

A photograph of three surgeons in an operating room, wearing green scrubs, masks, and caps, focused on a surgical procedure. The image has a teal color cast. The title text is overlaid on the middle of the image.

ccNexfin System: A New Interface Design

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Foreword

Carrying out my bachelor thesis project at Benchmark Almelo has been a valuable learning experience. Besides that, it gave me a good view on what working in an office looks like. The people at the department were always very kind to me and helped me when I had questions.

During this project I have learned a lot of things. Finding participants of the specific target group was hard, but eventually I was glad people were willing to help me to achieve my goal. Furthermore, doing a project on my own helped me to develop my skills further in graphical interface design and prototyping. I am satisfied with what I have created during this project. There are several things which still can be improved in the new user interface, but I think I have made a meaningful contribution to Benchmark.

I would like to thank everyone who provided me with assistance throughout the project. In particular, I wish to thank the following people:

Christian Suurmeijer, for offering his guidance and support throughout the project.

Arie Paul van de Beukel, for offering his guidance and advice. You have given me new inspiration to come to a better user interface.

All the participants of the usability test and especially Herman Weber. Herman helped me to find more participants in the ICU of the UMCG hospital in Groningen.

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Abstract

The assignment for this bachelor thesis was to discover guidelines for the ccNexfin user interface which contributes to make the user interface more intuitive and more consistent to prevent possible disastrous failures.

First, research was done about what the ccNexfin system measures and how it functions. An analysis has been done on the current user interface to map the menus and their product functions. During this mapping process conclusions were drawn of good and improvable product functions.

Second, the context of use and the stakeholders were analyzed to get requirements about in what sort of context the system should work and what the users their interests are.

A short analysis is done on competitors. Only a short description is given of the functioning of the competitors' system. Most of the attention went to the competitors' user interfaces. A comparison was made and notable differences and similarities were written down.

A heuristic evaluation and usability test/expert review was done in order map the major usability issues of the current user interface. Out of these results conclusions have been drawn about what needed to be improved to make the user interface more intuitive and consistent. Out of all the previous research requirements have been set up to use during further concept generation.

New user interface ideas have been made with a new graphical style and some new interaction possibilities. Also new interface features which were discovered as desirable by participants of the usability test were sketched.

Three different concepts were generated out of the previous ideas. These concepts contain another style, color scheme and menu visualizations. The three concepts which were generated were evaluated by doing a second usability test with experts. Out of the results of these tests conclusions were drawn about what elements the final concept should contain. After finding a way to fit in all positive points of the previous three concepts the final concept was generated. This final concept can be used by Benchmark to exhibit to their clients. Conclusions have been made to evaluate the guidelines which were discovered during the research and design process. Recommendations have been made for possible final iteration options and further interesting research options.

Introduction

The purpose of this Bachelor assignment is designing a more intuitive and consistent user interface for the ccNexfin system. The cc Nexfin system is a medical system which is specialized in non-invasive advanced hemodynamic monitoring and a product of Edwards Lifesciences. Because this interface has an important medical task, mistakes by entering data might have disastrous influence on people's life. Therefore, an intuitive and consistent user interface is needed to prevent users from making mistakes.

This assignment was carried out at Benchmark Electronics in Almelo, The Netherlands. Benchmark has offices spread on several continents. The European offices serve the telecommunication, industrial, medical and test and measurement market. Benchmark Electronics currently produces and designs components of products for Edwards Lifesciences which is specialized in medical equipment. Benchmark's interests, next to satisfy their customers, lie in expanding their product portfolio. This assignment is an example of expanding their product portfolio and will be presented to their customers or potential customers.

The main question which should be answered in this bachelor assignment is: What are the guidelines for the ccNexfin user interface which contributes to make the user interface more intuitive and more consistent to prevent possible disastrous failures? To answer of this question several redesigns will be made of the ccNexfin interface. The final redesign will be presented to the customer as an interactive prototype which can be controlled by a touch screen.

This report is divided into three phases: a research phase, a concept phase and a finalization phase.

During the research phase a closer look will be given to the current user interface and its functionalities in the first chapter. Chapter two will answer what the context of use is and who the stakeholders of this system are. The third chapter focuses on the competitors of the ccNexfin system. Chapter four answers what the points of improvement are. This chapter is divided in a heuristic evaluation, a usability test/expert review, an analysis of visual design trends and analyzing what difficulties color blinds experience. The last chapter of this phase focuses on integrating the previous findings into guidelines and requirements to give guidance during the concept phase.

The concept phase starts with chapter six which shows ideas and gives argumentation on these ideas. Chapters

seven till nine cover the three concepts generated. The argumentation of design choices and considerations will be given per concept in these chapters. The results of the second usability test together with the choice for elements of the generated concepts which will be used in the final concept can be found in chapter ten and eleven.

The finalization phase presents the final concept proposal. Chapter twelve will give a description of this proposal and will contain argumentation of the design choices. Based on the findings from the previous chapters, and based on reflection on the generated designs chapter thirteen will provide recommendations for designing the ccNexfin user interface and will therewith accomplish where this assignment aimed for.



1 / 5 | Research Phase

1 | Introducing the ccNexfin

| Research phase

1.1 The components of the ccNexfin system

The user interface of the ccNexfin system contains the EV1000 system platform. The user interface makes use of a touch screen. The ccNexfin system offers noninvasive advanced hemodynamic monitoring and guidance instead of the traditional invasive monitor equipment. Catheters need to be placed inside the artery which creates a high risk for other complications to the patient. Both invasive and noninvasive hemodynamic monitoring systems measure hemodynamic parameters which will show the status of the patient. Out of the status strategies can be made to improve the health status of the patient. (1) Several measured hemodynamic parameters, which will be explained hereafter, are visualized on the user interface. Additionally, the relations between the parameters are visualized in the user interface and target values for these parameters can be set by the user.

The finger cuff is placed around the finger and contains an infrared LED and photo diode. The finger cuff measures the blood pressure and other hemodynamic parameters. The finger cuffs are connected to the wrist unit positioned on the wrist of the patient. The wrist unit is connected to the pump by a wire and the pump to the monitor. The heart reference system (HRS) is also connected to the wrist unit. The heart reference system (HRS) is required to derive the brachial artery pressure (BAP), which is the blood pressure one acquires from the gold standard of blood pressure. The heart reference system uses a hydrostatic method to measure the difference in height between heart level and finger level. One side needs to be attached to the patient at heart level, the other side is placed on top of the cuff, and is subsequently connected to the wrist unit. The hydrostatic method is a highly efficient and accurate method to measure the distance in height, though it does add an extra cable to the system.

The total system does not only contain a monitor, it also consists of the following components: pump unit, finger cuff, HRS and wrist unit (Figure 1).

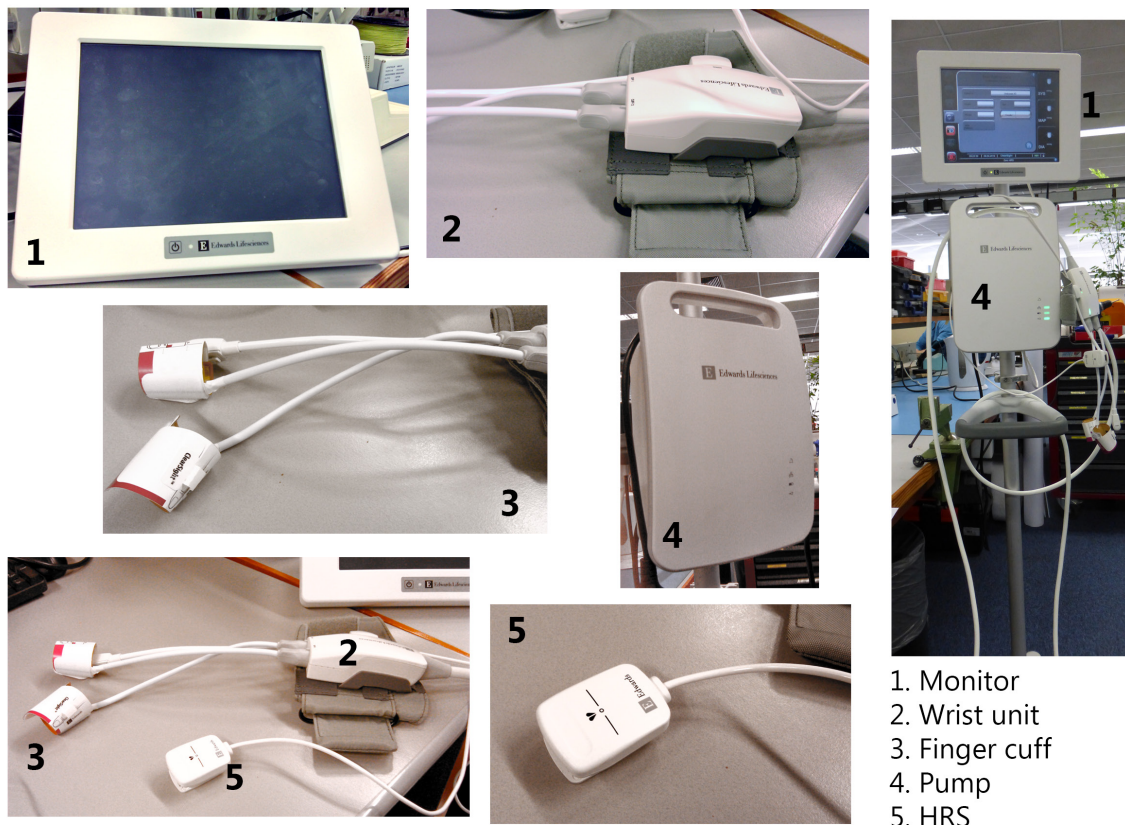


Figure 1. The components of the ccNexfin system

1.2 An overview of the displayed hemodynamic parameters

The interface displays a great variety of hemodynamic parameters, which makes this interface complex. An example of this great variety can be seen in Figure 2. Some of the parameters are measured directly and others will be calculated automatically by the system. The user can set the parameters which will be directly displayed in the main menu. A list of parameters and their definition can be found in Appendix I.

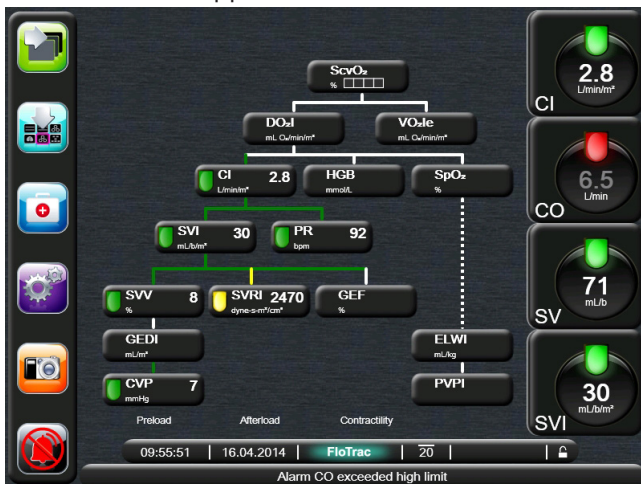


Figure 2. The great variety of parameters

Hemodynamics

In order to understand better what the ccNexfin system measures, it is useful to give a short description of hemodynamics. It is hard to learn all the knowledge of hemodynamics in a short time because of its complexity that is why only basic knowledge will be summed up.

Hemodynamics is the study of blood flow to the body tissues. All the tissues of the body need an adequate blood flow to deliver nutrients and oxygen and remove the products of metabolism. "Any circulatory disturbance leading to inadequate perfusion and inadequate oxygenation of the tissues" is as good a definition of shock as any, but cardiac failure, hypertension and hypotension even without inadequate perfusion all fall under the umbrella of hemodynamics. (2)

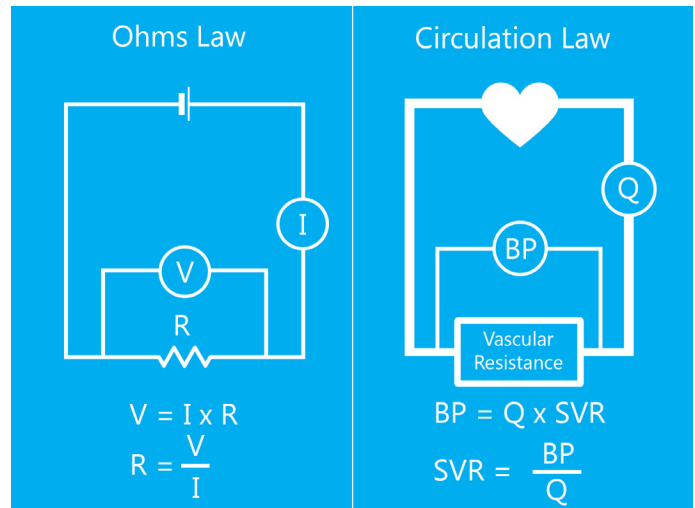


Figure 3. Ohms and circulation law

One of the main parameters is blood pressure (BP). The blood pressure can be too high, hypertension, or too low, hypotension. An analogy of Ohm's law can be used to give a better view on the blood circulation process. Ohms law and the circulation law are visualized in Figure 3. If the blood pressure is too low, it means that the cardiac output (CO) is too low, or the systemic vascular resistance (SVR) is too low, or both are too low. Similarly, it can be said that with a high blood pressure one or both of the parameters are too high. The formula for cardiac output is: Stroke Volume (SV) x Heart Rate (HR). If the patient has a low blood pressure and a low cardiac output it might be caused by a low stroke volume, low heart rate or both. These are some basic parameters which are again dependent on other parameters. The dependency of the parameters to one another can be seen from the list of parameters and their definition in Appendix I.

1.3 Menu descriptions and related product functions

Several menus and their contents will be described and explained during this paragraph. The descriptions will be explained by screenshots of the interface. During this description only a general overview will be given of the menu structure. Some of these screenshots were made during a demo mode on the machine. During this demo mode another way of measurement was shown. In some

screens is the start measuring BP option missing in the navigation bar because of this demo mode.

Installation process

The user can start the ccNexfin system by pressing on the on / off button on the monitor. During the startup process a startup screen with the Edwards Lifescience logo will emerge for a couple of seconds. The first menu the user will see is the Patient data menu. The user should first fill in the data before he can go to another menu option. After filling in the form the home button should be pressed

to confirm the data. Thereafter, the finger cuff should be installed to start measuring data. The menu Zero & Waveform will open during the placing of the finger cuff. This menu shows what the nurse should do during placing the finger cuff and HRS sensor and the zeroing process. By pressing on the question mark more explanation about this process will appear on the screen. After installation measuring can be started by pressing on the green Start measuring BP button. The screens which the user sees during this measurement preparation process are visualized in Figure 4.

Screens during measurement



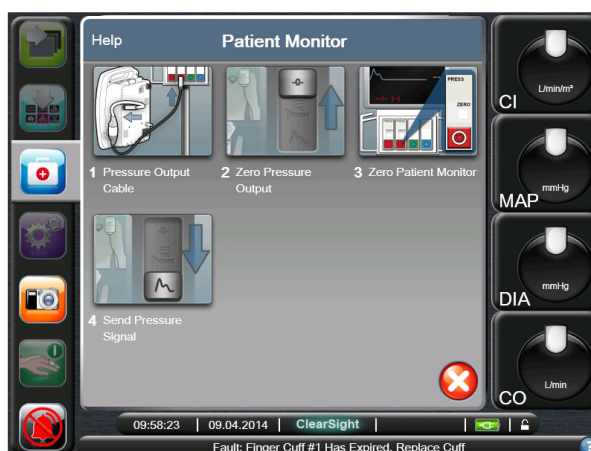
Patient Data Screen



Zero & Waveform menu



Align & Zero HRS help Screen



Zero Patient Monitor help Screen

Figure 4. Screens during measurement

Main menu

Figure 5 shows a picture of the main menu screen. A navigation bar is positioned on the left side of the main menu. The navigation bar contains seven colored icons which visualize menus and hotkeys for frequently used functions. The colors give recognition to the user; however it does create noise on screen. The remaining space on the main menu is filled with one of the following monitor screens:

- Tabular Trend Display
- Numeric Value Screen
- Big numbers
- Physiology Screen
- Cockpit Screen
- Physio-relationship Screen

These monitor screens are the most important and need therefore enough space on screen. The functions of these screens will be explained later during this paragraph. The extra information like time, date, warnings and battery status are placed on the lower side of the screen. Some of these buttons for example Screen Lock and the Help

Button can be pressed; however there is no distinction between buttons which can and cannot be pressed. This situation might lead to irritation to the user.

Quick scroll

By pressing the Quick Scroll button the user can scroll through the six different screens in the main menu. While pressing on this icon a second icon will appear with an arrow pointing to the opposite side. The second icon which points to the left is placed next to the right side of the right pointing icon (Figure 12 physio-relationship screen). This is not the standard placement of arrows which makes this function not intuitive to the user. Besides, the second icon is placed outside the navigation bar above another button in a monitor screen. This looks a bit sloppy while using this interface.

