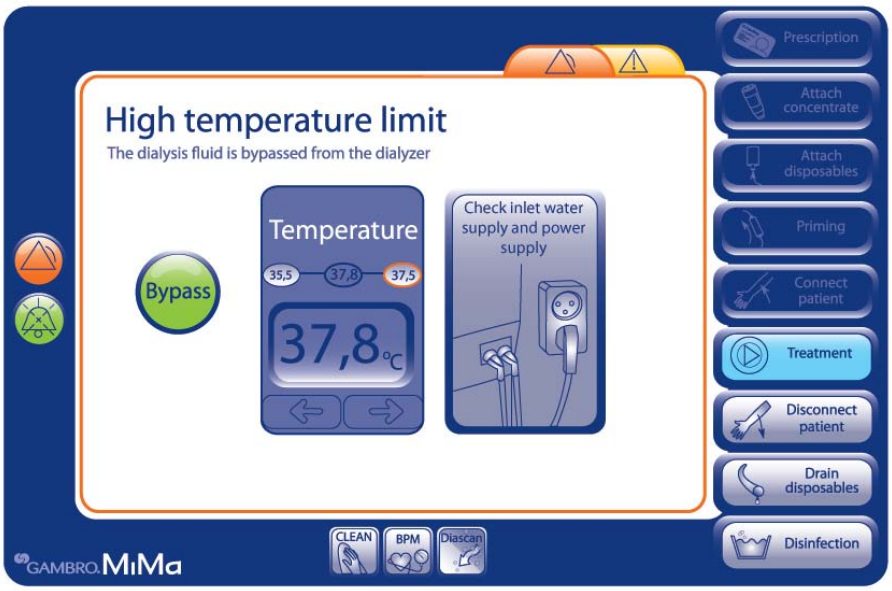

Figure 14-22. The *MiMa-alarm* window.

14.12 Variation of MiMa

If the user has activated something in one step and then press on then go to another step, the active step is coloured in *Gradient green*, and the pressed step is coloured in *Gradient blue*, this due to that the user always should know when they have activated a process, see Figure 14.23.

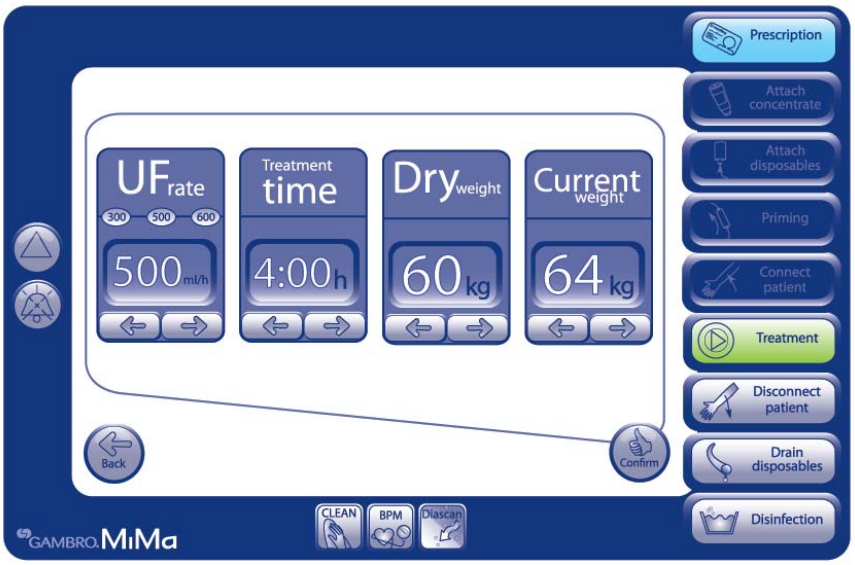

Figure 14-23. The *MiMa-window* with activated buttons in the *MiMa-nine steps.*

14.13 Screen saver

To get a more peaceful mode on the dialysis machine a screen saver will turn on after the treatment is started and running smoothly. Here the most necessary values will be shown, something that every user itself has to decide. A standard window could for example contain; venous pressure, arterial pressure, ultra filtration rate, blood flow and remaining time. If the user wants to go back from the screen saver they just have to touch the screen.

14.14 Configuration

The description of the concept has involved how a person with lower education level uses the interface. This user is supposed to follow the *MiMa-nine steps* from *Prescription* to *Disinfection* without any jumps in-between. This to secure a healthy treatment, but this concept is also created for people with higher education level. The solution of this problem has been to configure the concept for each user. A user with minor experience in dialysis need a more closed interface and the user with more experience needs a more opened interface.

Before the user starts to work with the dialysis machine for the first time, there's some decision to make, it's decisions about which boxes that are necessary and pleasant for the user and which kind of the adjustment and guidance boxes the user is in need of. The reason for this selection is to make the concept more suitable and pleasant for the user. For example the expert user doesn't need to be reminded of when it's time to puncture the arterial line, something that the less experienced user can be in huge help of.

Let's go back to the user who starts with the new interface for the first time. The user together with a doctor and a technician choose boxes and functions from a function

library, see Function library. The doctor choose which boxes and functions that the user needs for safety, the user choose which boxes and functions that are comfortable and pleasurable and the technician implement this.

14.15 Function library

This is a library for all functions that can be used in the *MiMa-concept*. From this library the configuration is created. It's the doctor and the user who chooses functions for the specific interface. There will be templates over how a typical interface should look like for an experienced and a less experienced user, in which functions and boxes that are recommended are included. This templates is flexible, functions and boxes can be removed from or placed in the interface. It's also possible to have templates over different cultures and countries.

14.16 Checkpoints

For an open interface there are some limits. The user shall not be able to start *Priming* before *Attach concentrate* and *Attach disposables* are done. The *Treatment* step shall not be able to start before the patient is connected and the *Prescription* step is done. The user shall always be able to disconnect the patient, but only if the patient is connected, this means that *Connect patient* has to be finished. The user shall not be able to *Drain disposables* before the patient is disconnected. Disinfection shall only be able to start if *Disconnect patient* and *Drain disposables* is done, see Figure 14.24.

There are also different checkpoints in every nine step, see under the specific steps.

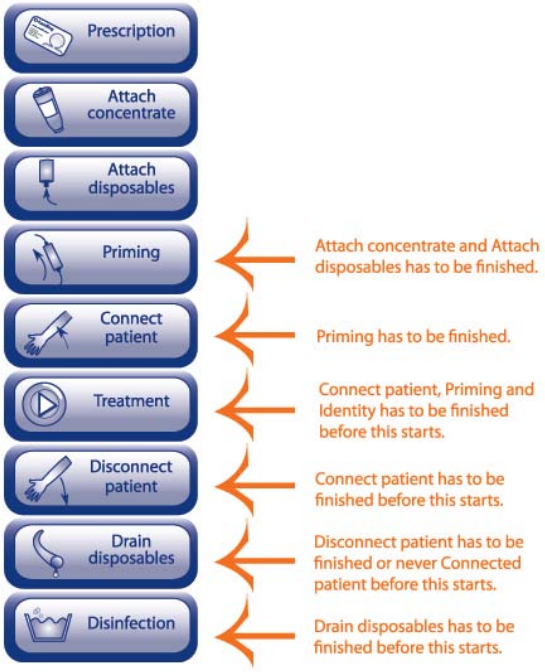

Figure 14-24. The *MiMa-nine steps* with checkpoints.

15 Discussion

The concept is built on the fact that every person is different. Every person has its own personal needs and requirement and therefore every dialysis machine have to be different to keep up with the different needs. After an interview with Ann-Katrin Davidsson at *Gambro*, the *Gambro* brand future became clearer. The branding and marketing department on *Gambro* is proud of the *IQD*^{TM} *program*; which means to deliver *Individualized Quality-assured Dialysis*. This is to improve the life for a dialysis patient. The branding people already see the *Gambro* products to fill in to this program, but now the hope is that they will see *MiMa* take the *IQD*^{TM} to a higher level. The *IQD*^{TM} focus on four corner stones values of *Gambro*(21):

- Your home of innovation – You inspire, We innovate

  MiMa takes the motto to another level due to the configuration concept. The *MiMa* concept is built on interaction between the user and the developers at *Gambro.*

- Freedom of choice – You choose, We provide

  MiMa has a clear solution for this motto. The user choose which guide boxes they need, *Gambro* provides it. The users choose if they want an open or a closed interface, which *MiMa Gambro* can provide.

- Moving forward in partnership – You know, We understand

  By having *MiMa, Gambro* shows the user that they trust them and believe in them. The user can choose which boxes that are best for them instead of that a company chooses it for them.