Monitor Screen Selection

A new menu will appear by pressing on the Monitor Screen Selection button (Figure 6). On the left side of the menu the numbers one, two, three and four will appear. By pressing on one of these numbers the user can decide how many key parameters will be visualized in the main menu. This is an easy way to change the amount of key

Main Menu



Figure 5. Main menu

parameters; however these four tabs might be overlooked by beginner users because most of the attention goes to the six screens. The six information screens mentioned previously are placed on the right side of this menu. The user can select an information screen either by using the Quick Scroll button or by using the Monitor Screen Selection tool which will be visualized in the main menu.



Figure 6. Monitor Screen Selection

Clinical Actions

By pressing on the Clinical Actions icon a new menu will appear above the main menu (Figure 7). The user can choose the following options in this menu:

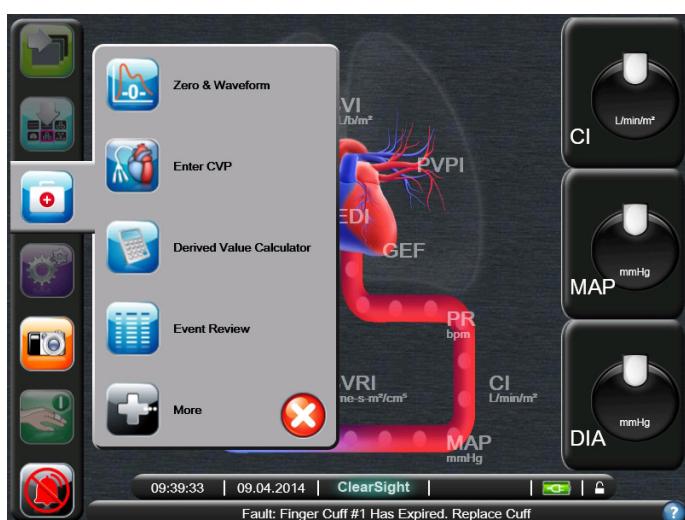


Figure 7. Clinical Actions

- Zero & Waveform
- Enter CVD
- Derived Value calculator
- Event Review
- More

Notable is that the menu size is different from the other two menus. Besides that, new icons are used instead of only text. Only text would probably be enough to make the menu functions clear to the user.

Settings

The user should press the Settings icon to change the settings of the ccNexfin system (Figure 8). The settings are divided into different categories which are:

- Patient Data
- Monitor Settings
- Parameter Settings
- Data Download
- Demo Mode
- Engineering
- Help

Inside these categories more options will be offered to the user. This menu structure is clear and does not give too many options to the user at once. A notable issue is that only this menu can be closed by pressing the home button instead of a cross.

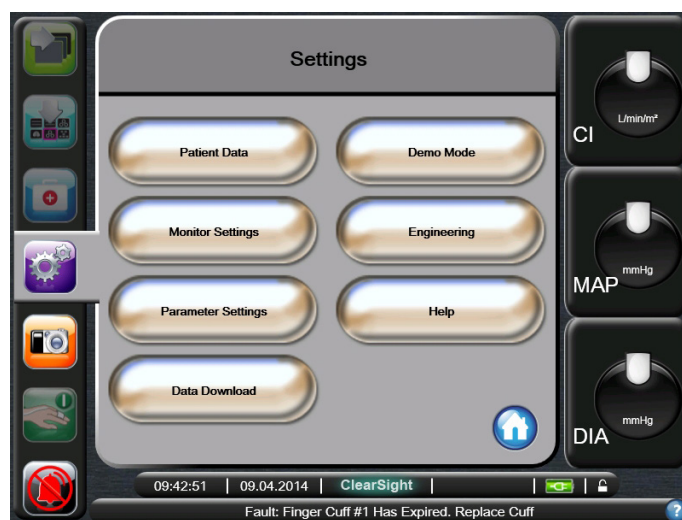


Figure 8. Settings

Screen Capture “Snap Shot”

The user can make a screen capture of for example a critical moment by pressing on the Screen Capture button. The pictures will be stored on a USB stick. In case no USB is detected by the device a warning will pop up which shows that a USB should be placed before a screen capture can be made. After the screen shot has been made the monitor mentions that the photo is being stored.

Start measuring BP

Measuring data will start by pressing on this button. This button has a grey overlay if the system is not zeroed.

Alarm Silence

An alarm signal will be given after filling in Patient Data every set number of seconds. The alarm can be set off by pressing the Alarm Silence icon.

Tabular Trend Display

One of the screens of the main menu is the Tabular Trend Display (Figure 12). The chosen parameters are displayed in a graph form. The time interval is set on the X-axis and can be adjusted by pressing on the graph. A popup menu will appear which gives several time interval options. The Y-axis contains the value range of the measured values which can be adjusted in the same way as the X-axis. A triangle which contains an intervention menu is positioned on the left side of the screen. Globes are positioned on the right side of the screen. The globe shows the measured or calculated value of the chosen parameter in the middle. A pointer is positioned above the value and has a certain color depending if the value is good or bad. The total functionality of the globe will explained later on.

Numeric Value Screen

The chosen parameters are also shown in this screen (Figure 12). The form in which it is visualized is different, because the graph is now placed in different rectangles. A rectangle visualizes a certain time interval. In this case the globes are also positioned on the right side of the screen.

Big Numbers Screen

The Big Numbers screen contains the globes of the selected parameters (Figure 12). This screen only contains the globes and does not visualize a graph. This screen is used to make it easier for clinicians and other personnel to see the values from a distance.

Physiology Screen

The globes are positioned on the right side of the screen. A visualization of the cardiovascular system and the lungs can be found in this screen (Figure 12). The visualization contains the following parameters: SVV, ScvO₂, CVP, SVRI, MAP, CI, PR, GEF, ELWI, GEDI, SVI and PVPI. Each parameter contains a pointer with a certain color which indicates whether the value is good or bad. The

visualization is an animation where the user can really see the heart pumping. This animation is probably not necessary because the user of this system already knows this information. Besides, this animation creates noise on screen which is not desirable for the user.

Cockpit Screen

This screen displays several extensive globes (Figure 12). The values of the chosen parameters are displayed in the middle of the circle. Around the circle is a schematic area which contains red, yellow and green areas. The grey pointer shows whether the measured values are in the red, yellow or green zone. The scale of the value is positioned around this colored area. This screen contains a lot of color and looks like a meter in a car. This might be a good metaphor, because most of the users are familiar with this concept.

Physio-relationship Screen

The Physio-relationship Screen shows a tree structure of all the parameters (Figure 12). The parameters which are shown in this tree are: ScvO₂, DO₂I, VO₂Ie, CI, HGB, SpO₂, SVI, PR, SVV, SVRI, GEF, GEDI, CVP, ELWI and PVPI. Relations are shown between these parameters as green stripes, white stripes, yellow stripes, red stripes and dotted white lines. On the right side globes of the selected parameters are shown. A lot of information is visualized in this screen; noise should be reduced as much as possible to reduce the complexity.

The Globe

The globe is a meter which shows the measured value of the chosen parameter (Figure 10). The figure in the form of a pointer can have different colors depending on the target values and the measured values. The color is grey, if there is no measured value available. The pointer is green if the measured value is in the desired target zone. The pointer is yellow if it is a certain percentage away from its target value and it is red in case the measured value is far away from the desirable target value. The globes in

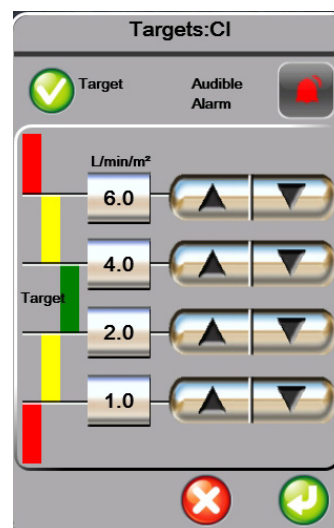


Figure 9. Target value menu

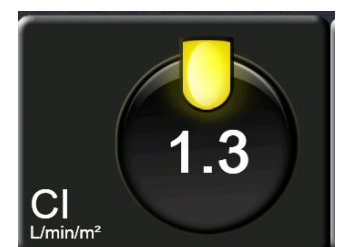


Figure 10. globe

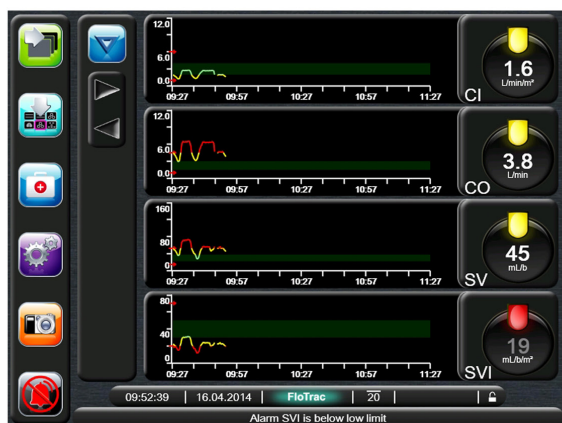


Figure 11. Cockpit Screen globe

the Cockpit screen are more extensive (Figure 11). In these globes it is more clear if the value positioning is too high or too low for its target value. If a measured value is in the red zone it starts blinking to gain attention from the user. By pressing around all the globes it is possible to change the parameter that will be visualized. A new menu will pop-up where the already chosen parameters are selected and

a new selection can be made. By pressing inside a globe it is possible to change target values and alarm settings (Figure 9). The adjustments of these settings can also be made in the settings menu. These shortcuts are quite useful; however the action of pressing inside or outside the globe will probably lead to difficulties by pressing the wrong side and getting the wrong menu.

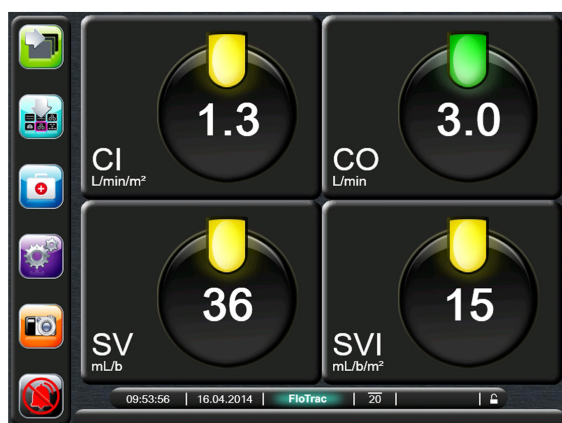
Monitor Screens



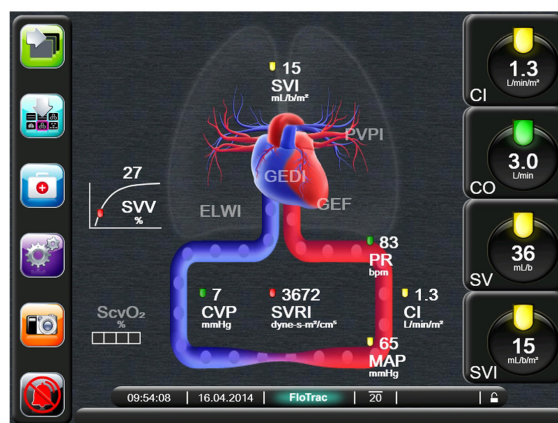
Tabular Trend Display



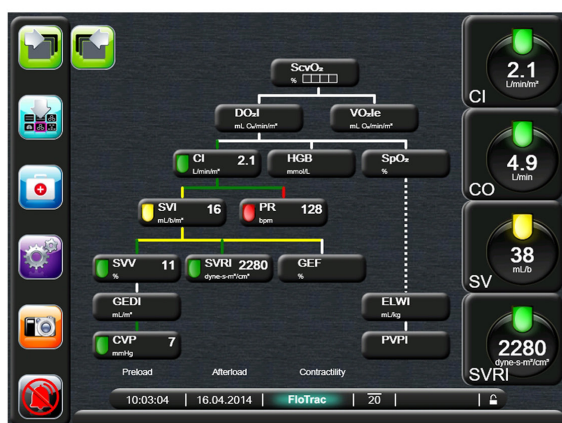
Numeric Value Screen



Big Numbers



Physiology Screen



Physio-relationship Screen



Cockpit Screen

Figure 12. Monitor Screens

Interaction styles

There are two main forms of interaction styles used in the Nexfin interface, namely menu selection and form fill. Most of the interaction forms are menu selection. Functions are organized to their tasks, especially in the settings menu. To give input to the system form fill interaction is used. For example patient data and target values can be set via a form fill.

Menu buttons

There are several kinds of buttons used: List buttons, value buttons, scroll buttons, normal buttons and slider buttons. Figure 13 visualizes these buttons. Notable is that the buttons have a chrome look except the slider button. The list button can be touched on both sides; a popup menu will appear with several choices. The choice made by the user will be placed on the right side of this button. Switching an option on and off can be done by using the slider button. A keypad will appear by touching the value buttons.

Examples of these keypads are shown in Figure 14. The user can give the input value and press enter to confirm the input data. In case the value does not meet the value range a warning will appear. The screen parameter menu has three different statuses: no color, color and stroked.

Keypads

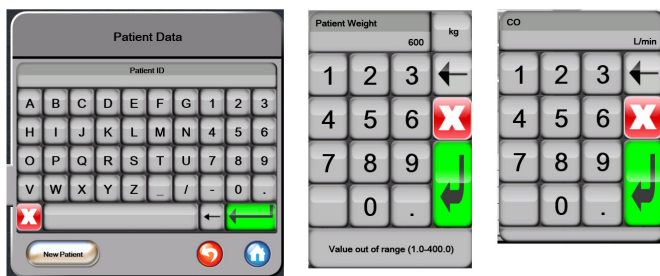


Figure 14. Keypads

Settings Menu



Figure 15. Settings Menu

Buttons

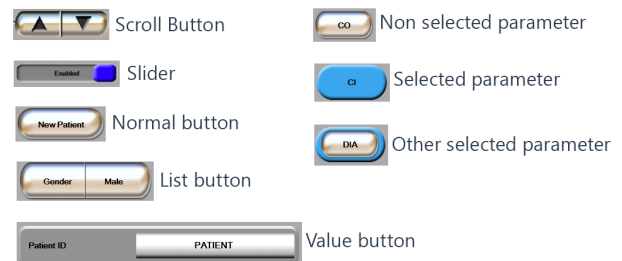


Figure 13. Buttons

1.4 Menustructure

A clear overview of the system will be given by describing the menu structure. The main functions are visualized in Figure 16. The main menu is the head of the tree structure. The navigation bar is the next layer of the tree. By touching the Quick Scroll button or Monitor Screen Selection button the different screens can be selected. In these six screens menu parameters, targets and alarms can be adapted to the preferred settings. This can also be done in the settings menu. The settings menu also has a tree structure with several choices of subgroups. An example of this structure is shown in Figure 15. Options which the user may need very quickly such as Snap Shot and Alarm Silence are also placed in the navigation bar.

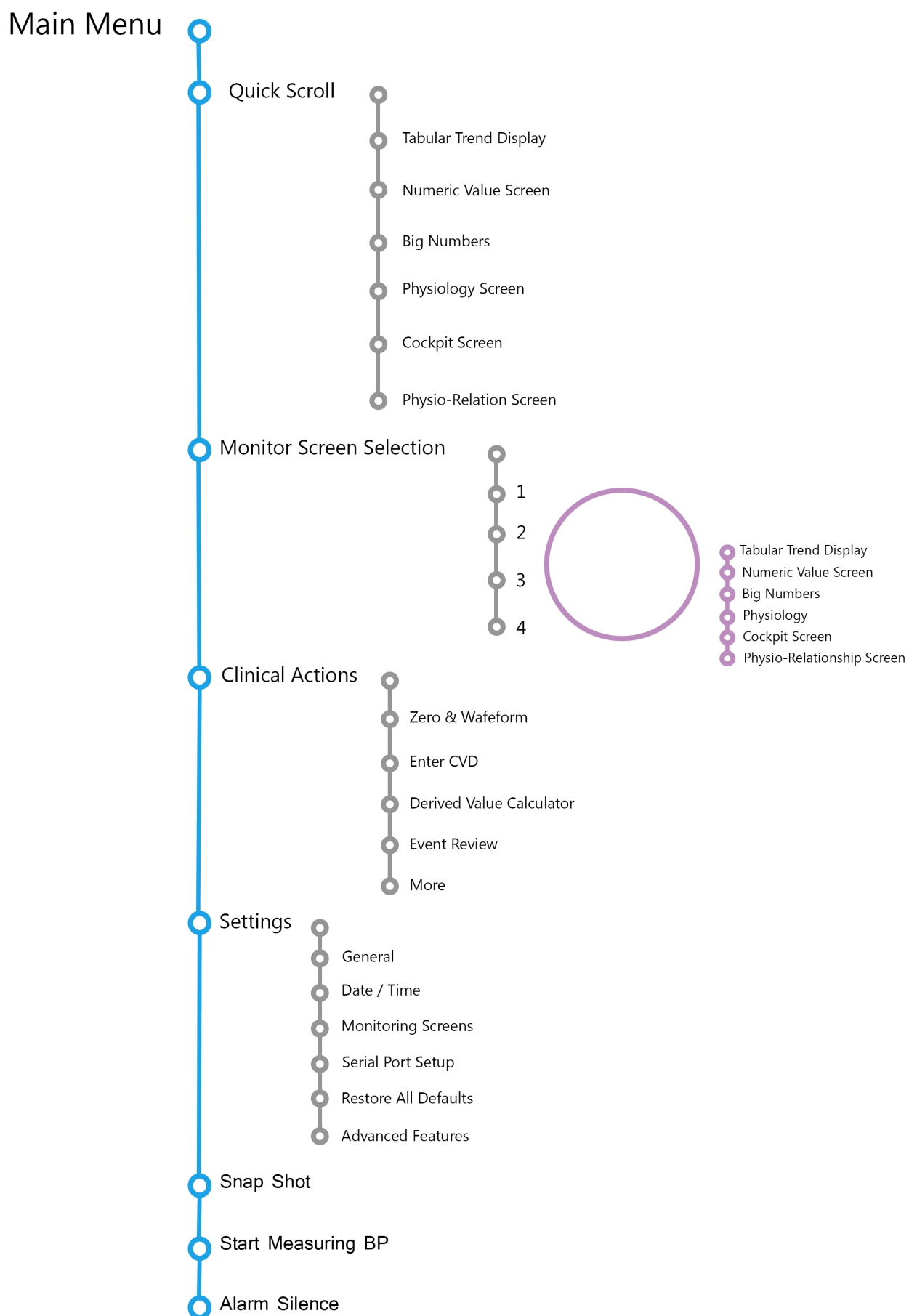


Figure 16. Menu Structure

2 | Context & Stakeholders of the ccNexfin system

2.1 The context of the ccNexfin system

The ccNexfin is aimed at the following two markets: cardiology and critical care (Grob, 2012). The following citation of the website of Edwards gives a clear overview in which situations the ccNexfin system might be used.

ccNexfin system offers the advanced physiological parameters that are necessary to help clinicians with the early detection of hemodynamic deterioration and for hemodynamic management. It is suited for surgical patients who are at risk of developing hemodynamic instability, or who may benefit from perioperative hemodynamic optimization. (3)

It can be concluded that the system can be used during the surgery but also during rehabilitation of the patient. A description of the context, in which the ccNexfin might be placed, will be described during the next paragraphs.