- Success in patient care- You care, We support

  Last but not least, it's important to show the user that they're the ones out at the clinics doing a big job, *Gambro* wants to support that job by moving forward in technology and support the interaction between them and the machine.

With these four corner stones as a focus point *MiMa* have become a more patient friendly product with more individualized solutions for different users. *MiMa* contains a platform that has a good overview of the process, something that *AK 96*^{TM} today is missing, see Chapter 7. Other problems that *MiMa* solves is how to understand when a value has been changed and when it hasn't. This is in *MiMa* solved with a safety button called *MiMa-confirm* button, see Chapter 13. In *MiMa*

the alarm processing will be handled differently inside the alarm window, see Chapter 13, this because *AK 96*^{TM} needs a more obvious alarm process something that can be more secure. The alarm processing in *MiMa* is clearer and more effective; the alarm can be solved directly in the window.

Consistency is a keyword for this project due to the lack of this in the *AK 96*^{TM}, something that has been taken very seriously. In the new concept there's a clear and consistently flow, the user shall immediately understand how the new system work or quickly learn it. If there's anything the user doesn't understand from the beginning, the user will have a shorter learning period because of the consistency.

To be able to clearly see the goals questions were written in the beginning. These questions will be used to see if the result has reached the expectations, see Chapter 2.

- *Gambro* users shall be able to see the *Gambro* brand in the machine

  With use of the *Gambro* logo and the *Gambro* brand colours, the belief is that *MiMa* radiates the *Gambro* brand. Today there's a clear difference between what *Gambro* wants to radiate and what the machines radiate. *MiMa* radiates *IQD*^{TM} with the configurations, which is a part of future *Gambro*. The *MiMa* shall radiate what *Gambro* brand want to be in the future, and the belief is that *MiMa* in this case has reached the goal.

- The user interface shall follow European standards

  MiMa uses European standards in the alarm symbols. Other than that all symbols are drawn from scratch. This is because of the lack of standard symbols that are usable on a dialysis machine. Many of the standard symbols are hard to understand and this is something that goes against the user-friendliness. Therefore there has been a consciously decision to use more custom made dialysis symbols.

- The user interface shall be suitable for people with different educations level in dialysis care.

  MiMa has reached the goals to be suitable for people with different educations level in dialysis care by the configuration system. Every user can have different *MiMa-guide boxes* and lock different function, therefore it shouldn't be possible to do wrong if you're a beginner in dialysis and if you're an expert the interface will be more opened with fewer guide boxes.

- *Artis*^{TM} users, see Chapter 5, shall be comfortable using the new interface

  MiMa uses the same mental model of how a dialysis works. This mental model contains a blood side and a dialysis side, and therefore all functions are divided in these two categories. The *MiMa* has been tested on nurses with *Artis*^{TM} background with good result. One test user even comment that she thought it reminded about *Artis*^{TM}. The *Gambro* nurses that tested the *MiMa*-concept also believed that this interface would work well for a person that has worked with *Artis*^{TM} but for other nurses as well. Something that's good.

MiMa uses touch screen just like *Artis*^{TM}, something that the test users find good both ergonomically but also to get a more futuristic look. *Artis*^{TM} uses information about what state the process is in with the buttons, the user can have advantage of this when they start using *MiMa.*

- The interface shall be suitable for the whole world

It's hard to evaluate if the concept is suitable for the whole world and therefore was the touch screen selected. With touch screen it's easy to change the interface depending on which country the *MiMa* should be used in. The illustrations are also good in terms to be international. The illustrations can help people in different countries to understand the interface without reading.

- To be consistent throughout *MiMa*'s design

The consistency in *MiMa* has brought a lot of discussion throughout the design. There're a lot of functions to consider when creating a consistent user interface. This has been hard, but these hard decisions have made it clear that a consistent design is really important to be able to make this interface user-friendly. That's why a big focus has been on consistent design and *MiMa* has now reached the goal of consistency.

- To have a good overview

The overview in *AK 96*^{TM} was hard to understand, and that's why a good overview has been a key factor throughout the development of *MiMa*. The *MiMa-nine steps* brings the overview that the *AK 96*^{TM} is missing. The *MiMa-nine step* describes a nine step program to go through a dialysis treatment.

- To have a lot of illustrations

There's almost an illustration in every box, step and button in the *MiMa interface,* with that said, *MiMa* have fulfilled that goal, something that speak for itself just by looking at the result.

- To put simplicity before complex technical design

To have a consistent design throughout the interface contributes to a more simple and easy to use interface. *MiMa* separate itself from *AK 96*^{TM} by looking more user friendly and less technical.

The configuration puts simplicity before technical design. The configuration reduces numbers of functions for the specific user. When only the necessary functions are shown the interface gives a non technical impression.

The result will also be compared with the usability goals. The usability goals include:

- *Effectiveness*

The belief is that by using *MiMa* the user can be as effective as possible to own ability, this due to the fact that the interface is individualized.

- *Efficiency*

Since the *MiMa-guide boxes* guide the user through the treatment the efficiency increases by avoiding mistakes.

- *Safety*

The checkpoint system reduces the risks that that the user makes mistake that could lead to any damage. The guide-boxes also help in the purpose to avoid mistake.

- *Utility*

Utility is something that has been well thought through with the configuration concept. A user shall never see more parameters than necessary for the specific treatment.

- *Learn ability*

The learn ability has increased from *AK 96*^{TM} by the consistency in *MiMa* and the clear overview.

- *Memo ability*

MiMa shouldn't have any problems consisting memo ability due to the clear overview and the guide-boxes in every step.

The touch screen seems in all user tests be a success; it's easy to use, better in an ergonomic aspect, more adaptable to different cultures and languages and better in an economical aspect. To have test user in an early stage is really useful. The test users contributed a lot to the development of *MiMa*. It should however have been good with more field studies to get more knowledge about the problems the users experience today. It also would have been good to meet users from different countries to see the differences and similarities in using the interface.
The hope is by *MiMa* that a discussion can start at Gambro and a new approach on user interface can take place, a discussion towards a more futuristic style, user-friendliness, consistent and more developed user interface.

16 Conclusions and Recommendations

The conclusion is that this Master Thesis has brought a new perspective to *Gambro* on the interface design and the design processes. The test users seem happy with the result but there's of course a lot to do before a launch. Recommendations for the future will therefore consider:

- An emergency stop on the side of the machine if for example the touch screen closes down.
- How it could be possible to solve the memory capacity to save different setting for different users. If it's for example is possible to save patient data on a patient card or transferred via Internet.
- There also have to be developed a system on how to save a log on confirmed steps and functions. The machines finished functions should also be included in the system. This system could help the user in case of a machine mistake.
- The whole *MiMa concept* has to be implemented and tested a lot further in order to launch it.
- For the future it could also be possible that the machine would do most of the task by itself and thereby would a lot more *MiMa-guide boxes* get a *BIB, Button in button,* on the guide box, for example *Turn the dialyzer* if the user would press on a button like that the dialyzer would be turn automatically by a motor in the dialysis machine.
- A fast processor connected to the touch screen is necessary. The touch screen has to support a good position with the finger and also a quick feedback.
- In the *MiMa-disinfection window* there should be a reminding of when the machine needs a weekly disinfection.

Important to emphasise is that *MiMa* is a concept. The most important aim is to inspire *Gambro* for a future development in the interface sector and the hope is that this can contribute to help users have a pleasant and flawless dialysis.

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Appendix A: Design method: towards a systematic approach to design, by Matt Cooke

This design process was produced by Matt Cooke to see if it was possible to systematize a design process. He wanted to prove that the structured design processes can help organizations to tackle social problems in order to deliver more efficient design solutions. He also wanted to prove that such design process would not prevent or reduce creativity to a project. Here are the steps of the process explained in order. There are four main steps in the process, which can then be divided into smaller pieces, see Figure A-1.

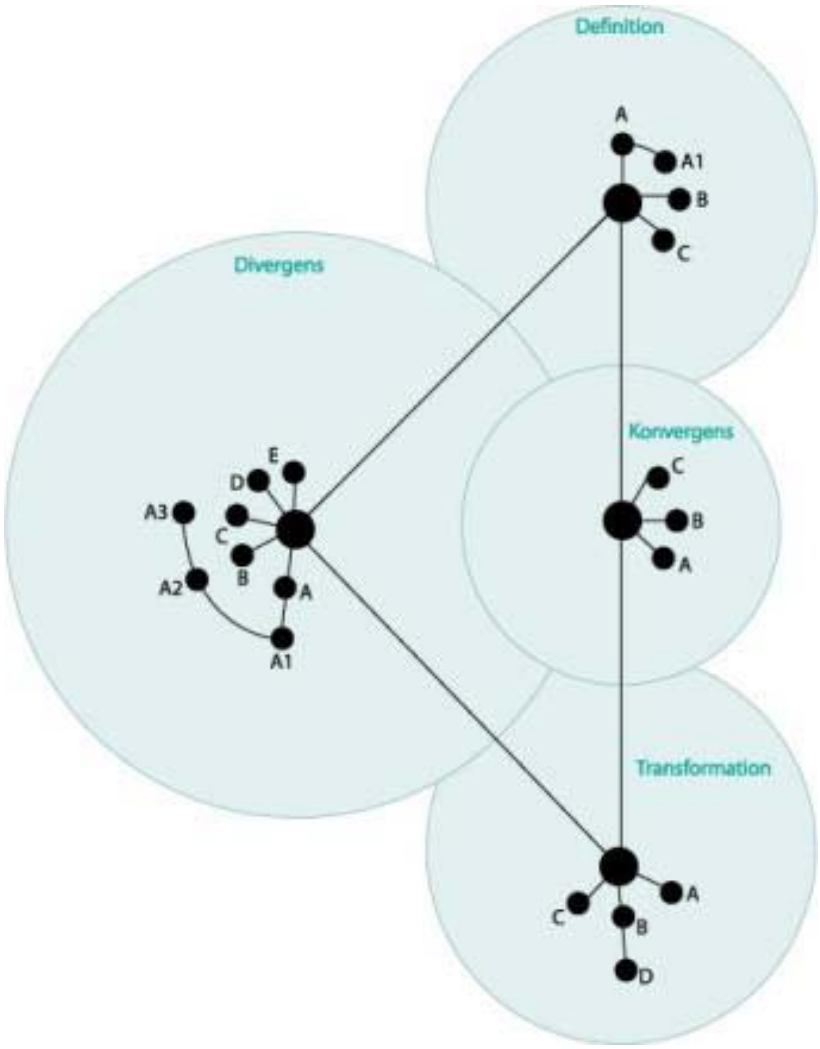


Figure A-1. The figure describes a design methodology by Matt Cooke (5)

A.1 Definition

The first step in Matt Cooke's theory is to define. In this step the design group comes up with a number of issues to form an idea about the nature of the problem and whether this can be solved with a graphical improvement.

A.1.1 Define the design problem (A)

The first step is to define the problem, so that everyone is clear about the task.

A.1.1.1 Is the problem significant? Can visual communication contribute to a solution? (A1)

This step simply examines the answers to questions about the problem signification, and if this can be solved by communication design.

A.1.1.2 Defining the cause of the problem (B)

The reason for the problem is examined and evaluated. In this step information can be available from the literature and studies so that an adequate reason of the problem can be found.

A.1.2 Define the target group (C)

In the final step of definition, it's important to define the target group. This may be through long discussions and through surveys of target groups. Is this a completely new product, a target group for the case will be presented. Trying to reach out to a too big a crowd, or so-called target group is usually a disadvantage, the audience shall always be limited.

A.2 Divergence

The second step in the process is called divergence. This step creates a deeper insight into the problem.

A.2.1.1 Start converges searching (A)

The design group learn the user's "language". This so-called language is both verbally and graphically and will reflect on how the user perceives different things. In this step as much information as possible about users is collected, this means that a design team member can put themselves firmly into the user's situation.

A.2.1.2 Collect quantitative data (A1)

To collect a variety of data is good and then summarize this and apply it to different trends. Here, observations made on different facts and whether they contain the same visual elements and from this determine the general fonts, sizes, colors, visual images, weight, qualities and so on. By identifying different trends a broad conclusions can be drawn that can give a weak directions towards a popular visual language.

A.2.1.3 Collect qualitative data (A2)

In qualitative inquiry the goal is to understand more about how things work in the real environment. The collection of qualitative data for a design process focus less on formal tasks and more on human behavior.

A.2.1.4 Visual examination of the target group (A3)

The idea of visual examination is to win enough facts and knowledge about the target group so that the design team can see the aesthetic values but also so they can

understand some of the cognitive explanations behind their decisions. Speaking “target language” is crucial in an effort to get customers to understand one's product.

In this step, the target population itself has to make a *mood board, see Mood board,* where they put together a variety of images that they like. This is done to see what the audience is interested in. Based on these collages a *brain storming* session is made, *see Brain Storming,* and here the design group’s aim is to produce as many proposals as possible by using different methods.

A.2.1.5 Elevated design problems (B)

Based on previous steps in this design process, general conclusions about elevated design problems are defined. At this step a cleaner objective and a framework for the project is build.

A.2.1.6 Suitable design goals (C)

In this design process step it’s measured how effective the proposals are. Here’s realistic and achievable goals provided so that it’s possible to relate to them and measure the proposals. It must be a measurement system generated by agreement between the parties.

A.2.1.7 Agreed channels of distribution (D)

All persons that are involved in a design process have to make decisions about which channels that should be used in order to distribute the material that will be produced. This decision is based on both efficiency and quality but also on financial aspects.

A.3 Transformation

Having completed the design stage of the background, it’s time a high level of creativity. Here designers shake off any underlying creativity and let all the innovation spread out. The previous steps provide a good basis for a change in human understanding. Those who perform this step can, through the knowledge of previous processes design sustainable solutions instead of falling for the funny and the "trendy".

A.3.1.1 Design of graphical prototype (A)

Design of graphical prototyping means; creating a variety of suggestions of visual arrangements from raw materials, conceptual forms and fast-developed proposal. Here’s a structure defined including, the type of treatment, colour palette and so on.

A.3.1.2 Testing on target (B)

In this design process step is an additional tests on the target group shall be performed to get an understanding of how the proposal works in the real context. This step is to avoid errors at a launch who may contribute to high financial mistakes and a large reduction in the capital.

A.3.1.3 Was the test a success? (C)

In the last transformation step you find out if the test on the target was a success or not. If it was a success the next step *convergence* can start, else the *transformation* can take place again.

A.4 Convergence

In the earlier stages the background has been studied, the objectives of the design has been agreed, the channels of distribution are clear, and the prototypes are tested. Now the time is to continue and bring the product to market in a full-scale environment.

A.4.1.1 Full-scale production (A)

The previous extensive tests were carried out to allow the parties to quickly reach the market from the decisions taken.

A.4.1.2 Measuring effectiveness (B)

When the product is in the market the work to examine the effectiveness of the new product starts. Here complains of the product provides useful background material for a new process.

A.4.1.3 Recommendations (C)

The final step in the design development process is to provide recommendations for improvement. This is done based on the conducted tests.

Appendix B: Ulrich and Eppingers' concept development methodology

Ulrich and Eppinger have developed a methodology of the product design and development process(4). *The method goes through all stages from planning to the available product on the market. Since the purpose of this work is to develop a concept, the following description is about the first phase, i.e. concept development.*

B.1 Identifying customer needs

The method's first step is customer requirements. This is carried out so that the final product must comply with customer's key needs. First, customer opinion is gathered in, for example in the form of surveys. Then the opinions will be formulated to customer needs. At last it's important with a reflection on the result and decisions.

B.2 Product specifications

To ensure that the final product meets the identified customer needs, they must be translated into measurable quantities and product specifications. Information is collected on the various product specifications, by comparison with similar products, this is known as *benchmarking*. The limits are set and the ideal values of product specifications and a new reflection on the outcome occurs.

B.3 Concept Generation

This is the creative part where lots of concept proposals are created. The task for all the people that are involved will be clarified. If the product is complicated, it can be divided into smaller parts. Then the process of generate ideas starts, different methods can be used such as *brainstorming, see Chapter 3*. Ideas can be searched both external and in-house; improvements to existing solutions can be a good source of inspiration. Ideas can structure up and a clearer description can be added if necessary. Like in the other steps, this step will end up with a reflection on results and process.

B.4 Selection of concepts

After concept generation it's time for the evaluation of the ideas, this is based on the customer's needs, strengths, weaknesses, and other criteria the group considers important. The evaluation is done in two stages, screening and concept scorings. The first selection is a quick selection to sort out the impossible and complex concepts; the second sample is a more detailed assessment to carry out the best ideas. Both steps are carried out in the following six steps:
1st *Preparation of the sample matrix*
2nd *Valuation of the concept*

3rd *Ranking of concepts*
4th *Combination and improvement of concepts*
5th *Selection of concepts*
6th *Reflection and results of process*
The evaluation should sharply reduce all concepts to one or two. At last it’s important with a reflection on the result and decisions.