Operating Room (OR)

The surgery takes place in an operating room (OR) (Figure 17). This is the unit in the hospital where surgical procedures are taking place. Operating rooms are sterile environments; therefore all personnel needs to wear protective clothing called scrubs. They also need to wear shoe covers, masks, caps, eye shields, and other coverings to prevent the spread of germs. The operating room is brightly lit and the temperature is very cool. Furthermore, the operating room is air-conditioned to help prevent infections. The operation takes place on an operation table, which is narrow and has safety straps to keep the patient positioned correctly. During the operation monitoring equipment is used. The monitoring equipment and anesthesia used during surgery are usually kept at the head of the bed. The anesthesiologist sits here to monitor the patient's condition during surgery. An operating room has special equipment such as respiratory and cardiac support, emergency resuscitative devices, patient monitors, and diagnostic tools. (4) The ccNexfin system is one of these monitoring equipments which are placed at the head of the bed next to other monitoring equipment.

Intensive care unit (ICU)

Another place where the ccNexfin system can be implemented is the intensive care unit (ICU). An intensive care unit, or ICU, is a specialized section of a hospital that provides comprehensive and continuous care for persons who are critically ill and who can benefit from treatment. ICUs are highly regulated departments, typically limiting the number of visitors to the patient's immediate family even during visiting hours. The average size of an ICU is 10 to 12 beds per unit. The patient usually has several monitors attached to various parts of his or her body for real-time evaluation of medical stability. The intensivist will make periodic assessments of the patient's cardiac status, breathing rate, urinary output, and blood levels for nutritional and hormonal problems that may arise and require urgent attention or treatment. Patients who are admitted to the ICU for observation after surgery may have special requirements for monitoring. These patients may have catheters placed to detect hemodynamic (blood pressure) changes, or require endotracheal intubation to help their breathing, with the breathing tube connected to a mechanical ventilator. (5)

Medium care unit (MCU)

A third place where the Nexfin system will fit in well is the medium care unit. The MCU is suitable for patients who do not need the entire intensive care service, however they need more care than which is given on the standard nursing department. (6) Patients can be attached to a heart monitoring system, an infusion and / or ventilator system. A scenario made by L Schäffer visualizes the situation on the MCU (Figure 18).

Context of use



Figure 17. Context of use

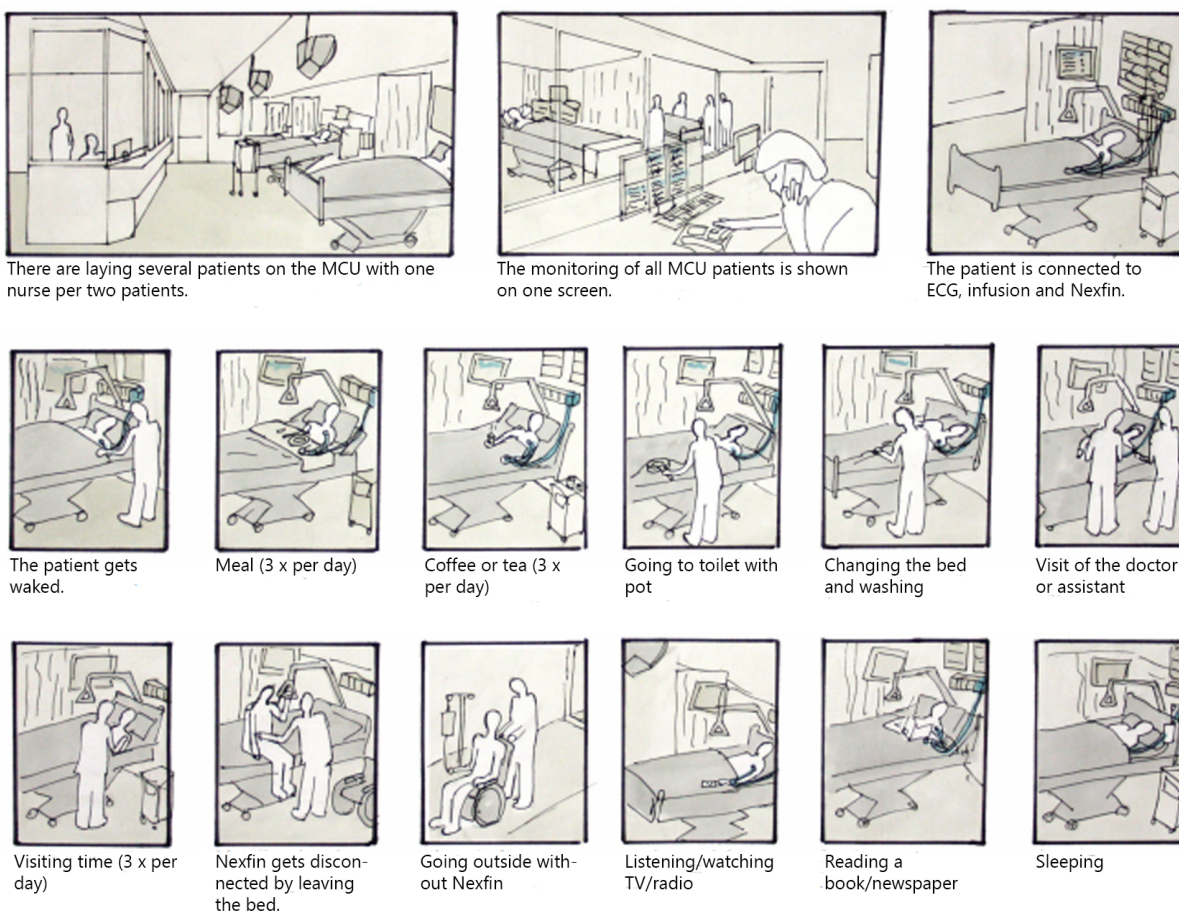


Figure 18. Medium Care scenario

2.2 Stakeholders and their interests

The stakeholders on both cardiology and critical care are comparable. The stakeholders in these situations are: patients, nursing staff, doctor, surgeon, anesthesiologist, and acquisition. From the analysis of the context can be concluded that the anesthesiologist and the intensivist have most of the interaction with the user interface of the ccNexfin system, because they have to control the measured parameters of the patient. An overview of interests of the stakeholders made by M. Grob can be seen in table 1.

Stakeholder	Interest
Patient	Comfort Unobtrusiveness Freedom of movement
Nursing staff	Ease of use High guess ability Unobtrusiveness in OR
Doctor	Accurate data Ease of access to data
Surgeon	Accurate data Ease of access to data Unobtrusiveness
Aesthesiologist	Accurate data Ease of access to data Ease of use
Acquisition	Accurate data Low price High quality / durability
Maintenance	Easy access to components Easy to tag and identify

Table 1. Stakeholders

2.3 Characteristics of the main stakeholders

During this paragraph the two main stakeholders who

have direct contact with the user interface will be specified.

Anesthesiologists

Anesthesiologists are the physicians trained to administer and manage anesthesia given during a surgical procedure. They are also responsible for managing and treating changes in your critical life functions - breathing, heart rate, and blood pressure - as they are affected by the surgery being performed. Furthermore, they immediately diagnose and treat any medical problems that might arise during and immediately after surgery. Prior to surgery, the anesthesiologist will evaluate the patient's medical condition and formulate an anesthetic plan which takes that patient's physical condition into account. It is vital that the anesthesiologist knows as much about your medical history, lifestyle, and medications as possible. (7) The age of anesthesiologists lies approximately between 30 to 65 years old. (8) They have a high educational level and are male or female.

Intensivist

Intensivists are physicians who direct and provide medical care in a hospital's intensive care unit (ICU), working with the physician on duty and other staff such as critical care nurses, pharmacists, respiratory therapists, nutritionists, rehabilitation services, social workers, case managers and especially spiritual care - as well as physician specialists. (9)

2.4 Use Situation of the cc-Nexfin system

The health status of the patient should be measured during a surgery or when the patient rehabilitates from a surgery. The ccNexfin monitors the hemodynamic parameters of the patient during the surgery in the OR and the critical care time in the ICU. As already mentioned before the ccNexfin is suited for surgical patients who are at risk of developing hemodynamic instability, or who may benefit from perioperative hemodynamic optimization.

2.5 Process of use

During prior researches done by L.S. Schäffer and M.B.C Grob, a scenario of use in the OR and ICU settings was made. This scenario focuses more on the actions to prepare for measurements and after (Figure 19). The interaction with the user interface is not mentioned in this scenario.

- Depending on the condition of the patient, he will be placed on the nursing ward, medium care, intensive care or emergency care.
- The patient will be transported and moved to the pre-OR where he will receive an ECG pad.
- The Nexfin is taken into the OR.
- The patient is moved from the bed to the OR table.
- The patient will receive an infusion line and anesthetics
- The Nexfin is applied and hooked up.
- During surgery the patient may lie in a wide variety of positions.
- After surgery, all equipment is disconnected and wiped down.
- The patient is transferred to the recovery room.
- In the recovery room the patient will be monitored.
- During a longer stay, the patient will be washed, during which equipment may be moved or even removed.
- After surgery all equipment will be disconnected and wiped down.

The tasks of the anesthesiologists and intensivists are more dependent on the user interface. They need a continuous update of the hemodynamic parameters in order to decide what actions should be taken to meet the target values of the set parameters. Actions such as giving an intervention should also be updated to the system by the anesthesiologist or intensivist.

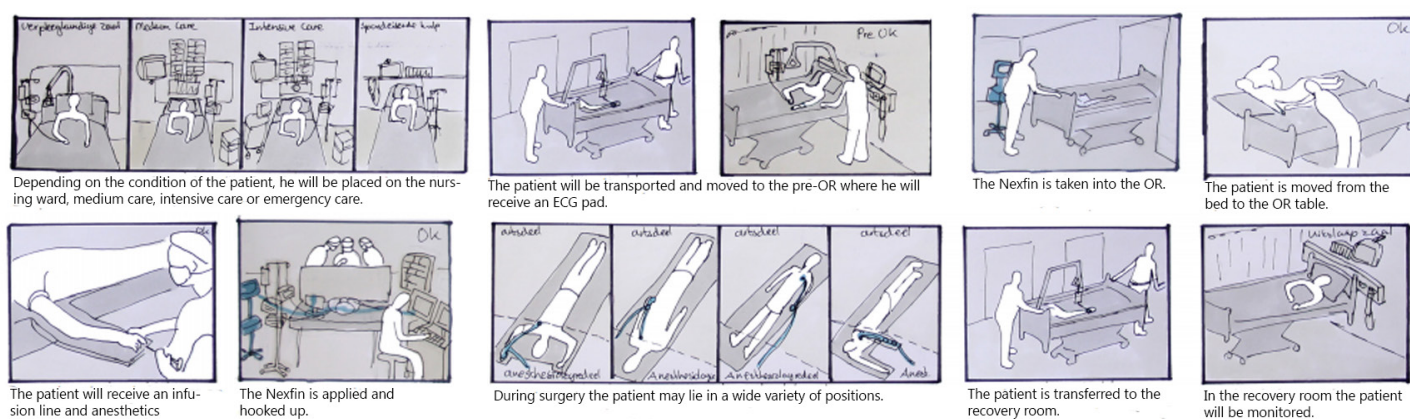


Figure 19. Use scenario OR and ICU

3 | Identification of the competitors

3.1 Competitors

During previous market research done by M.B.C Grob several important competitors on hemodynamic monitoring systems were uncovered. The competitors who are mentioned in this research are: Finapres, Tensys, Atys, Dräger, and CNSystems. This paragraph will give a short description how the competitors present their products. Pictures of the competitors are shown in Figure 20.

Finapres

The Finapres® NOVA is hemodynamic monitoring system. The Finapres® NOVA is a non-invasive continuous blood pressure monitor that can be expanded at any time with several hardware modules and software applications of choice, enabling to define the monitor appropriately for daily operations. (10) Other devices from Finapres are: The Finometer and Portapres.

Tensys

The company's CE-Marked T-Line technology is presently used in hospital operating rooms, ICUs and electrophysiology labs to provide a patient's real-time pulse pressure waveform and blood pressure. The T-Line family of products allows early recognition and treatment of rapid changes in blood pressure in the OR and improves diagnosis and management of cardiovascular conditions. (11)

Atys SysToe

This system makes use of the same volume clamp method as Edwards. However, instead of being placed on the more uniformly shaped finger, it is placed on the patient's toe. As a result of the less convenient shape of the toe, the SysToe features a dual sensor: the occluding cuff is wrapped on the proximal phalanx of the big toe and the sensor is placed on the distal pad of the toe.

Dräger

The Infinity® CNAP™ (Continuous Noninvasive Arterial Pressure) SmartPod® provides a simple, accurate method for measuring systolic, diastolic and mean blood pressure. Simply slip the sensor cuff onto the patient's fingers. Once applied, the patient monitor can continuously display the arterial pressure values and pressure waveform. CNAP offers a fast and simple way to create a continuous blood pressure reading. (12)

CNSystems

The CNAP® Monitor 500 standalone is designed for continuous noninvasive hemodynamic monitoring in a wide range of applications, i.e. electrophysiology, operating theatres, critical- and intermediate care, emergency room and transport. (13)

3.2 Analyzing the competitors' interfaces

During this paragraph the user interfaces of the competitors will be analyzed. It was not possible to find all the appearances of the interfaces, however the interfaces which were available will give a good insight of other options for interface design. An overview of menu appearances of several competitors' interfaces are shown in Figure 21.

The Finapres NOVA and the T-line of Tensys use a touch screen equal to the Nexfin system. Most of the interfaces use a black background color except for the SysToe. A black background color provides a high contrast with the high saturated colors used in the interface. A white background color is not better in this situation because of the lack of contrast. The SysToe only uses blue and white to visualize the measurements and does not give an indication by color whether a measured value is good or dangerous.

Interfaces like the T-line and CNSystems, comparable to the ccNexfin, use a small color palette with almost all basic colors. A white line separates the different functions displayed. Notable is that the use of icons is less in these interfaces. The date and time are positioned at the top of the screen just like a Smartphone or tablet. The patient data is also visualized at the top of the screen at the T-line system. These two interfaces do not work with other background colors for menus as the Nexfin uses different types of grey. The CNSystem does not contain or does not have a clear navigation bar where the user is able to get into another menu. Interesting is that the Tensys

Competitors

CNSystems



Tensys T-line



Dräger



Finapres



Atys SysToe



Figure 20. Competitors

interface contains “A road to health” menu where a real-time snapshot of the patient’s key hemodynamic parameters is shown. It can be compared with the Physiology Screen of the Nexfin.

It might be said that these two interfaces look more professional than the colorfull and round interface of the Nexfin, because it has less noise. However, the interface of the Nexfin looks more intuitive because of the use of symbols. The CNSystem and Tensys interfaces have more text which makes it harder to understand a function in a short time. Besides, the Tensys system is not consistent in the placing of the navigation bar.