B.5 Results and analysis

In this step it’s time to decide which concepts that should proceed in the product development phase. In this product development phase, a description of the future product's shape, function and characteristics are developed, this information is based on product specifications, analysis of competitive products and economic asset for the project.

Appendix C: Ten Usability Heuristics, by Jakob Nielsen

These are ten general principles for user interface design(11). *They are called "heuristics" because they are more in the nature of rules of thumb than specific usability guidelines.*

C.1 Visibility of system status

The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.

C.2 Match between system and the real world

The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.

C.3 User control and freedom

Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.

C.4 Consistency and standards

Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.

C.5 Error prevention

Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.

C.6 Recognition rather than recall

Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.

C.7 Flexibility and efficiency of use

Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.

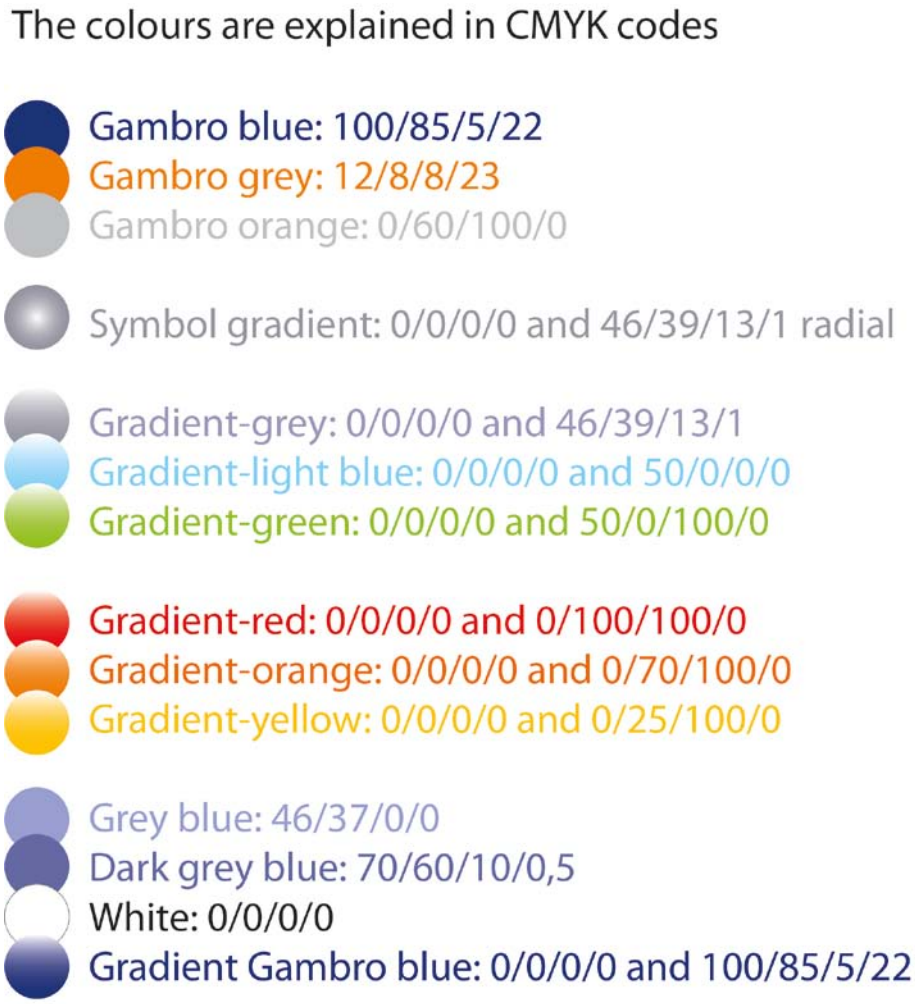
C.8 Aesthetic and minimalist design

Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.

C.9 Help and documentation

Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

Appendix D: Colours in the graphic profile



Appendix E: Dimensions in the graphic profile

The quantity of boxes in each window varies and depends on how many boxes the user wants and the quantity of necessary boxes, such as start the blood pump. There are measurements over the boxes in different quantities, see Figures E-1-E-5. If the user needs more than 10 boxes, a new window will be added.

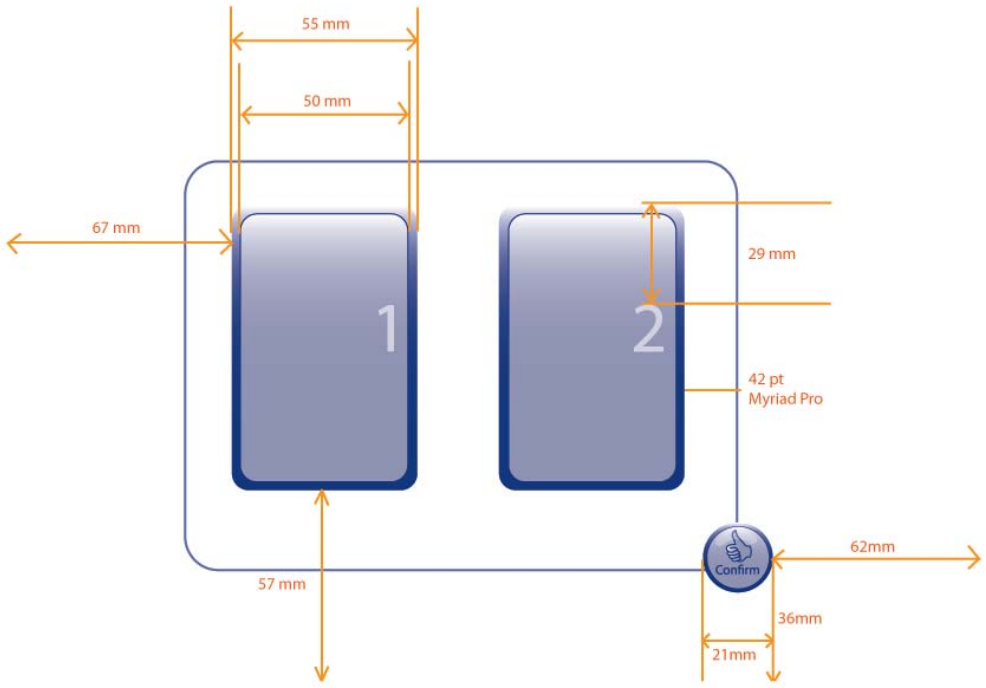


Figure E-1. Measurements 1-3 boxes.

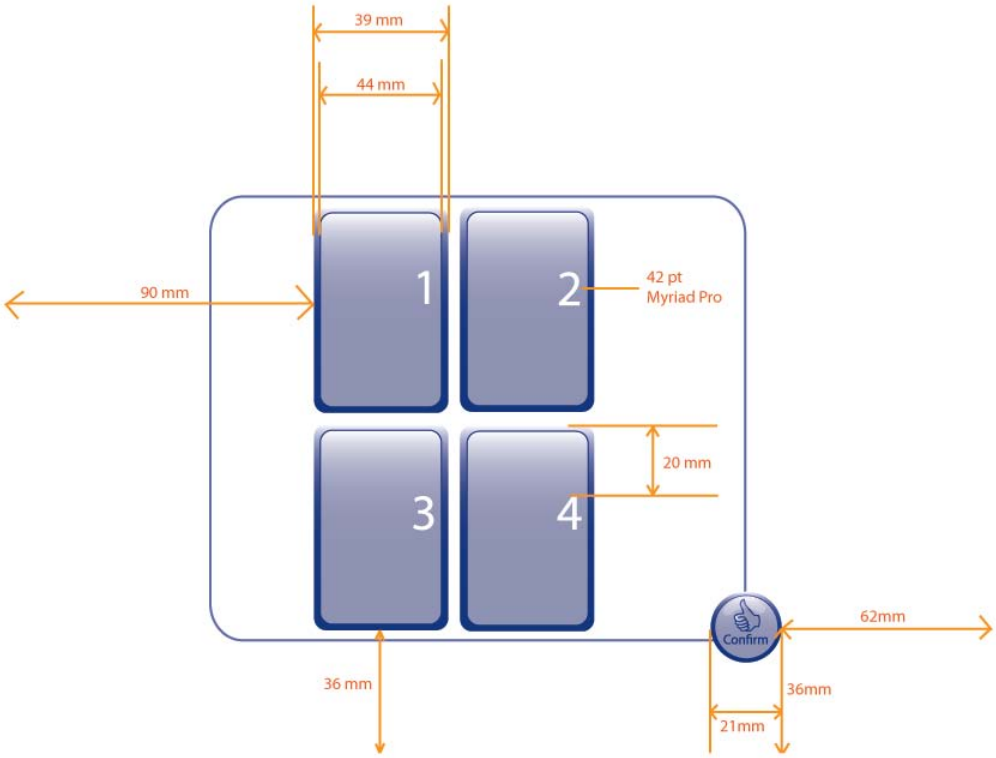


Figure E-2. Measurements 4-5 boxes.

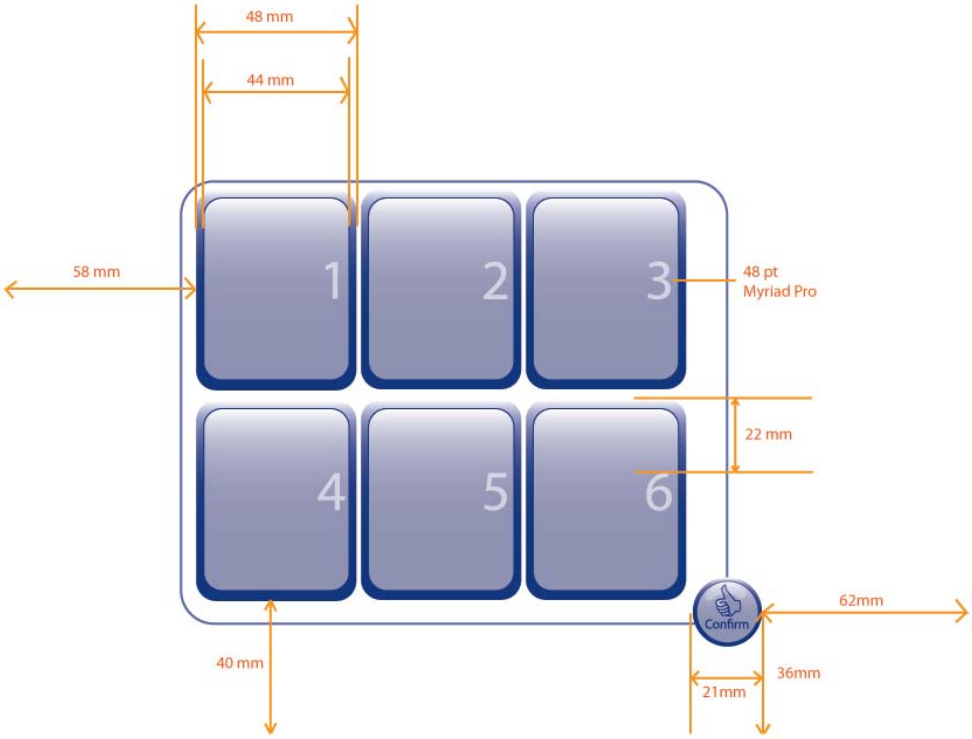


Figure E-3. Measurements 6-7 boxes.

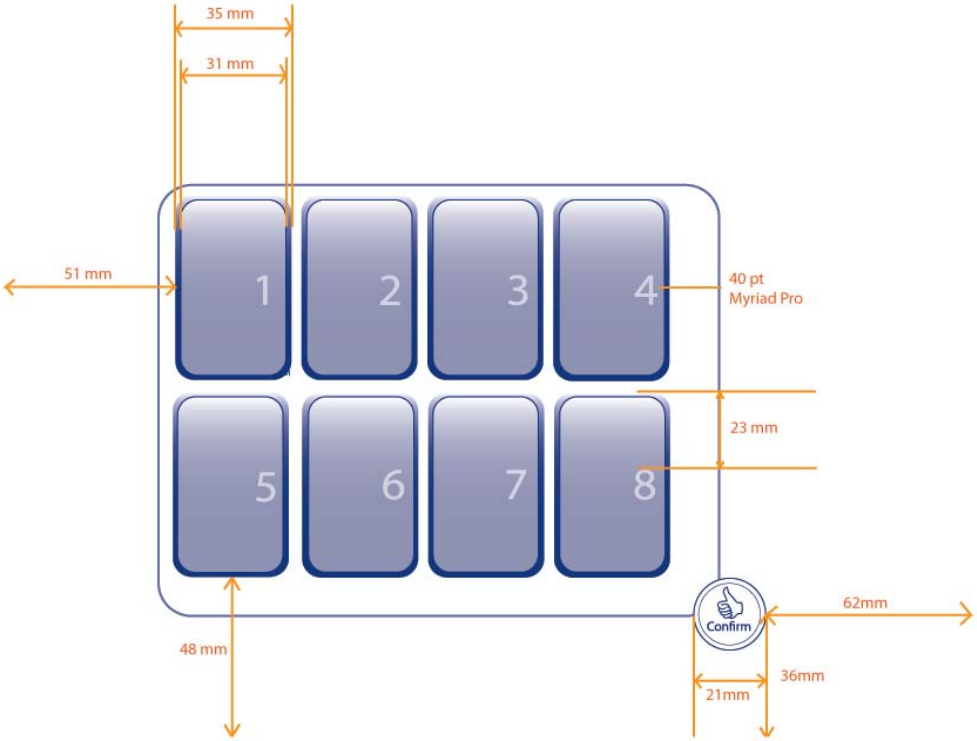


Figure E-4. Measurements 8-9 boxes.

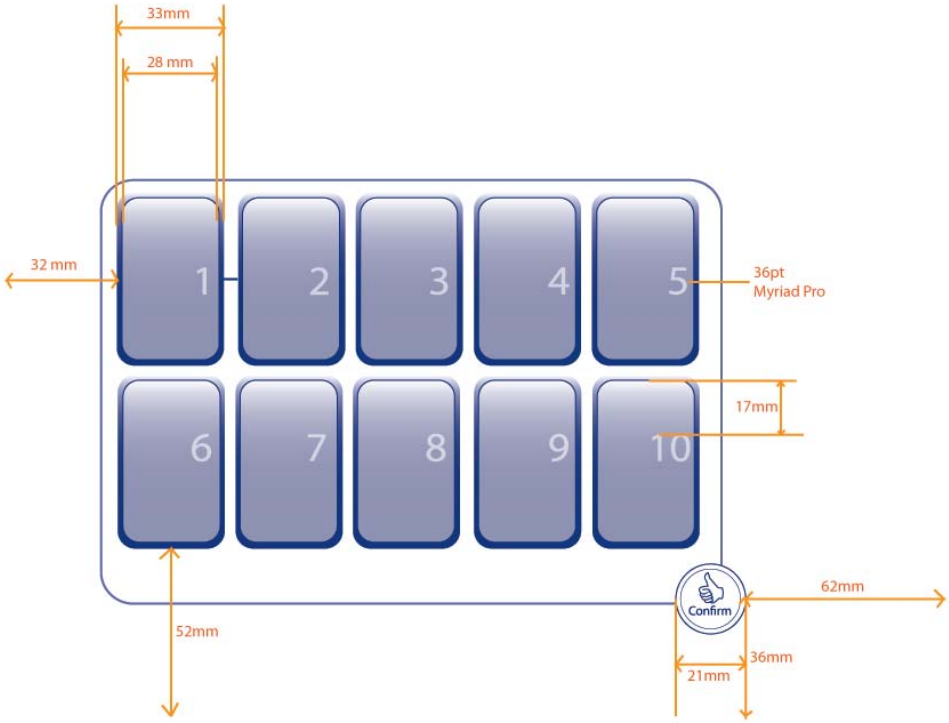


Figure E-5. Measurements 10 boxes.

Appendix F: Evaluation of initial brainstorming proposals

The concept was evaluated and the different parameters were rated equally important.

Table F-1. Validation of different proposals.

Criteria \ Proposal	*Touch screen*	*Remote control*	*Sms*	*Sensor*	*Manual keys*	*Laser*	*Odor*	*Blow on*
Eminate future Gambro	**4**	3	2	1	4	1	1	1
Limiting unnecessary units	**5**	2	2	2	3	1	1	2
Work international/cultural	**5**	4	1	3	4	2	5	5
Carrying structure	**5**	5	1	3	4	3	1	1
Pleace the user	**4**	2	2	1	4	1	1	1
Resist abrasion	**4**	2	2	3	3	2	2	1
Total	**27**	18	10	13	22	10	11	11

Appendix G: Evaluation of concept generation

The concept was evaluated and the different parameters were rated equally important.

TableG-1. *E*valuation of 8 concepts.