It can be concluded that in many medical devices for hemodynamic purpose a black background color is used. The black background is needed to obtain a high contrast with the basic colors which have to warn the user. Symbols and colors can make the user interface more intuitive but an overload should be avoided to keep the interface clean.

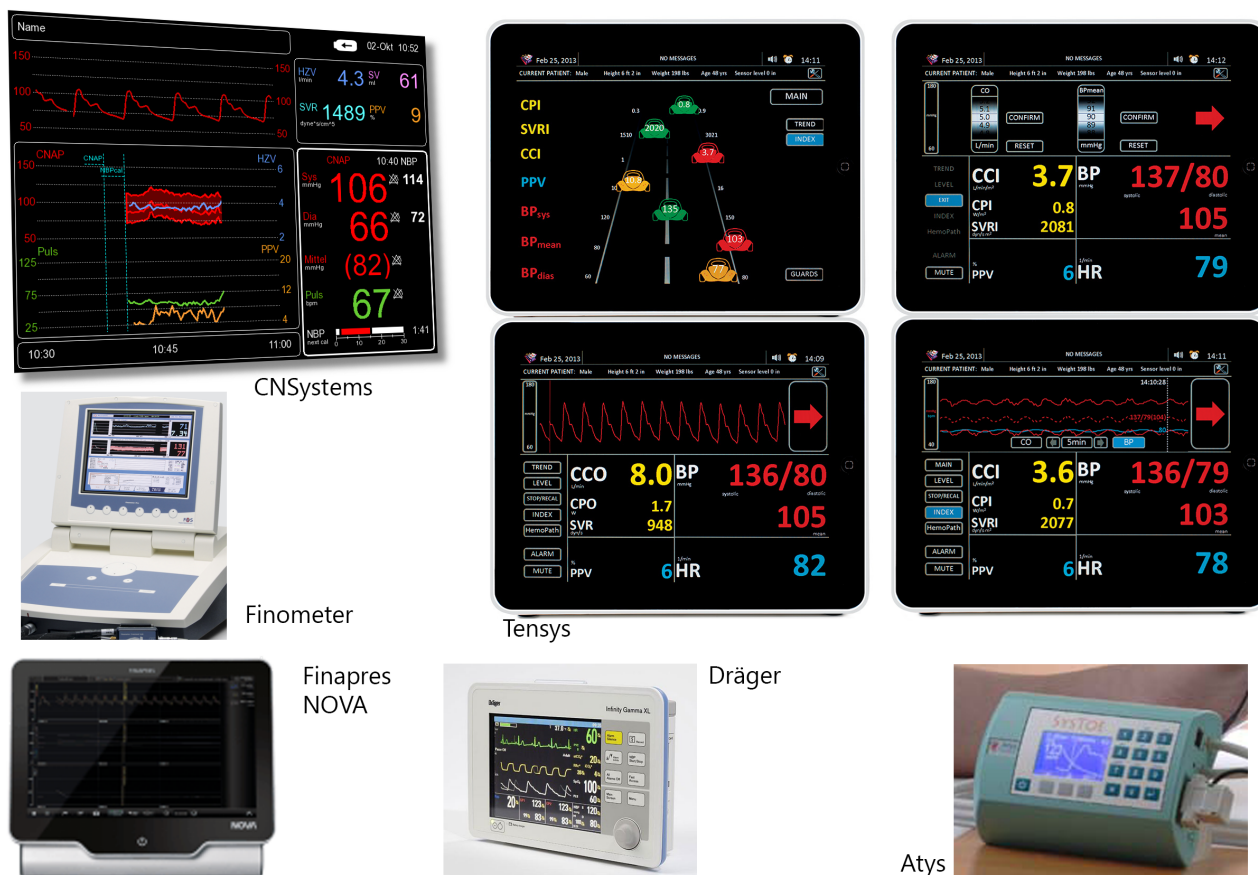


Figure 21. Competitors interfaces

4 | Discovering the Points of improvement

Before actually starting to make a redesign it is important to know what usability issues are and what the end-user expects from this system. Besides that, it is important to know what the visual design trends are to create a new input for a graphical look. A list with points of improvements will be the result of this paragraph.

4.1 Heuristic evaluation

The first step to identify interaction problems is by doing a heuristic evaluation. The heuristics which are used during this evaluation are the heuristics made by Nielsen.

10 heuristics of Nielsen (14)

1. Visibility of system status

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

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.

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.

4. Consistency and standards

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

5. Error prevention

Even better than good error messages is a careful design which prevents a problem from occurring in the first place.

6. Recognition rather than recall

Make 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.

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.

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.

9. Help users recognize, diagnose, and recover from errors

Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.

10. 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.

Results

The usability problems which were found during this evaluation are visualized in table 2. The problems which were found are also rated with the following scale:

Mean severity rating:

- 0: Not a usability problem at all.
- 1: Only a cosmetic problem.
- 2: Minor usability problem.
- 3: Major usability problem.
- 4: Usability catastrophe.

A visualization of several usability issues are shown in Figure 22.

Table 2. Heuristic evaluation

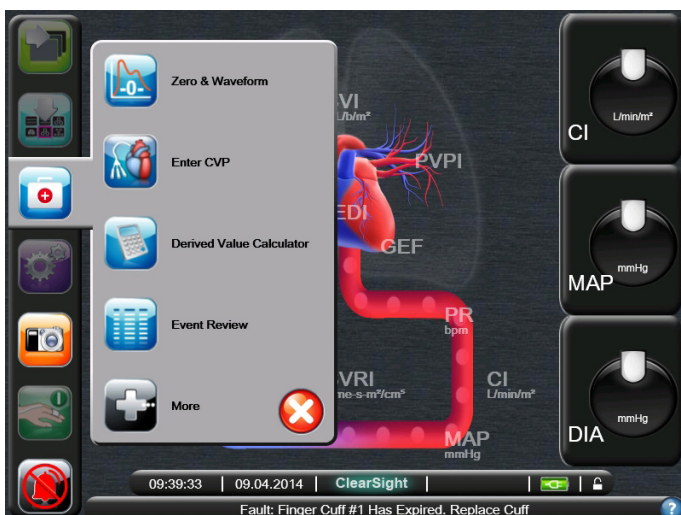
Places of occurrence	Usability problem description	Heuristics violated	Mean severity rating
Patient Data menu	It is possible to give patient data input which are in relation with each other not realistic. For example: A two year old female with the length of 35 cm and a weight of 130 kg. No error was given.	5	3
Startup screen	There is not any indication given how long the startup stage takes.	1	1
Monitor screen selection menu	A number can be selected, but it can only be confirmed by touching one of the six screens and not by touching the X afterwards.	7	2
Globe	A shortcut is possible to change the globes settings. By touching the outside of the globe the parameter can be changed. By touching inside the globe the parameters' targets can be changed. When there are four small globes it is harder to touch in or outside the globe.	6, 7	2
Type menu target value	The non optional icons do not have a grey layer on them which implies that the option is still optional.	4	2
Navigation menu	The home button should first be touched in the submenus before the menu closes. It is not possible to escape from a menu by touching the icon again.	7	2
Settings menu	The route that the user has taken is not visible. For example: Settings – Parameter Settings – Alarm / Targets is not visible.	6	2
Monitor Screen selection/ Medical Actions	Some menus or important screens do not contain a menu name. But have a name mentioned in the manual.	4, 6	2
Medical Actions	It is not possible in this menu when the user chooses the wrong option to go one step back. The menu should first be closed and the Medical Actions icon should again be touched. There is no previous button just like in the settings menu.	3, 4	3
Medical Actions	By opening medical actions does this menu does not spread over the total screen as the two other options do.	4	1

Places of occurrence	Usability problem description	Heuristics violated	Mean severity rating
Main menu	Several options are grouped together by an outline which looks like a button. However, the navigation bar, warnings, time and date bar are not buttons.	4	2
Value button	Value button has a gradient overlay which might lead to less recognition.	2	1
Patient data / Settings	A title and a menu selection are visualized as one button with a small stripe in between. This might not be familiar to the user	2	1
Patient data	While entering the patients name a keyboard will pop up. Under the keyboard are the back icon and home icon still visible, they do not have a grey gradient over it. The buttons can however not be pressed.	4	2
Menu	Some menus can be closed by pressing the cross and others by pressing the home button.	4	2
Globes	The unit of the parameter is positioned on the left beneath the globe in the big numbers and cockpit screen. In the other globes of the monitor screens the unit is positioned under the parameter value in the Globe.	4	1
Sliders in Settings menu	The sliders are blue instead of chrome like the other buttons in the menu.	4	1
Several menus	Menu name is black with a dark grey background. This may lead to difficulties in a bright lighted environment because of the lack of contrast.	1	1
Error popup	Error popup does not contain a darker color in the menu title area. Other menus do have this distinction.	4	1
Main menu	There are many different boxes with different styles. This causes noise to the user.	8, 4	3



- Not all non optional buttons have a grey overlay.
- The warning and date/time bar look like buttons but do not have this function

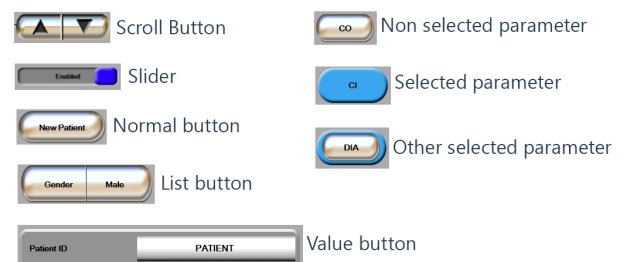
- No route indication.



- Menu is smaller than other menus.
- Menu can be closed by pressing on cross instead of home button.
- Menu does not contain name.
- Icons and text are used together.

- This menu does not contain a name.
- Choice of amount of parameters can only be confirmed by pressing on one of the six screens.
- The background contains the same color as title bar within other menus.

Buttons

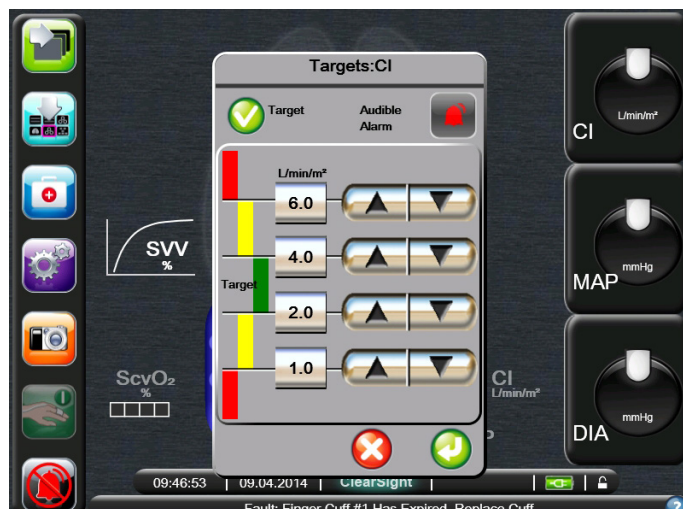


- Buttons do not have the same look.

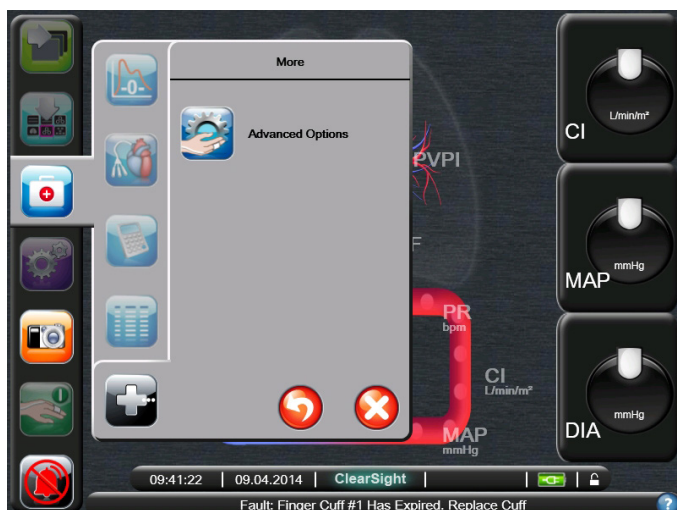
Figure 22. Usability issues



- Title part does not have a dark background.
- Not all non optional buttons have a grey overlay.
- There is no standard size for pop up screens.



- There is no standard size for pop up screens.
- Not all non optional buttons have a grey overlay.
- Title part does not have a dark background.



- Menu is smaller than other menus.
- Title part does not have a dark background.



- There is no standard size for pop up screens.
- Not all non optional buttons have a grey overlay.
- Title is missing.



- Instruction pictures were not clear to the participants of the usability test.
- Screen does not contain a back button.

Most of the problems found are minor usability problems or only a cosmetic problem. The patient data problem is quite interesting, because each value on its own has a certain value range but if the user puts in all the data between these value ranges but in case they are not realistic in combination with each other, it is still possible to make a mistake. Another major usability problem is the medical actions menu. In case the user has to go fast to a certain sub option but accidentally chooses the wrong option he first needs to close the whole menu which means one extra action for the user. The big amount of inconsistency in the interface might lead to crucial mistakes which might lead to wrong intervention by the user. A clear and consistent interface will reduce mistakes and make it easier to use.

4.2 Usability test/Expert review

A usability test and expert review has been made in order to evaluate the usability of the current interface. The participants all have a different background: nurse in training to become IC nurse, TG student and two IC nurses. All have used medical equipment before and have at least some medical knowledge.

The participants first had a brief introduction after which they had to execute several tasks to get acquainted with the interface. After the tasks had been executed opinions about several aspects were asked during an interview. The tasks and questions can be found in Appendix II. The tasks were executed by the participants with barely any information about the functionality in order to test the intuitiveness of the interface. This has led to the fact that the participant could not find some options without help.

Results of the usability test

Most common mistakes

Most of the tasks were executed much slower than previously assumed. This shows that not all options were clear to the users during their first interaction experience. One of the hardest tasks was to change parameters in the monitor screen. Two participants could not find it without help and two participants found it by accident. Some users

recommended that this option should be in the settings menu and/or a cue next to the globes that the user knows that it has a function. Another error that occurred was pressing next to a menu to go to another menu. The menu should first be closed before the user can navigate to another menu. The placement of the components during the zeroing process and starting the process were not clear. Notable is that none of the users recognized they had to push the zero button. Changing the number of parameters on the main screen also led to some difficulties. They press the right number but after this action they press on X. The menu closes and their choice has not been saved. The last task which has led to problems is changing the temperature from Celsius to Fahrenheit. The participants started to search in the parameter settings instead of the general settings. Another notable issue is the intervention button, participants were trying to use this button to scroll to another monitor screen or trying to change the amount of parameters visualized on screen.

Review

The participants are satisfied with the user interface. It looks compact and clear to them. However, they did experience some poor or not logical interaction. This means that there is room for improvement. One of the IC nurses missed the heart rate on the monitor screen which should have been measured to calculate Cardiac Output. Another point which he mentioned was that it would be desirable to measure saturation next to the hemodynamic parameters. The scroll button and snapshot were regarded as an 'unnecessary feature'. They use the monitor screen menu to navigate to another monitor screen instead of using the scroll button. Participants would like to change the start measuring BP button in a start/stop/pause icon button. It is more recognizable to use standard symbols. Another issue is the numbers of different parameters choices to visualize on the screen. They would like to decide during entering patient data which parameters are important for this patient and other parameters should not be visualized on screen in order to prevent noise. The placement of the navigation bar is not a major issue. Some participants said it might be useful for the user to decide where the navigation bar is placed but it is not necessary. Not all the icons in the navigation bar were clear. One participant thought that the scroll button was a save button because of the arrow and green background. The clinical actions menu button has an emergency trunk symbol. One participant thought intervention should be

placed there. However, there are only options placed which do not have anything in common with emergencies. Another point mentioned is that it is desirable to have as few options as possible in the navigation bar. The participants desire the use of icons instead of text; however the icons should be clear. The text will not be read after using the interface for a few times.

The six ways to visualize the parameters were clear to all participants. However, points of improvement are also discovered. The screens which are the most important are: Tabular Trend Screen, Numeric Value Screen and Big Numbers. The Physiology Screen is considered as useful, but not necessary because the user already has this knowledge. The animation of the pumping heart during measurement is not appreciated and might annoy users after a certain time. Three participants thought the cockpit screen looked like a car or computer game and they think it does not fit with the system. The physio-relation screen is useful, however all parameters are visualized including the ones which are not measured. To prevent any noise it would be desirable to visualize only the chosen parameters.

One of the IC nurses finds the use of colors not consistent. He desires one color per parameter. This means that each parameter has its own color for a trend graph color. The current interface can have three different colors in the trend line to visualize if it is in the red, green or yellow target zone. However, having four parameters on screen it is not easy to see which trend graph fits with which parameter. This creates less noise and more oversight. All the participants think that the different colors of the navigation menu options are useful to remember functionality of these buttons.

All the participants liked the style of the interface and think it fits well to the device. All the participants prefer the current style and the style most of the medical interfaces have: black background and a few colors.