Criteria/ Concept	1	2	3	4	5	6	**7**	***8***
Work multi cultural	4	3	2	2	3	3	**3**	2
Limiting unnecessary units	3	5	3	2	2	3	**5**	2
Eminate future *Gambro*	5	2	2	2	2	3	**4**	3
Work for *Artis*^{TM} users	2	3	3	2	2	2	**4**	5
Overview	4	4	1	4	1	3	**5**	1
Intuitive	4	4	4	2	4	2	**2**	4
Carrying structure	4	4	1	4	1	3	**5**	1
Explanatory easily understand	3	5	4	2	4	3	**4**	4
Safe	4	3	2	2	2	3	**5**	3
Stable	2	5	2	2	2	3	**5**	3
Total	35	38	24	24	23	28	**42**	28

Appendix H: Welcome speech

Välkommen!
Vi är mycket tacksamma att ha er här som deltagare i detta test.

Först av allt skulle jag vilja säga att vi gör dessa tester för att utvärdera användbarheten av maskinen och inte dig som användare. Under testet kommer jag att vara mycket formell och läsa de mesta av informationen från ett papper. Detta eftersom att vi vill att alla deltagare ska få samma information och så att resultaten blir jämförbara.

Jag och min kollega kommer att vara i rummet under hela testet. Jag skall ge er ett antal uppgifter som är normala uppgifter för en dialys maskin operatör. Efter några av de uppgifter som jag gett er kommer jag att följa upp med frågor.

Maskinen och vissa funktioner är nya för dig. Om du är osäker på vad du ska göra, se om datorn eller användargränssnitt tillhandahåller någon information eller tips innan du frågar. Jag kan med viss begränsning hjälpa dig och ge hjälp om du behöver, men försök att göra ditt bästa utan hjälp, detta är också viktig information för oss. Om det däremot gäller texten och språket, så fråga gärna, så översätter vi.

Jag vill att du ska tänka högt under testet och beskriva vad du gör, vad du tänker göra och varför. Testet kommer att spelas in, det inspelade materialet används för utvärdering.

Testet kommer att pågå i ungefär två timmar och vi kommer att bryta testet på den tiden.

Du kan när som helst avsluta testet.

Efter provet jag kommer att följa upp med några frågor som handlar om det test som du just har gjort.

Har du några frågor?

Appendix I: Question formulary Basic information

Formulär för användartest

Användartest ID:

Datum:

Vänligen fyll i nedanstående frågor så noggrant och saningsenligt som möjligt

A. Bas information

1. Kön: Man ☐

Kvinna ☐

2. Ålder _____

3. Yrke _____

4. Högsta utbildning

_____

B. Hörsel, syn och rörlighet

5. Vänligen gradera din synförmåga (med glasögon)

Fullgod syn	☐
Mindre synproblem	☐
Måttliga synproblem	☐
Ett flertal synproblem	☐

Blind

6. Är du färgblind? Ja

Nej

7. Om du har några synproblem, vänligen ge fler detaljer:

8. Vänligen gradera din hörsel

Fullgod hörsel	
Mindre hörselproblem	
Måttliga hörselproblem	
Ett flertal hörselproblem	
Döv	

9.Om du har några hörselproblem, vänligen ge fler detaljer:

10. Vänligen gradera din rörlighet

Fullgod rörlighet	
Mindre rörlighetsproblem	
Måttliga rörlighetsproblem	
Ett flertal rörlighetsproblem	

9.Om du har några rörlighetsproblem, vänligen ge fler detaljer:

Appendix J: Findings during the user test

In this appendix a compilation of the findings during the usability test is committed.

The finding could be rated in different categories; C= participant comment, O= observation, E= use error, P= prompt, A= assist

J.1 Identity

Below are the answers and observations during the task *Identity* committed.

Task during *Identity:* We have just started the dialysis machine, and this is the first window that you will see. You are now going to get something similar to a patient journal that contains important values and parameters to this treatment. I want you to confirm and control these values with the values that the screen is showing.

Table I-1. Identity, ID: 1

Finding	**Notes**
o	The participant found the confirm button immediately
o	Hard to read the patient journal, but did find the right values
o	Did understand the arrows
o	Want to confirm on the box
c	Didn't know if you could confirm all steps at ones or seperatly

Table I-2. Identity, ID: 2

Finding	**Notes**
o	Correct reading of the parameters
o	Wanted to confirm with the right column, but learned the confirm button after a while

Table I-3. Identity, ID: 3

Finding	**Notes**
o	Confirm direct

Table I-4. Identity, ID: 4

Finding	**Notes**
o	Want to set parameters for UF, how much that will be drawn
o	Want to look in the different steps on the right
o	First the buttons to the right, then the boxes, at last the arrows
o	The confirm button is used direct

Table I-5. Identity, ID: 5

Finding	**Notes**
o	Confirm correct

Table I-6. Identity, ID: 6

Finding	**Notes**
c	Want to set UF volume instead of UF rate
c	Want to see if the computer calculate the parameters by itself
o	Understood the confirm button

Table I-7. Identity, ID: 7

Finding	**Notes**

o	Confirmed all parameters correct.

Table I-8. Identity, ID: 8

Finding	**Notes**
o	Searching for information about dialysis filter
o	Searching for prescription in the 9 steps
o	In general wants the participant use the 9 steps
o	Doesn't understand the confirmation button, is it the box or the hole window that is confirmed

J.2 Attach concentrate, Attach disposables, Help

Below are the answers and observations during the task *Attach concentrate, Attach disposables, Help* committed.

Task during *Attach concentrate, Attach disposables, Help:*

- (At the step A*ttach concentrate*) If you wanted help with how to put in the concentrate, how would you do?
- Now I want you to prepare the machine so that *priming* can start.

Table I-9. Attach concentrate, Attach disposables, Help, ID: 1

Finding	**Notes**
o	Did find the help immediately
c	Wanted another flow in the steps
o	Did learn to always use the arrows to move around
o	Didn't see the right columns
e	Thought priming was done before it was

Table I-10. Attach concentrate, Attach disposables, Help, ID: 2

Finding	**Notes**

o	Searching for help in the right column and then *Attach disposables*. Did find the help button with guidance from the interview person
o	Understood the back button immediately
o	Learned to use the confirm button
o	Often ant to use the right column, but did soon find the arrows

Table I-11. Attach concentrate, Attach disposables, Help, ID: 3

Finding	**Notes**
o	Looking for a help button
c	Feel like the one with red frame is chosen
c	Feel like the symbols to the right is for manoeuvring
o	Arrow back works good

Table I-12. Attach concentrate, Attach disposables, Help, ID: 4

Finding	**Notes**
o	Correct use of confirm button
o	Read on the screen what to do
o	Correct use of how to get the help

Table I-13. Attach concentrate, Attach disposables, Help, ID: 5

Finding	**Notes**
c	(For help) Ask a colleague
o	Did press correct button to get to help
o	Correct use on confirm

Table I-14. Attach concentrate, Attach disposables, Help, ID: 6

Finding	**Notes**
o	Looking for a question mark, but chosen to press on the right button
c	“I want to check if it’s the right concentrate”
c	Seemed unclear what was confirmed, the boxes or the whole page
c	“want colour code, blue for venous and red for arterial”

Table I-15. Attach concentrate, Attach disposables, Help, ID: 7

Finding	**Notes**
o	The participant did find the help directly
c	The help viewed wrong help window.
c	The pink frame is confusing, the proposal is either used like something you can check or either something that starts.

Table I-16. Attach concentrate, Attach disposables, Help, ID: 8

Finding	**Notes**
o	Find the help immediately
o	Wanted to further instead of back after the help
o	Searching for a confirmation that the concentrate is connected

J.3 Priming

Below are the answers and observations during the task *Priming* committed.

Task during *Priming:* Now the thought is that you should perform *priming* and I would like you to do this.

Table I-17. Priming, ID: 1

Finding	**Notes**

o	Did immediately understand the so called KIK buttons the first time, unclear in the rest of the test
c	Priming value achieved button was understandable, the text made the participant understand
o	Didn't understand that the KIK buttons were active
c	The dialyzer shouldn't turn as many times as *Gambro* want to according to the participants.

Table I-18. Priming, ID: 2

Finding	**Notes**
o	Understood the KIK buttons immediately
o	Didn't seem to understand the pink frames around the boxes
o	Didn't understand that *priming* and *air detector* was inactive

Table I-19. Priming, ID: 3

Finding	**Notes**
o	The participant guide with the aid of illustrations
o	Learned the *KIK* after one time
c	Now the priming seem to be ready (this was right)

Table I-20. Priming, ID: 4

Finding	**Notes**
o	Look at the screen and do not get the information from the memory
o	Did understand the *KIK* immediately, but wanted to confirm that it was activated
o	Want to press the *KIK* buttons even though they are not red marked
o	Think that the arrows bring you to next page not next step.