Interesting subjects about the target group is that the user probably will not work with this device every day. This means that it should be easy to understand and intuitive to prevent errors. A short manual of 2 pages must be enough to understand the basic functions for the user. Help options for the description of parameters can help the user to know the definition of the parameter. Sometimes the screens of different patients need to be watched for a long

time this means that the interface should be clear with as little distraction as possible. It should also be clear from a distance what is measured and what the measured values are.

Conclusion

It can be concluded that the following parts need to be changed. The snapshot and scroll option are not useful and should be removed from the navigation bar. Besides, icons should fit their function especially clinical actions and start measuring BP should be more intuitive. Buttons which cannot be pressed should not be visible to the user or give an indication that they cannot be pressed. It should be possible for the user to choose beforehand which parameters he wants to monitor on screen. Changing parameters also needs to become more intuitive to the user. Besides, the user should also be able to find it in the settings menu. Colors should be used in a logical way; however, oversight is the most important. The participants mostly preferred a darker background with an interface which looks like most of the medical equipment interfaces.

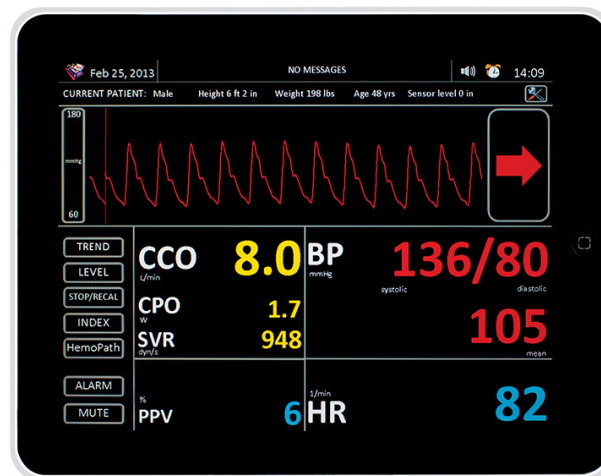


Figure 23. Medical interface with black background.

4.3 Visual design trends

Before starting sketching ideas it is useful to get inspiration from visual design trends of other areas of user interface design such as Smartphones, tablets, computer interfaces and web design trends. This is a fast developing market of consumer goods and gives a great insight of what is going on in the graphical market. Besides, the end-user of the ccNexfin is already in contact with the consumer goods and may find it helpful that the interface style is already familiar to him/her.

Flat design

The most recent visual design trend is called flat design. Flat design is based on simplicity and functionality. Flat design gets rid of shadows, reflections, and beveled edges. Nowadays almost everyone is used to working with visual interfaces. To make the user feel more comfortable, the graphical interface starts focusing more intuition instead of focusing on realism. Instead of adding to the design, the designer will remove unnecessary elements. (15) Windows 8 and Apple's iOS7 are one of the first examples of flat design. However, more brands will embrace flat design. (16) Examples of flat design elements are visualized in Figure 24. A more complete overview of visual design trends can be found in Appendix III.

Interactive infographic

Interactive infographics is a popular way to take data and present it in a colorful way. By clicking or pressing in a certain region, the user is presented with specific data about that particular region of the infographic. Some examples of infographics are shown in Figure 24.

Visual trends medical devices

Medical interfaces are different from web interfaces which were mentioned before. A collage is made to give an overview of medical interfaces and options to visualize graphs. (Figure 24) Remarkable is that again blue and black are favorite background colors comparable to the interfaces mentioned in the competitors analysis. Furthermore, bright colors are used to transport information to the user.

Typography design trends

There are four main typography design trends for web pages:

- Handwritten fonts
- Flat design typography
- Mix & match typography
- Large type

Especially the Flat design fonts might be interesting to consider using in the user interface. (17) A visualization of these trends is shown in Figure 24. Besides, it is useful to search for fonts which work good in a user interface. Fonts which were mentioned as suitable for a user interface are: Segoe UI, Lucida Grande, Ubuntu, Helvetica Neue, Droid Sans, Aller Sans, Azuro, PT Sans. (18) Sans serifs are used most of the time on screen. My personal favorite Microsoft's Segoe UI which is used in the Windows 7 and Windows 8 interfaces.

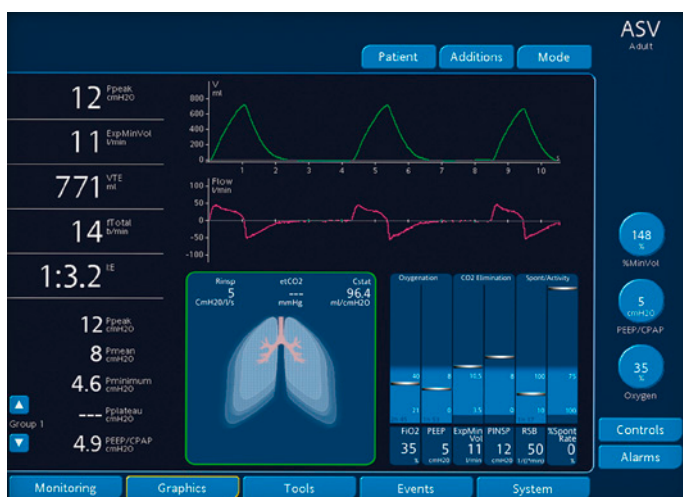
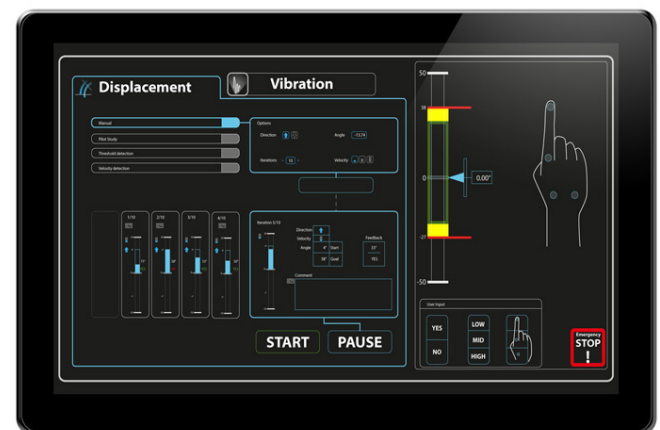
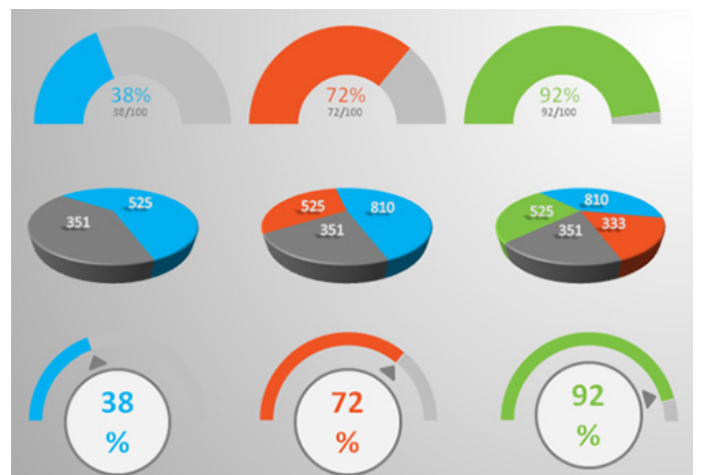
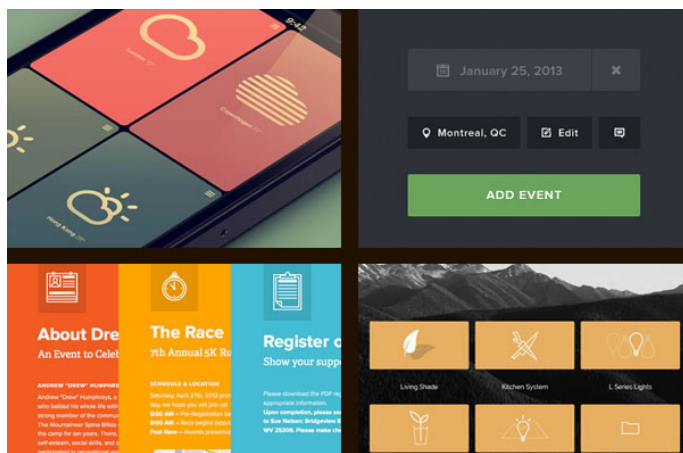
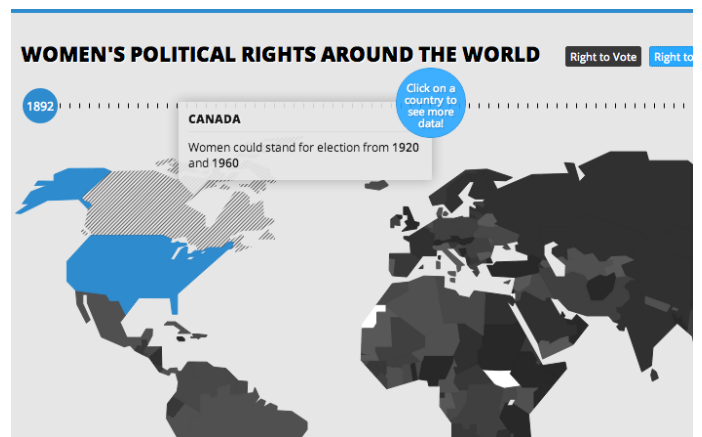
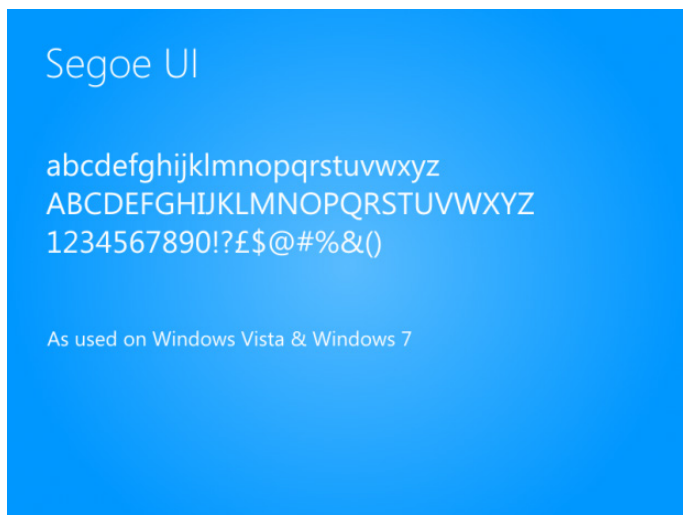


Figure 24. Visual Design Trends

4.4 Color blindness

It is possible to become an anesthetist while experiencing color blindness. Therefore, the use of colors should be investigated. However, at first should be analyzed what kinds of color blindness do exist.

There are different kinds of color blindness:

- Protanomaly: i.e. reduced sensitivity to red light.
- Deuteranomaly: i.e. reduced sensitivity to green light.
- Tritanomaly: i.e. reduced sensitivity to blue light.
- Monochromacy: i.e. no color vision.

Some of the difficulties which might be experienced are:

Protanopia

Protanopes are more likely to confuse:

1. Black with many shades of red
2. Dark brown with dark green, dark orange and dark red
3. Some blues with some reds, purples and dark pinks
4. Mid-greens with some oranges

Deuteranopes

Deuteranopes are more likely to confuse:

1. Mid-reds with mid-greens
2. Blue-greens with grey and mid-pinks
3. Bright greens with yellows
4. Pale pinks with light grey
5. Mid-reds with mid-brown
6. Light blues with lilac

Tritanopes

The most common color confusions for tritanopes are light blues with greys, dark purples with black, mid-greens with blues and oranges with reds. (19)

The current user interface has a black background. Within this background red, yellow and green are used. As already shown in Figure 25, reds and greens are getting darker and lead to a very low contrast. Red, yellow and green are the alarm colors and are very important to warn the user. It is useful for these users to create more contrast between the background and information colors. Another valuable option is to give other hints to users besides colors.



Figure 25. Color vision

Requirements from context

- The parameter values should be readable from 3 meter distance.
- The interface should be readable in a dark environment.
- The interface should be readable in a bright environment.

Functional requirements

- A signal must be given to alert the user if the measured values are dangerous.
- The interface should not contain more than four parameters on screen.
- The user interface should visualize accurate data.
- The user interface should contain a log.
- The user should be able to set interventions in the system.
- Switching between screens should not take longer than 0,5 s.
- A nurse should be able to install the equipment within 2 minutes.
- The user interface should be readable for color blinds.
- It should be possible to show the heart rate of the patient on the user interface.
- The user should always be allowed to set the alarm on and off.
- The user should always be allowed to stop or pause the measurement.
- The user should be able to choose which parameters are visualized on screen.
- The interface should contain standardized symbols.
- All parameter options should be available in the settings menu.
- The interface should contain a list of parameter definitions.

Requirements from heuristics

- The user interface should be consistent on the following subjects:
 - a. Sequences of actions
 - b. Color
 - c. Layout and position
 - d. Font, capitalization
 - e. Terminology and language
- Users should be informed about what is going on with the system through appropriate feedback and display of information.

- a. The interface should visualize what the current state of the system is.
- b. The user should be informed what can be done in a current state.
- c. The user should be informed what change is made after an action.

- The user interface should be minimalistic to prevent distraction and a slowdown.
- Users should not be required to memorize a lot of information to carry out tasks.
- Users should be given prompt and informative feedback about their actions.
 - a. The information should be concrete and specific, not abstract and general.
- The user interface should give users the flexibility of creating customization and shortcuts to accelerate their performance.
- The messages should be informative enough such that users can understand the nature of errors, learn from errors, and recover from errors.
 - a. The error should be phrased in clear language.
 - b. The information should be precise.
 - c. The error should be brought politely to the user.
- The user interface should prevent errors.
- Users should be clearly notified about the completion of a task.
- Users should be allowed to recover from errors.
- The language should be always presented in a form understandable by the intended users.
 - a. The user interface should use standard meanings of words.
- The user interface should always provide help when needed.

Requirements menu selection and form-fill interaction

- Menu item titles should have names that reflect their functions.
- Menu items should have short names.
- Menu items should be grouped meaningfully.
- Form-Fill items should provide error correction for individual characters and entire fields.



6 / 11 | Concept Phase

Ideation

During the ideation phase sketches were made to create ideas for several different screens and parts of the interface. The difficulties which were discovered during the heuristic evaluation and interviews were kept in mind throughout the sketching process. Furthermore, it is attempted to apply the preferred styles during the ideation phase by using Photoshop and Illustrator to create several different screens in a more realistic way. A few ideas will be shown in this chapter, more ideas can be found in Appendix IV.

Screen structure

The first part of the sketches was made to obtain knowledge about the mapping possibilities. Two main ideas were generated: a navigation bar on the left side of the screen and a navigation bar on the upper side of the screen (Figure 26). The existing interface already has the navigation menu on the left side of the screen. While most people read from left to right, it is useful to place the navigation bar on the left side of the screen. However, a navigation bar on the upper side of the screen might have a stronger relation with the content beneath it. Second, in this case it is possible to work with text alongside icons because there is more space on the vertical direction. The use of 5 navigation icons instead of 7 is noticeable in all screen structures. The two options which were called superfluous by the participants were eliminated to create more space and fewer options on screen. The warning, time, date and screen lock are placed on the upper side just like on a Smartphone or tablet.

Big Numbers

Challenges which were experienced during sketching were the use of color and the visualization of the parameters. While choosing colors it is important to know what meaning colors have and their visibility for color blinds. The hardest case was combining a warning color, which visualizes the status of the parameter, and a parameter color. Using eight different colors creates noise quite easy which has effect on the readability of the screen. A lot of possibilities which were created by playing with different shapes and colors are shown in Figure 27.

Globe

The globes which are used in other monitor screens are almost the same as the big numbers screen. However, this globe is smaller and should contain the same amount of information as the big number globes. The hardest part was to place the necessary information in an orderly manner to prevent noise.

Physiology screen

The participants of the usability test were content with this screen except that it might be a bit too noisy. This noise is caused because of the drawing of the vascular system. By leaving unnecessary details in this drawing, tranquility will be given to this screen without losing its information.

Physio-relation screen

The challenge of this screen is to show the information clearly. The warning colors should be visible from a distance. However, the warning colors should not create noise on the screen. Besides, the parameters which have no measured value should be visible but not set to the front.

Zero and Waveform

During the usability test participants did not understand the zeroing process because of the lack of information. More information can be given to the user by adding more steps and textual explanation. A few ideas were generated with different navigation styles and a different amount of steps.

Target value/Globe parameter

The way to change the target value in the current interface is quite easy. However, it is rather confusing to press inside the globe to navigate to the target value menu and outside the globe to change the parameter of the globe. By merging these menus together to one menu the user cannot make the mistake of pressing in the wrong area anymore.

Parameter Selection

This menu was missed in the current interface. This menu should allow the user to set parameters on and off to prevent noise on screen. Besides, it should be possible to set the four main globe parameters with on globe 1 for example the most important parameter which should always be on screen. This menu also creates the possibility to introduce the different abbreviations with their full name to the user in order to prevent miscommunication.

Keypads

Keypads are important for the user to give input to the system. The keypads should have their boundaries to prevent the user from giving wrong input. For example, during entering patient weight only numbers are needed and it should be clear to the user in which unit this information should be entered.



Figure 26. Screen structure



Figure 27. Big Numbers

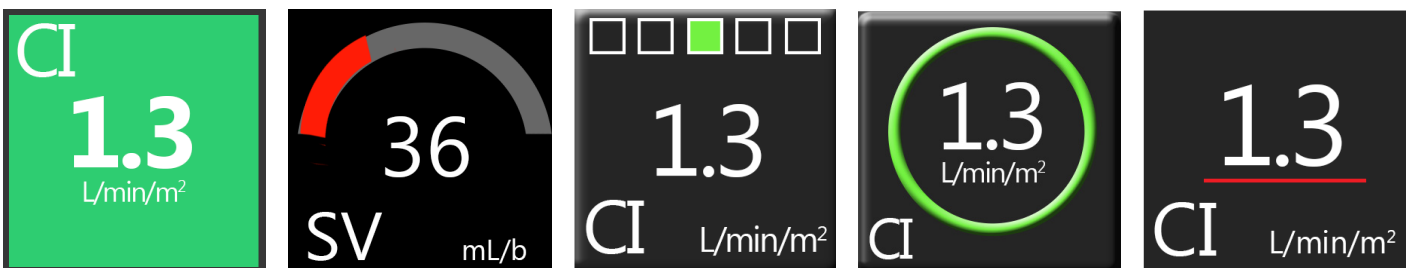


Figure 28. Globes

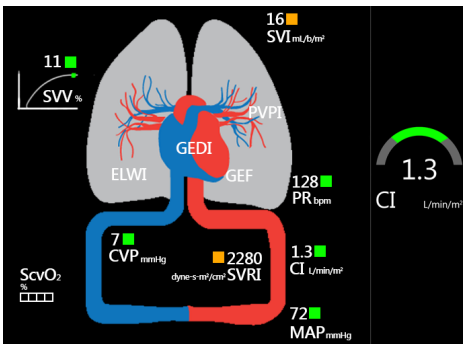


Figure 29. Physiology screen

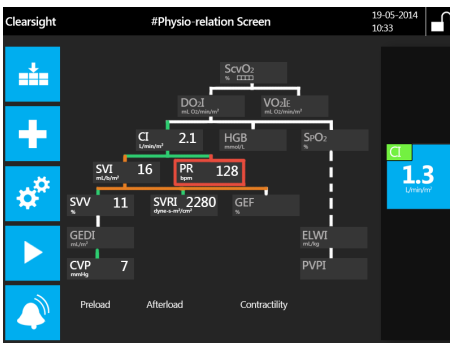
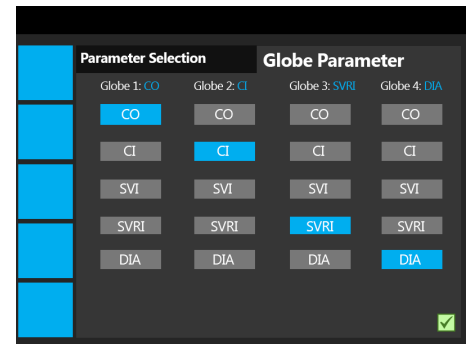
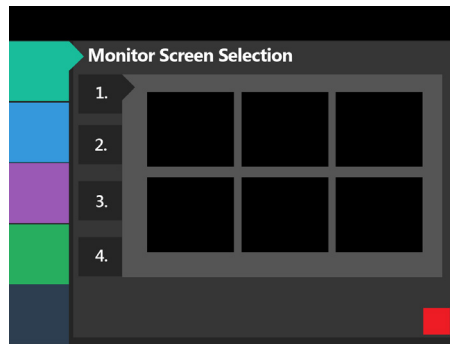


Figure 30. Physio-relation screen

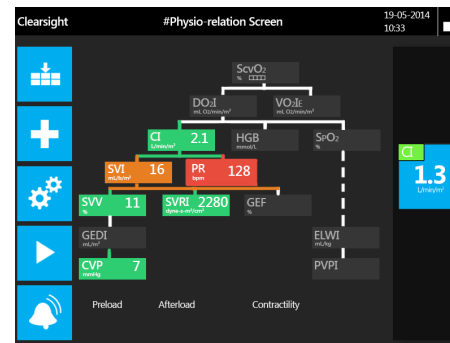


Figure 31. Parameter Selection

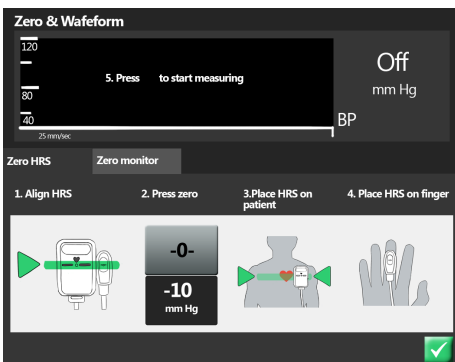


Figure 32. Zero & Waform

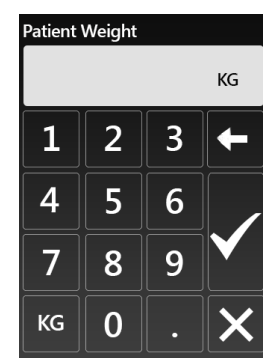
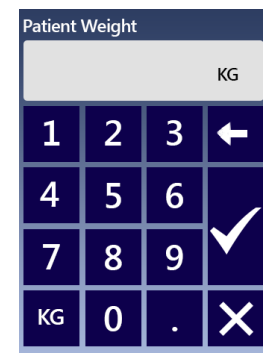
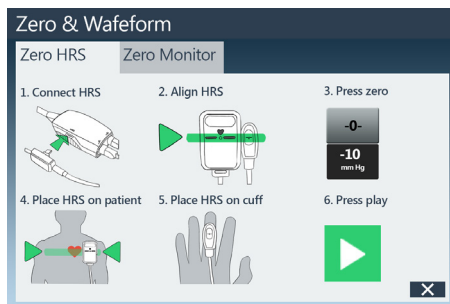
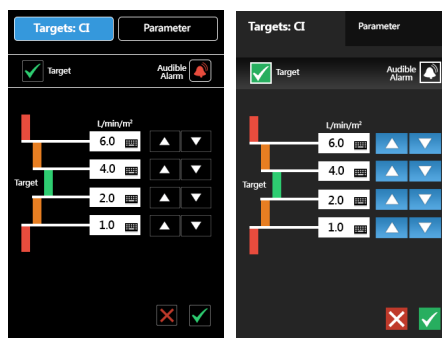


Figure 34. Keypad



Figure 33. Target Value/Globe parameter



7 | Concept 1: Nexfin Black

After ideation three different concepts were generated. All three concepts have a different style and some different visualizations and interactions of several aspects which were marked as improvable during the first usability test. The three styles are based on the styles which the participants preferred the most during the first usability test.

7.1 Style sheet

Buttons

- Selectable: *White contour*
- Disabled: *Grey contour*
- Selected: *Blue contour*
- Start measuring and Alarm on: *Green rectangle*
- Stop measuring and Alarm off: *Red rectangle*

The colors blue, white and grey are distinguishable by color blinds which make it suitable to use these colors in the interface. The green and red rectangles are harder to separate for color blinds; therefore, color blinds have no benefit from this extra cue. However, the text and the icon changes which makes it possible for the color blind user to see what the measurement and alarm status is. The green and red colors are used to make a separation visible between navigation/menu buttons and action buttons. Even color blind users can see the difference between a black background and light brown shades instead of red and green for the general user.

Text colors

- Button text: *White*
- Menu title: *Blue*
- Active Parameters: *White*
- Passive Parameters: *Grey*
- Graph text: *White*
- Time/date: *White*
- Measurement name: *White*

While the background color is black for most of the texts it is desirable to use a color with a high intrinsic brightness (Stone, Jarrett, Woodroffe, & Minocha, 2005). White has a very high intrinsic brightness which makes it easy to read on a black background which has no intrinsic brightness. The blue color for the menu title is used to imply a relation between the selected navigation bar option and the menu title. However, the condition should be that the blue color should have at least a medium to high intrinsic brightness.

Text field

The active text field has a white background with black text which creates a high contrast that is easy to read. A light gray background is used in the passive text field to create a distinction between active and passive. A light grey color still has a high intrinsic brightness which makes black text suitable in this situation.

Background

The total background is black, because it fits with the style of the Tensys interface. The tab menu background has a slightly different color to prevent too much noise; however, it separates this from the background. The grey separations lines are used to map the content on screen but should not create noise on screen. This is why a thin line of less intrinsic brightness is chosen.

7.2 Interactions

Step 1: Turn on the device

The device can be turned on with the on/off button positioned on the underside of the casing. This button contains a standardized on/off icon to prevent indistinctness. A startup screen will pop up with a loading bar and the logo of Edwards. Thereafter the startup menu will appear.

Startup menu

The startup menu contains three steps which have to be carried out before the measurement can be started (Figure 36). This startup menu is made to make a distinction between the startup stage and the measurement stage. Numbers are used to indicate in which step the user currently is and how many steps he/she still has to go through. The user can navigate to the next step by confirming their choice and go to the previous step by pressing on the back button. The user should always be allowed to change the data input, for example if they have made a mistake.

Step 2: Patient data

Fill up the patient data form in the startup menu. This form contains:

- Patient ID
- Height
- Weight
- Age
- Gender

These data should be filled up first before the user is able to go to the next step. Selecting a new patient is also a possibility. The BSA (Body Surface Area) is calculated out of the input data. The user should confirm this data to go to the next step in the startup stage.

Step 3: Choosing the globe parameters

The first screen the user sees contains four empty globes. By pressing on the first globe a parameter can be selected which will be visualized on the first globe. So, if the user chooses to have one parameter on screen in the measurement stage only the first globe will be visualized. It is important to choose for this first globe the parameter which is the most important to have always on screen. The same process can be applied for globe 2, 3 and 4. After selecting all four parameters the choice should be confirmed to navigate to the next stage.

Step 4: Zeroing the HRS sensor

The HRS sensor should first be zeroed to get a correct measurement. By showing pictures of the steps in a chronological order the user gets information how the zeroing process should be executed. This screen has no confirm button but a start measuring button. By pressing the start measuring button the measurement will be started and the user will get in the measurement stage. It should also be possible in this screen to zero the monitor. However, no further attention has been given to this subject.



Figure 36. Startup menu

Measurement stage

The measurement stage contains three main menus:

- **Monitor Screen Selection:** This menu gives an oversight of all five monitor screens. Users can also select the amount of parameters which will be visualized on screen. The user should first select the amount of parameters and then one of the five monitor screens. The monitor screen options are small pictures of the monitor screens to give a preview of the screen. The user can quickly choose the right screen without scrolling through all the monitor screens.

- **Clinical Actions (Figure 42):** This menu allows the user to go back to the Zero & waveform menu. Besides, it gives the user the option to navigate to the Derived Value Calculator where the user can calculate DO₂, VO₂, SVR and CPO by giving input from other parameters. The Event Review and Enter CVP are options as well. Only the Zero & Waveform option can be chosen in this concept.

- **Settings:** The settings tab allows the user to change several settings. Only the patient data, parameter settings and monitor settings can be chosen in this concept. The user is allowed to change the patient data settings and globe settings via this menu.

The menu buttons contain the menu name and an icon to make clear to the user what their function is. Because the navigation bar is horizontal there is enough space for text next to the icons without losing important space.

All menus can be closed without saving changes by pressing on the X or by choosing another menu tab from the navigation bar. All changes can be confirmed by pressing on the button with the checkmark. Besides, the user is always able to press on the back button to go to the upper layer of the menu the user is in.

Monitor Screens

The five different monitor screens are:

- **Tabular Trend screen (Figure 37):** This screen shows the tabular trend of a parameter. The globe is placed at the right side of the graph to indicate which parameter belongs to which graph. The arrow keys can be used to scroll back and forward through time. The globe shows the last measured value and gives an indication if it is in target range (green), almost in target range (orange) and far above or below target range (red). Color blinds can indicate the state of the parameter by the placement of the color, because the globe works like a meter. The button with the triangle pointing downwards can be used to declare interventions during measurements, for example changing the position of the patient.

- **Numeric Value Screen (Figure 38):** This screen shows the averaged measured value over a selected time interval. The globes are placed at the right side of the screen. Each globe visualizes a parameter and gives an indication of which parameter belongs to which numeric value set. The scroll buttons are placed at the same spot as in the tabular trend display.

- **Big Number screen (Figure 39):** This screen only shows the globes. This screen gives a clear overlook to the user how the patient is doing. The noise which might be experienced in other monitor screens is canceled by only having a maximum of four globes on screen.

- **Physiology screen (Figure 40):** The physiology screen visualizes the vascular system in a less detailed way than in the current interface. The way the data is visualized has not been changed because it was clear to the participants of the usability test. The globes are as well placed at the right side of the screen.

- **Physio-Relation screen (Figure 41):** This screen shows the different kind of relations between parameters. The parameters which are active have a black background and a colored contour:

- Green: Measured value is in target range
- Orange: Measured value is almost in target range
- Red: Measured value is far out of target range and action is needed

The whole tile of a parameter will be red if the measured value of the parameter is far out of range. This is done to get more attention from the user. The tiles which are not active are grey with light grey text to create less attention for these parameters which will send them to the background. However, the user is still able to see their relation to other parameters.

7.3 Conclusion

It can be concluded that this concept is focused on minimalism and bright color warnings to the user. However, the minimalism disappears while using text next to the icons. On the other hand during the first few usage moments it might be quite helpful to have text. The style of this interface fits in with the style of similar products of Edwards and other medical equipment. A strong point of this concept is the globe which visualizes the status of the parameter. Even color blinds can see if a measured value is too high or too low.