Table I-21. Priming, ID: 5

Finding	**Notes**
o	Get the hang of the *KIK* after a while
o	Understand the priming volume achieved and the pressure test achieved
e	Want to confirm to start priming
o	Want to press on the box

Table I-22. Priming, ID: 6

Finding	**Notes**
e	Wanted to confirm the whole page with out starting priming. Thought that the steps were supposed to be automatically started.
o	Didn't see the *start blood pump* button, whanted to use the right hand buttons.
o	Step 9 was important (*turn the dialyzer*)

Table I-23. Priming, ID: 7

Finding	**Notes**
o	Start using the BIB buttons directly and correct.
o	The participant thinks the priming volume and venous pressure starts automatic when it's time for it.
o	Wants to skip step 10, *the infusion line*, and wants to go further with the 9 steps.
o	Can't see if the BIB buttons is activated or not. Wants the buttons to be up lighted in a colour, such as green.

Table I-24. Priming ID 8

Finding	**Notes**
c	If you're unsure of something in the last step, can you then go back with the 9 steps
o	Now starts the participant to understand that the whole window is confirmed with the confirm button.
c	Step 10 shouldn't be there, doesn't want to turn the dialyzer.
o	Understood the BIB buttons

J.4 Connect patient

Below are the answers and observations during the task C*onnect patient* committed.

Task during *Connect patient*: Now you shall finish all preparations so that the *treatment* can start.

Table I-25. Connect patient ID: 1

Finding	**Notes**
o	Have learn the KIK buttons
c	The dialyzer shouldn't turn as many times as *Gambro* want to according to the participants.

Table I-26. Connect patient ID: 2

Finding	**Notes**
o	The participant begin to read from the screen and the guidance
o	Continue to use the KIK buttons correctly

Table I-27. Connect patient ID: 3

Finding	**Notes**

o	Have learn how the *KIK* buttons work

Table I-28. Connect patient ID: 4

Finding	**Notes**
o	Use the screen not the memory
o	The participant seems confused of the order (correct: it's wong in the prototype)
o	Now use the *KIK* buttons immediately

Table I-29. Connect patient ID: 5

Finding	**Notes**
o	The participant have learn the *KIK* buttons
c	Want to see the blood pump the whole time

Table I-30. Connect patient ID: 6

Finding	**Notes**
c	Wanted to see if it was straight connection or the other
c	Small text
o	Understood the KIK buttons

Table I-31. Connect patient ID: 7

Finding	**Notes**
o	Understood the BIB buttons
o	Wanted to push the BIB button twice, first to start and second time to stop.

Table I-32. Connect patient ID: 8

Finding	**Notes**
c	Both needles should be connected in the first step, not only one
o	The participant finds the error in step 4
c	Doesn't want to turn the dialyzer

J.5 Treatment

Below are the answers and observations during the task *Treatment* committed.

Task during *Treatment*:

- Now the treatment is started and I wonder what you can deduce from the screen.
- If you should set the parameters for the arterial pressure, how would you do?
- Now I wonder what the value is on conductivity.

Table I-33. Treatment, ID: 1

Finding	**Notes**
o	Did see all the values, and did understand that it was time left
o	Thought that you would be able to see the UF value if you pressed UF button
c	It was enough information on the treatment screen
o	Wanted to press Pa in the showing area of the treatment
o	Did understand the arrows to get back to treatment
o	Did learn the second time when the cond value should be read

Table I-34. Treatment, ID: 2

Finding	**Notes**
o	Did read the parameters correctly, with exceptions of the time, the participant thought it was time gone instead of time left.
o	UF, Bypass and Pump button: The participant thought all buttons was inactive

c	UF, Bypass and Pump button: The participant wanted more colour and light
o	Wanted to press Pa in the showing area of the treatment, but then the participant used the Blood flow button and could see the Pa and understood how to change it.
o	Find the conductivity immediately

Table I-35. Treatment, ID: 3

Finding	**Notes**
o	The time is showing how much time have went, then she regret the saying and says that it's time left.
o	Believe you can change UF and bypass
c	"Hard to say if they are active or not" (about UF, bypass, start blood pump)
o	Understand the arrows of change value
o	Easy to find the conductivity value

Table I-36. Treatment, ID: 4

Finding	**Notes**
c	Want to know how much have been drawn (UF)
o	Thinks that they are all active by thinks that bypass shouldn't be active
o	Use and find the blood pressure parameters to regulate correct
o	Use and find the conductivity parameters to regulate correct

Table I-37. Treatment ID: 5

Finding	**Notes**
o	Read the values showing correct, except from UF rate thought it was UF volume
o	Couldn't see if the buttons were active or inactive

c	Want to se the limits
o	Want to press direct on the Pa after that blood values
o	Correct way to conductivity.

Table I-38. Treatment ID: 6

Finding	**Notes**
o	Understood the time and the rest of the treatment parameters
c	Wanted to know if it was a set or confirmed value
c	UBP: Thought that all should be active, and therefore was active
o	Didn't understand the blood pump symbol at first
c	She thought the blood pump symbol was unclear
O	Wanted to press Pa in the showing area of the treatment, but did understand that you could find it under blood values
c	Wanted to be able to change the blood flow in the showing area direct
o	Understood the dialysis fluid button
c	Wanted to see the concentrate type in the dialysis window as well

Table I-39. Treatment ID: 7

Finding	**Notes**
o	Understood all parameters.
o	Thought that UF and Pump was activated, and Bypass inactivated, but it wasn't obvious.
o	Wanted to change the arterial pressure with the treatment display, then with the blood box.
o	Find the conductivity in first try.
o	Wants to use the confirm button to go back to the treatment window.

Table I-40. Treatment ID: 8

Finding	**Notes**
o	Understood UF and Bypass
o	Didn't understand the blood pump button, the participant was looking for arrows to increase or decrease the value of the blood pump
c	There shouldn't be any alarm limits in blood flow
o	Correctly reading of conductivity
o	Comments that the user adjustment arrows can have different meaning

J.6 Alarm

Below are the answers and observations during the task *Alarmt* committed.

Task during *Alarm*:

- *Oh, now you got an alarm, what have happened?*
- *How would you do to solve the problem?*
- *Finally, how many alarms do you see and what type of alarm is it?*

Table I-41. Alarm ID: 1

Finding	**Notes**
o	Did understand that the temperature was over the highest value
c	This is not a common alarm, haven't seen it before
o	Use the arrow to arrange the temperature value
c	See only one alarm
o	Thought it was two alarm that where shown, the box were one alarm

Table I-42. Alarm ID: 2

Finding	**Notes**
o	Understood way the alarm appeared and how to change the temperature
o	Thought the *Bypass* was inactive, because it wasn't up-lighted
c	Thought it was 4 (flikar) x 2 (boxar) alarm

c	Thought it was different alarms, but not what the difference was

Table I-43. Alarm ID: 3

Finding	**Notes**
o	Did see the right type of alarm
o	Thought it was the worst type of alarm
c	“4 alarms and of these 1 information, 2 the same,1 worse”
c	“3 different types of alarm”
o	The participant understand what to do

Table I-44. Alarm ID: 4

Finding	**Notes**
c	The temperature is to high
o	Understands the alarm correct
c	See 4 alarms, yellow=warning
o	Want to press the “*q-alarms”*

Table I-45. Alarm ID: 5

Finding	**Notes**
o	Correct use of how to solve the problem
o	3 alarm is showing (bypass, temp, electricity)

Table I-46. Alarm ID: 6

Finding	**Notes**
o	The participant understood the alarm

o	Checked both boxes and seem to understand them
o	The participant saw 4 alarm, 3 red alarm (more important) and 1 yellow (less important)
c	The participant looked for a pump button
o	Didn't know if the Bypass was activate or not
c	She wanted blue for info, red for inactive pump
c	Not good that the whole screen is covered with the alarm window, wanted to see treatment parameters

Table I-47. Alarm ID: 7

Finding	**Notes**
o	To solve the alarm: The participant should wait and see if the temperature go back to the right value, didn't want to change the limit.
o	The participant thought there were some info below the alarm-lamp
o	Observed 4 alarm: 3 alarm and 1 with lower priority

Table I-48. Alarm ID: 8

Finding	**Notes**
o	Understood the alarm
c	There should be a blood pump button
o	The participant sees 4 alarm, 3 with higher priority and 1 with lower priority
o	The queue is in alarm priority

J.7 Discussion

Below are the answers during the task *Discussion* committed.