Figure 37. Tabular trend screen

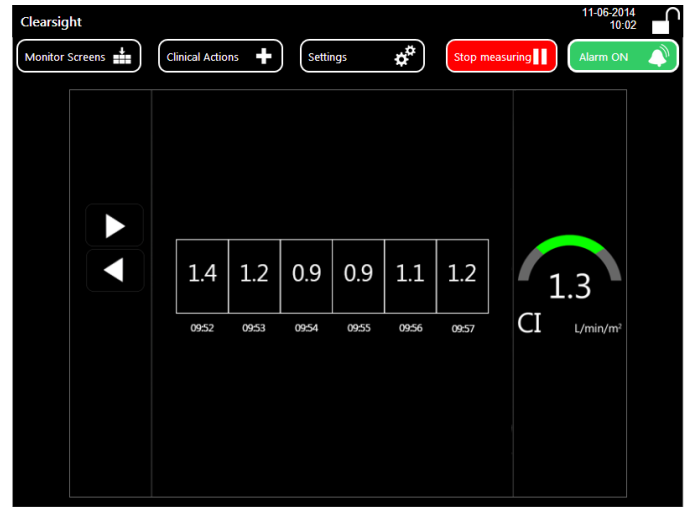


Figure 38. Numeric value screen

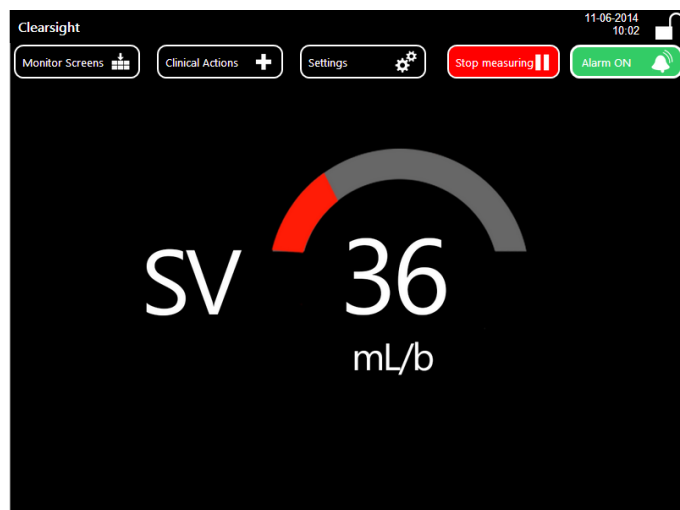


Figure 39. Big number screen

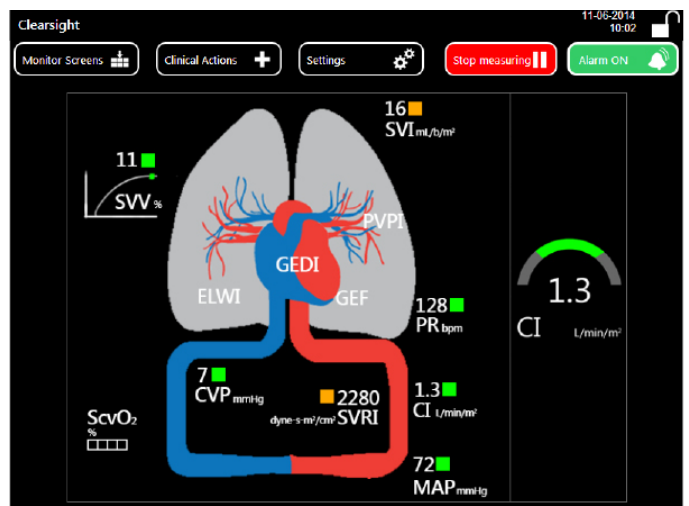


Figure 40. Physiology screen

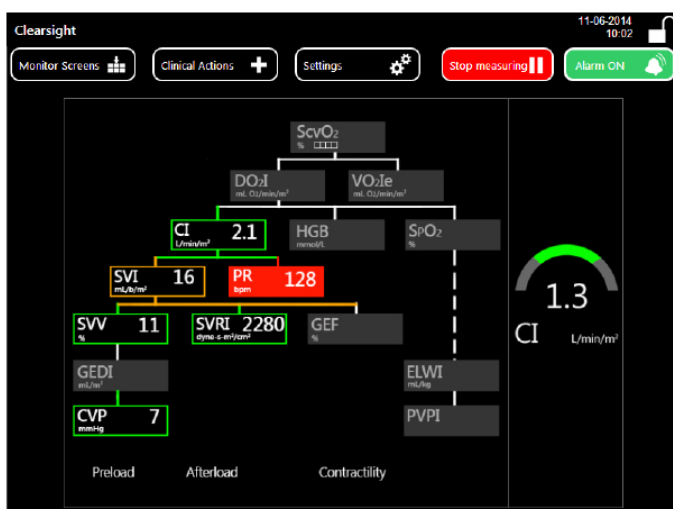


Figure 41. Physio-relationship screen

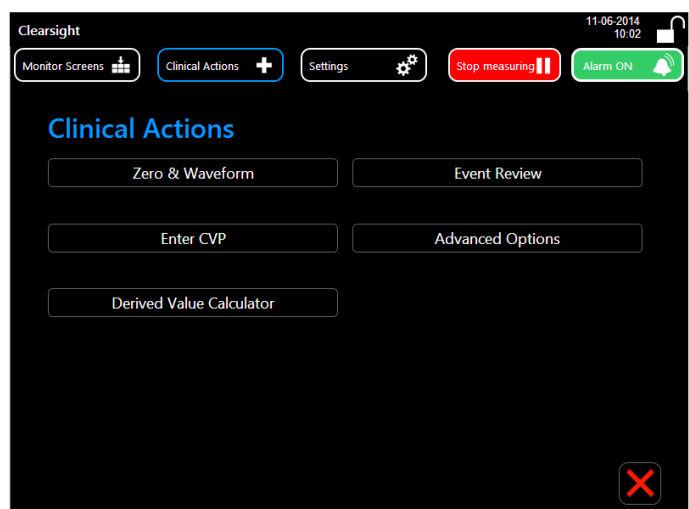


Figure 42. Clinical Actions menu

8 | Concept 2: Nexfin Flat

8.1 Inspiration

The second concept gets its inspiration out of the flat design trend, which is characterized by simplicity and functionality. As already mentioned before, flat design gets rid of shadows, reflections, and beveled edges. Flat design is all about intuition instead of realism and is therefore suitable for improving the usability of the ccNexfin interface.

8.2 Style sheet

Buttons

Selectable: *Light blue*

Selected: *Light blue*

Deselected: *Light grey overlay*

Disabled: *Dark grey overlay*

Start/stop measuring button: *purple*

Alarm on/off: *purple*

The navigation buttons are square buttons with a bright blue color and an icon in the middle. The button changes in an arrow while pressing on one of the navigation buttons. The other navigation buttons get a dark grey overlay which creates an illusion that the opened menu comes to the foreground. This way of navigating gives a clear overview to the user in which menu he/she is located. The colors blue and purple are used while it does not have a specific meaning in this category of interfaces. Besides it gives a good contrast with the background color and the white color of the icon. The purple buttons can always be selected by the user and do not contain a menu. While the blue buttons in the navigation bar contain a menu and cannot be selected while another menu is opened. The only downside is that color blinds cannot distinguish the difference between blue and purple.

Text color

The text color is white because it has a good contrast with the dark grey background as well as the blue button color. The text color of the input text field is black because of the white background.

Text field

The text fields have a white background to give an indication to the user that they can give input to the system.

Background color

The background color is dark grey to not make the

display totally black but allows creating high contrasts with bright colors. Popup menus have a lighter shade of grey and the time/warning bar at the upper side of the screen is black. This is done to make a distinction between different options and to create layers.

8.3 Interactions

Starting the device

The device can be started by pressing the on/off button on the front side of the casing. The user will see a startup screen with a loading bar. After the startup screen the user will get into a startup menu. The user should fill in all the data and set up the basic settings before the measurement can be started.

Startup menu

The startup menu contains three steps which are made clear to the user by giving an indication in which step the user is located and how many steps he/she still has to fulfill (Figure 43). The user is only able to go to the next step by confirming their input data. Users are not able to navigate through the steps by pressing on: Step 1, Step 2 or Step 3. This choice has been made to prevent users to forget or giving wrong data input.

The first step which the user should fulfill is the patient data. This can be done on the exact same way as in the first concept. By confirming the patient data input the user is able to navigate to the next step: parameter selection.

During the parameter selection the user is able to set parameters active or non active in the interface. If the parameter is active it will be shown in the interface. However if the parameter is non active it will not be shown in the total interface to prevent unnecessary noise. The user can also select in the globe selection tab which parameter should be visualized in which globe. The choices should first be confirmed to go to the next step: Zeroing the HRS sensor.

The steps which the user should go through to zero the HRS sensor are separated in different screens. The user can read and see the instruction picture to get to know what he/she should do. The user can navigate with the arrows to the next or previous step. By giving the information by this way it is clear to the user what to do and not to forget a step. After the user has started the measurement he/she should close the startup menu to get into the measurement menu.

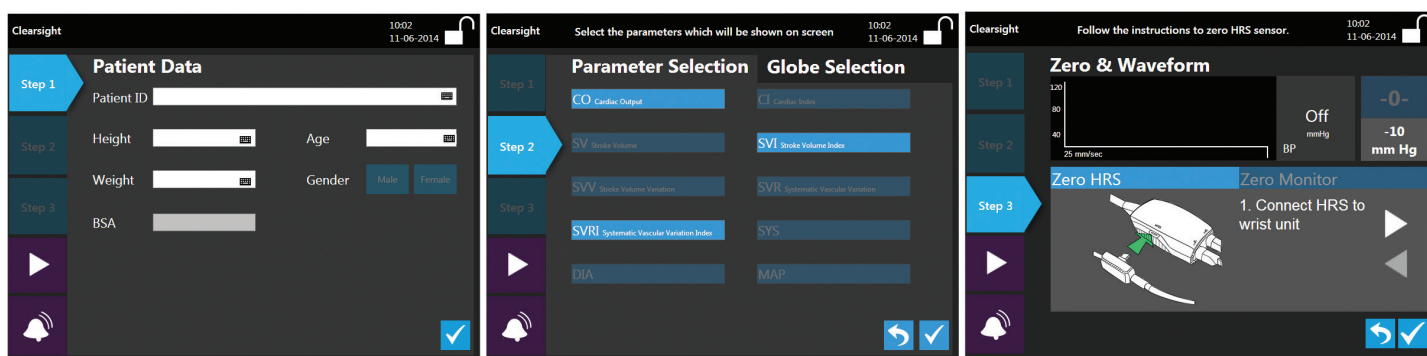


Figure 43. Startup menu

Measurement Stage

During the measurement stage only three menu options are possible. These three options are: Monitor Screen Selection, Clinical Actions and Settings.

- **Monitor Screen Selection:** The user is able to switch monitor screens and switching the amount of parameters. An arrow on the left side, just like in the navigation menu, shows if the user has chosen 1, 2, 3 or 4 parameters. A small preview picture of the screen shows the user what the actual screen will look like. This small picture prevents the user from picking the wrong screen.

- **The Clinical Actions menu and the Settings menu** both have the same style (Figure 44). Light blue buttons with white text. The user is always able to navigate to the previous state of the menu to prevent situations that

menus should first be closed and opened again. These two menus inter alia allow the user to change settings which were made during the startup stage.

Monitor screens

The tabular trend screen (Figure 45) shows a maximum of four trend graphs. The trend line is blue and the green rectangle shows if the value is in the good range. If the value is in the red range, the trend line will be above or under the red arrows which visualize this boundary. The current measured value can be seen in the square globe at the right side of the screen. The color of the globe visualizes if the measured value is good (green), starting to get dangerous (orange) and if the value is dangerously high or low (red). This color metaphor is globally used in traffic lights which will lead to recognition to the users.

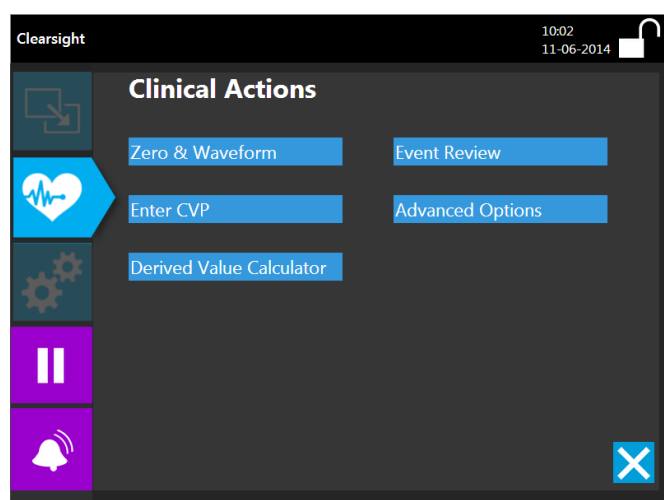


Figure 44. Clinical Actions menu

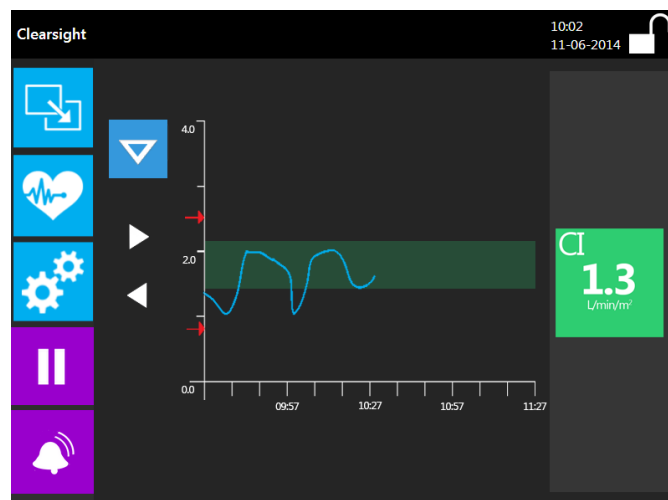


Figure 45. Tabular trend screen

The numeric value screen (Figure 46) shows the average measurement data in a certain time interval. The globe at the right side indicates which parameter is shown in which number set. Besides, it gives just like in the tabular trend screen the status of the parameter.

The big number screen (Figure 47) only shows the globes. A maximum of four globes can be shown on screen. The color of the globes shows the status of the parameter. Because of the large area of color it is easy to see from a distance what the status of a parameter is.

The physiology screen (Figure 48) is almost the same as the first concept. Because simplicity and tranquility is needed no shadows or effects are used in this info graphic.

The measured values have a contour color in the physio-relationship screen (Figure 49). Parameters which do not contain data have light grey text which will make it send backwards. Only contour colors are used because color areas would create too much noise. Since the navigation bar and globes already have color areas.

8.4 Conclusion

This concept focuses on functionality and simplicity. By using the metaphor of arrows it gets clear to the user in which menu or step the user is in. Besides the target value popup uses the arrow to show its relation to the globe. The status of the parameter can be seen from a long distance because of the big color tiles. The zeroing process is divided in several smaller steps to lead the user through every necessary step to zero the HRS sensor without skipping a step.

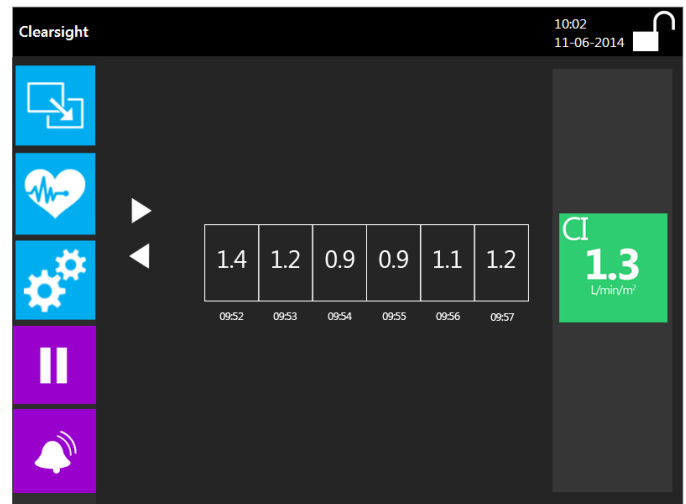


Figure 46. Numeric value screen

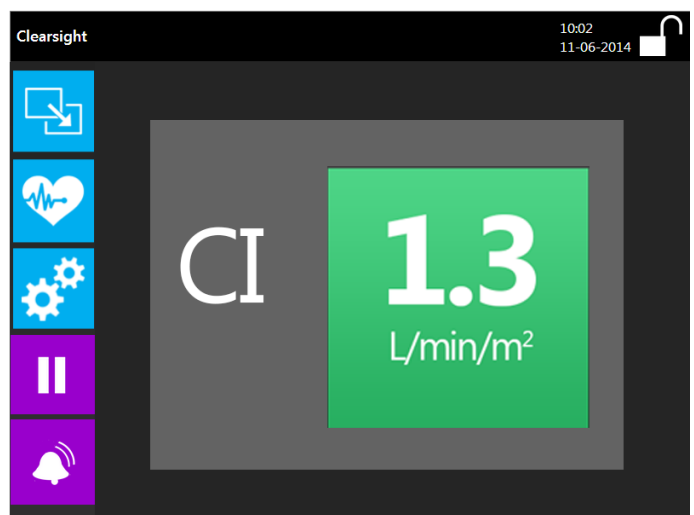


Figure 47. Big numbers screen

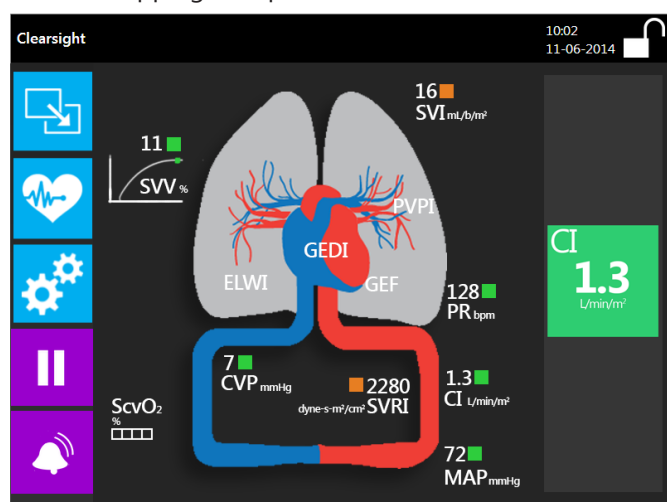


Figure 48. Physiology screen

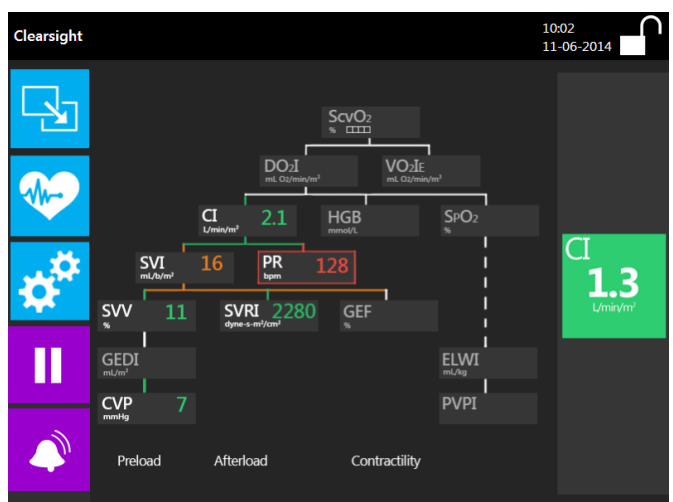


Figure 49. Physio-relationship screen

9 | Concept 3: Nexfin Blue

| Concept phase

9.1 Inspiration

This interface is inspired by another medical interface which participants preferred during the usability test (Figure 50). This interface is characterized by light blue and white colors. These lighter colors make it clear and easier to read for the user. This might lead to a better usability which is the main goal of this project.



Figure 50. Inspiration

9.2 Style sheet

Buttons

Selectable: *Dark blue*

Selected: *Light grey*

Deselected: *Grey overlay*

Disabled: *Dark grey overlay*

Start/stop measuring button: *Dark blue*

Alarm on/off: *Dark blue*

Back button: *Dark blue*

Confirm button: *Green*

Cancel button: *Red*

The colors which are most used in this interface are: dark blue for the buttons, light grey for the menu background and a blue to white gradient for the total background.