Questions during *Discussion*:

- How do you think the test went? What went well and what didn't?

- What did you think of the stock tracking on this page? (for example; *Connect patient*)
- What did you think of the different steps under the stock tracking?
- Which symbols did you think were extra clear or less clear?
- In the treatment window, where there any parameters that you missed or want to erase?
- (BMP and Diascan): What do you think these two buttons are for?
- How did you think the alarm was working?
- You rather read the text or watch the pictures?
- Do you have any propositions on improvements?

Table I-49. Discussion ID: 1

Finding	**Notes**
c	Did recognise the flow, and thought it was the same as in reality
c	Thought it was good in the beginning during learning
c	Thought it was clear and easy
c	Thought the box gave enough information
c	Hadn't seen diascan before
c	Did understand the BMP button
c	During alarm: Good that you could solve the problem right a way
c	During alarm: the q system didn't give any information at all
c	During alarm: Clear that it was about the temperature
c	Are first interested in the pictures, and if you didn't understand read the text
c	The screen should be able to turn of
c	Would be nice with a screen saver

Table I-50. Discussion ID: 2

Finding	**Notes**
c	Alarm:Want to hear sound and see blinking
c	Good flow
c	Obvious pictures
c	Good with a red frame that shows were you are

c	Want Swedish text
c	No unclear symbols
c	Didn’t think Pv and Pa was to any help during treatment just after
c	BPM and Diascan: Didn’t understand what the meant
c	Alarm: Good with q system
c	Alarm: Understand that it was different kinds of alarm but didn’t understand the difference.
c	Looked at pictures before text
c	Want to save information about the treatment on a usb-stick so that you don’t have to write it down
c	A choice to turn of the light on the screen during night treatment

Table I-51. Discussion ID: 3

Finding	**Notes**
c	Went well especially since the participant haven’t worked with dialysis
c	Hard to know when you should press on the right icons or the boxes
c	Big and clear
c	The overview was easy to understand
c	Easy to understand the box
c	*(KIK*) hard to see if you could press them or not
c	Hard to see if UF, bypass, or start blood pump were active or not
c	Did understand BMP and Diascan
c	*(Alarm):* White less serious the red

Table I-52. Discussion ID: 4

Finding	**Notes**
c	The ordination was clear
c	Touch screen makes it easy to understand

c	Want to see blood pump the whole time
c	Doesn't make sense that that 500ml/h in 4 h gives an treatment of 4 L (correct this is an mistake in the prototype)
c	The right columns are good but want them to be press able.
c	Good with the boxes
c	Should show how to put the lines in the blood pump, this is a difficult step.
c	Empty disposables illustration is looking a bit unclear
c	Want to be able to see UF volume in treatment window
c	Understand the BMP but not the Diascan (have never heard of diascan before)
c	The alarm works good, you can fix it direct in the window
c	Good with orange frame, not as stressful
c	Read text before look at illustrations but after a couple of times, just the illustrations
c	Unclear if the blood pump is active
c	Want bigger text
c	The whole box should lid up
c	Knobs feels better
c	This interface could work at a clinic
c	Is similar to Artis
c	Good with touch screen; save the thumb
c	Have a lock mode so you can clean it
c	Would be good with height adjustable screen
c	A good screen when sunlight is on it
c	Don't want the blood pump as a tactile button, would confuse if everything else is on a touch screen
c	The blood pump button is not easy to understand, but the symbole need a new start from the old one on AK96.

Table I-53. Discussion ID: 5

Finding	**Notes**
c	The ordination was clear
c	Touch screen makes it easy to understand
c	Want to see blood pump the whole time
c	Doesn't make sense that that 500ml/h in 4 h gives an treatment of 4 L (correct this is an mistake in the prototype)
c	The right columns are good but want them to be press able.
c	Good with the boxes
c	Should show how to put the lines in the blood pump, this is a difficult step.
c	Empty disposables illustration is looking a bit unclear
c	Want to be able to see UF volume in treatment window
c	Understand the BMP but not the Diascan (have never heard of diascan before)
c	The alarm works good, you can fix it direct in the window
c	Good with orange frame, not as stressful
c	Read text before look at illustrations but after a couple of times, just the illustrations
c	Unclear if the blood pump is active
c	Want bigger text
c	The whole box should lid up
c	Knobs feels better
c	This interface could work at a clinic
c	Is similar to Artis
c	Good with touch screen; save the thumb
c	Have a lock mode so you can clean it
c	Would be good with height adjustable screen
c	A good screen when sunlight is on it
c	Don't want the blood pump as a tactile button, would confuse if everything else is on a touch screen
c	The blood pump button is not easy to understand, but the symbole need a

	new start from the old one on AK96.

Table I-54. Discussion ID: 6

Finding	**Notes**
c	Wanted a manual
c	Better info about concentrate
c	Illustrations should be important, should be colour-coded
c	Unclear when *priming* should start
c	Unsafe to not always see the blood pump
c	*Set prescription* instead of *Identity* in the right column
c	Good with illustrations for a new nurse
c	AK 96 has the arrow for *Priming* in the other direction
c	Attach disposibles: Should be illustrated with lines instead of a saline-bag
c	ID: Looks like you can use a patient card
c	Want to see treatment time and reality time always on the screen
c	Patients loves when the time thick down
c	Didn't want the same icon on *Blood pump* and *Treatment* (in the right column)
c	Wanted to se the limits in Pv and Pa, and UF total volume
c	Understood BPM and Diascan
c	Read the text instead of the look at illustrations
c	Easy and simple user interface, there is space for other buttons
c	Wanted a tactile blood pump button
c	The limits for Pa and Pv should be seen in the treatment screen
c	There should be a red and green line too look more like Artis and *Gambro*
c	Blood values and Dialysis fluid has the same philosophy like Artis
c	Green line is good for nurses, they can see the line from a distance
c	If you use touch screen there must always be a way back
c	People like touch screen

Table I-55. Discussion ID: 7

Finding	**Notes**
c	The concept should be more obvious with more distinct colour and up-lighted buttons on UF, Bypass and Pump
c	The 9 steps felt good and natural
c	There is a lot of unnecessary button presses if the user need to confirm every box.
c	The symbols were good and clear
c	Was missing UF volume in the treatment display
c	Diascan had a good symbol
c	Alarm: Good with illustrations and not only text
c	The participant rather read than watch the illustrations

Table I-56. Discussion ID: 8

Finding	**Notes**
c	Want to change Identity to Prescription
c	The prescription step should also view information about concentrate, filter and heparin
c	Make it more clear were you should use the confirmation button
c	Good overview
c	Change the illustration on Disposables, for example dialyzes and lines, the dialyzes has higher dignity
c	Unclear blood pump symbol
c	About treatment: UF rate isn't so important, UF volume is more important
c	Understood the BPM and Diascan buttons
c	Good illustration to Diascan
c	Diascan is important for the clinics, this gives a value of how good the treatment is.

c	The alarm symbol could maybe be an alarm symbol, but the participant isn't sure
c	The participant read the text and then watching the illustrations
c	In the adjustments boxes: The limit button should be round like the confirm button, this gives an impression that you can press the button
c	During Priming: Change the "priming" button to a "by pass" button
c	When the user confirming, a home window could appear
c	"Profilering" could be good to have
c	Colour code the arterial and venous side on the illustrations of dialyser, for example in the step *Turn the dialyser*.
c	Develop the Priming symbol, for example more lines to the dialysis fluid
c	More illustration disposables in the *Attach disposables* step
c	Change the *priming volume achieved* and *venous pressure test*, change the line to two lines instead of one
c	Priming: Make an animation of when the machine has detected blood, i.e when the blood pump is stopped
c	Change Bf (blood flow) to QB.
c	*Empty disposables* to *Drain disposables*

Table I-57. Other information ID: 1

Finding	**Notes**
c	Reduce the function test time
c	Hard to press the big clamps on the lines, the small clamps would be enough

Table I-58. Other information ID: 2

Finding	**Notes**
c	Want to save information about the treatment on a usb-stick so that you don't have to write it down

Table I-59. Other information ID: 3

Finding	**Notes**
	none

Table I-60. Other information ID: 4

Finding	**Notes**
	Artis is good to work with

Table I-61. Other information ID: 5

Finding	**Notes**
	The clamps on *Gambro* is better than the one on Fresenius

Table I-62. Other information ID: 6

Finding	**Notes**
c	Should BVS be a function in AK 96?
c	Should TMP be seen in AK 96?