Because consistency is important it has been chosen to give every selectable button, except confirm and cancel, the same color. A tabs metaphor is used to map the menus and submenus. Tabs are used very often and therefore it is clear to the user how to use them. The confirm and cancel button colors are set green and red, because most of the world population associates green with good (confirm) and red with bad (cancel).

Text color

The text color for most of the menu is white because this gives a high contrast with the dark blue background. White has a very high intrinsic value and dark blue a low value. The text color is dark blue if the background of the text is white or light grey. Examples can be found in the monitor screens and patient data input.

Text field

The text fields have a white background to give an indication to the user that they can give input to the system. Text fields which do not allow user input are grey to give an indication that they can't be selected.

Background color

As mentioned before the user interface colors are: dark blue for the buttons, light grey for the menu background and a blue to white gradient for the total background. This lighter background makes it easier to read in a bright lighted area. This is because there is less reflection on the screen. Another benefit is that it is easier in dark areas to work with a bright screen because there is a reference point for the waveform instead that it is floating (Flikkema, 1997).

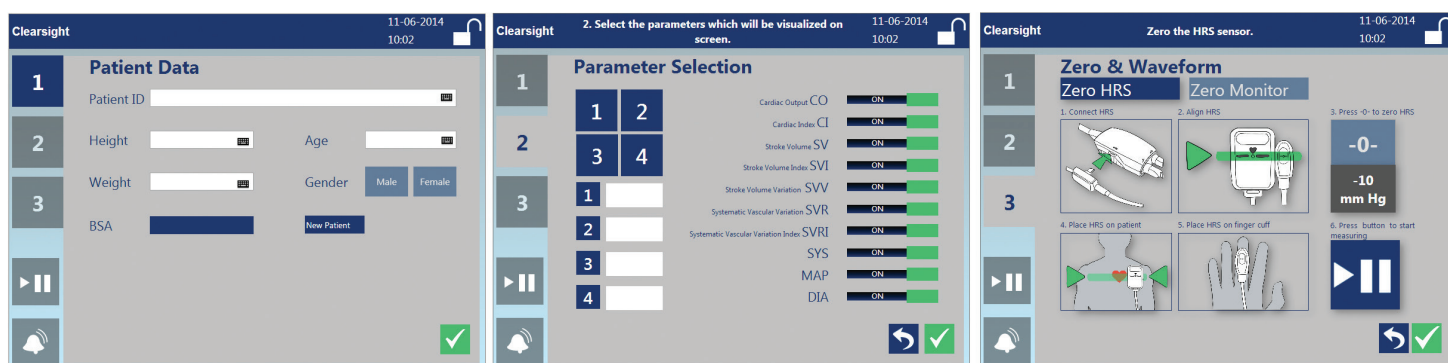


Figure 51. Startup menu

9.3 Interactions

Startup stage

Just like the other two concepts the interface can be started by pressing the on/off button. A startup screen will appear which shows the startup process to the user. After the startup stage the user gets into the startup menu (Figure 51). The startup menu already uses the tab metaphor. The user can see how many steps he/she should go through. The user is not able to navigate between the steps by using the tabs. This choice has been made to prevent the user from going to another tab without confirming their choices or forgetting to fill in data. The user is able to go to the next step by confirming their choices.

The parameter selection menu allows the user to put on and off some parameters by pushing on the slide button. Besides, it allows the user to setup the four globe parameters. The user should press on the number, choose a parameter and confirm their choice. This action can be done for all four parameters. If the user is content with its parameter selection he/she can navigate to the zero & waveform menu by confirming their choice.

The zero & waveform menu contains six steps to visualize to the user which steps has to be done to zero the HRS sensor. These pictures with text give a good overview for new users how they should zero the sensor and to advanced users a clear overview. The benefit of this idea is that no extra actions are needed to get information about the zeroing process and advanced users can zero without extra clicking as needed in the second concept. The user should close the startup menu after starting the measurement by selecting the confirm button. After confirming the user is navigated to the measurement stage.

Measurement stage

During the measurement stage only three menu options are possible just like in the other two concepts. These three options are: Monitor Screen Selection, Clinical Actions and Settings.

- Monitor Screen Selection: The user is able to switch monitor screens and switching the amount of parameters. A tab metaphor is simulated for the options 1, 2, 3 and 4 parameters by using shadows and giving a grey overlay over the other numbers. There is not been chosen for a new color to create a tab menu because it will lead to too much noise. A small preview picture of the screen shows the user what the actual screen will look like. This small picture prevents the user from picking the wrong screen.

- The Clinical Actions menu and the Settings menu both have the same style. Dark blue buttons with white text. The user is always able to navigate to the previous state of the menu to prevent situations that menus should first be closed and opened again. These two menus inter alia allow the user to change settings which were made during the startup stage.

Monitor screens

The tabular trend screen shows a maximum of four parameters (Figure 52). The big difference with the other two concepts is that the globes are on the left side of the screen and each parameter trend has its own color. By giving a small color accent in the globe it should be clear to the user which trend color belongs to which parameter color.

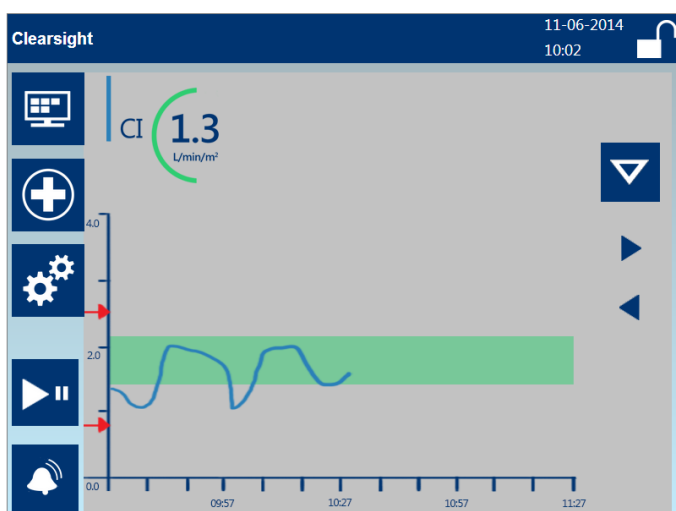


Figure 52. Tabular trend screen

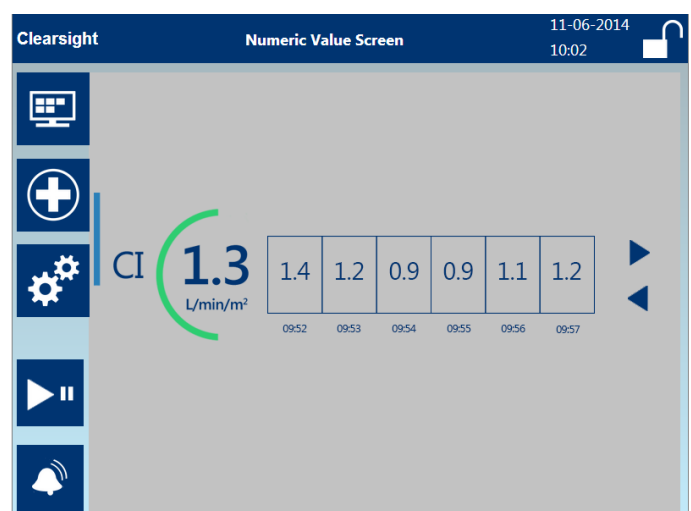


Figure 53. Numeric value screen

It has been tried to select parameter colors which do not have a special meaning in this setting. Next to the color accent a semicircle is used to visualize the status of the measured parameter. A benefit of this semicircle is that it initiates a relation with the trend graph.

The numeric value screen (Figure 53) shows the average measurement data in a certain time interval. The globe at the left side indicates which parameter is shown in which number set. Besides it gives just like in the tabular trend screen the status of the parameter. The color coding is not used for the numbers because this might influence the readability of these numbers.

The big number screen (Figure 54) only shows the globes. A maximum of four globes can be shown on screen. The color of the globes shows the status of the parameter. The small color accent on the left shows the parameter color to the user. Several medical equipment uses the system that each parameter has an own color to make it easier to recognize which parameter is on screen.

The physiology screen (Figure 55) is almost the same as in the previous concepts. Because simplicity and tranquility is needed no shadows or effects are used in this info graphic. The only shadow which is used is to make the picture come forward from the background otherwise it will blend in with the background too much.

The measured values have a colored bar at the right side of one tile in the physio-relationship screen (Figure 56). Parameters which do not contain data have light grey text

which will make it send backwards. Only colored bars are used because color areas would create too much noise. Besides, it will lead to inconsistent color use in the interface. Since all the buttons have the style: dark blue buttons with white text.

9.4 Conclusion

This interface uses a totally different color scheme as the traditional medical interfaces have. Instead of a dark background a light background has been chosen with dark blue navigation elements. This light background might increase the readability and the clarity of the interface. Another striking point is the parameter color combined with the parameter status color. This might lead to a more intuitive way to recognize the trend line next to the globe.

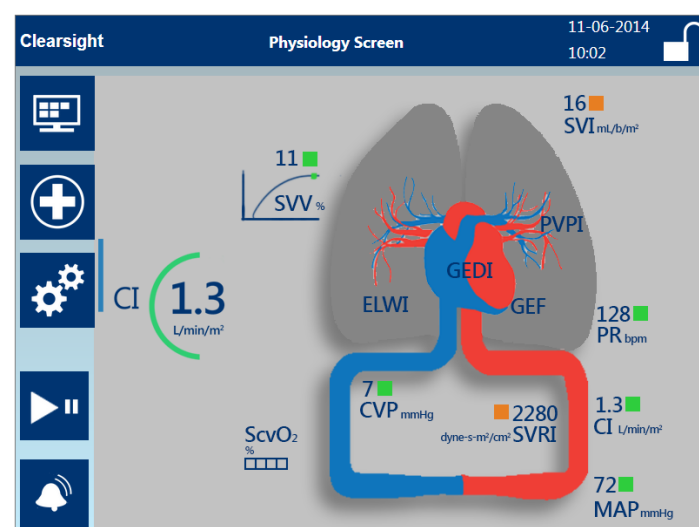


Figure 55. Physiology screen

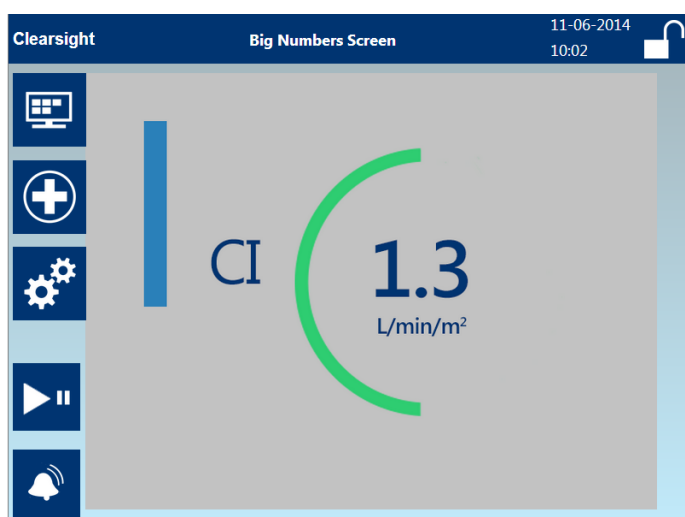


Figure 54. Big numbers screen

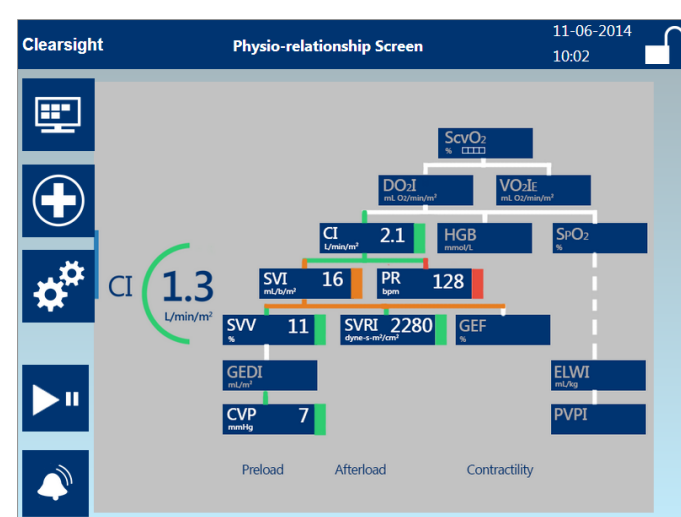


Figure 56. Physio-relationship screen

10 | Evaluating the generated concepts

A second usability test has been performed to get an indication which concept or aspects of concepts end users prefer. A second reason is to indicate whether there are still usability issues in the new interfaces. During this usability test seven intensive care nurses have tested the current user interface and the new concepts. The participants had to perform the same tasks for every concept. The test sequence of concepts in which each participant had to test was different for all participants to prevent a learning process. All the participants had to fill in a survey afterwards in which they had to rank aspects of the interface and declare which symbols they understand and which are unclear to them. Out of the choices of several aspects can be made up what end users prefer. These preferences will help to choose and create the final design concept. The total usability test setup can be seen in Appendix V.

10.1 Mistakes and comments for Concept 1 Nexfin Black

No mistakes were made by turning on the device. During startup stage several participants tried to switch between steps by clicking on the buttons which indicates the user in which step they are in. Three of the seven participants had the idea that patient ID means a number instead of a name. However, the user should be free to enter the name of the patient or its ID number. Another comment which was given by three participants was that the signal which the user gets while pressing male or female is too weak. A thicker line would probably solve this issue. Four of the seven participants set up the parameter selection without any errors. Two of the seven participants had the comment that it was not clear for them what they had to do in this step. During the zeroing process participants had experienced indistinctness. Two participants forgot to zero and it was not clear to most of the participants whether they had already zeroed. Comments which were made by this menu are that they missed the text and that they would like to see more steps like in the other two concepts. The only stronger point is that the user should not close the startup menu, because it will automatically close while starting the measurement.

During the measurement stage the participants were asked to change the amount of parameters. Two of the

participants first started to search in the settings and clinical actions menu. After they had discovered how the process works of changing the amount of parameters they found it very logical.

Comments

Some of the comments which were made of the monitor screens are:

- The globes are very clear and it is good to have an extra indication to see if a value is too high or too low.
- The red area in the physio-relationship screen and the bright color contours set the most important information to the foreground and set the non-measured values to the background.
- This interface gives less irritation because you do not have to close every screen before you are able to go to another menu.
- The way to change the target value is very intuitive and combining it with parameter selection for a globe makes it just easier to use.
- The text next to the alarm icon is not necessary, because the icon is clear enough.

Conclusion

From these comments can be concluded that the participants liked the way they get warned about the status of a parameter. Also the indication colors are bright and can be seen from a distance. Another point which can be concluded is that too much confirming your choices leads to irritation and probably not to fewer mistakes.

10.2 Mistakes and comments for Concept 2 Nexfin Flat

No mistakes were made while turning on the device. The only comment which was given in the patient data menu was that the text male/female was not good readable because of the grey overlay. This same problem occurred during parameter selection. Although the readability was bad all participants could easily select the four parameters. However, all participants forgot the globe selection. This should be placed in a next step or the tab should be made clearer to the user.

Five of the seven participants were content with separation of steps and also textual explanation. One of the biggest issues were finding the zero button and starting the measurement. These buttons were not included in the step which resulted in participants trying several buttons. Some of the participants did not immediately close the startup menu after they were done with the startup process. One participant said that it will be useful that the menu closes automatically after you started the measurement.

Only one participant was in doubt while searching for the menu to change monitor screens and amount of parameters. Remarkable is that participants most of the time forget to close the menu first before navigating to another menu.

Comments

Some comments which were made during switching between monitor screens are:

- The menus are intuitive and clear
- This is the ideal way to navigate between the monitor screens. Just perfect!
- The navigation buttons have a good contrast with the white icon.
- The green indication bar does not come enough to the front in the tabular trend screen.
- The huge color areas make the parameter status come very good to the front.
- It will be useful if only the red status of the parameter has a large color area. The other parameter statuses could have their measured data in the status color but not the whole tile.
- The non-measured data should be sent more to the background in the physio-relationship screen.
- There is less noise on screen as in the current user interface which makes it easier to use.

Conclusion

It can be concluded that participants liked the way they have to navigate through the interface. However, for some participants it was too colorful because of the amount of colored areas. This should be reduced if this concept would be developed further. Another point of improvement is the readability of the text of a deselected button. A solution could be to make the text white. The last point which needs attention is the placing of the zero and start measuring button in the zero & waveform menu. Placing the buttons next to the text might lead to a solution for this problem.

10.3 Mistakes and comments for Concept 3 Nexfin Blue

No mistakes were made during turning on the device and entering patient data. However, the parameter selection menu created some difficulties for four of the seven users. There were a lot of irritations during the globe selection because you have to confirm everything. Though, setting parameters active or non-active was no problem for every participant.

Two of the seven participants were not able to find the zero button in the zero & waveform menu and were not able to find the button to start the measurement. However, one participant said that this menu gives a clear overview of the steps without clicking every time as in concept 2.

Comments

During the measurement stage task of navigating through the monitor screens the following comments were made:

- By using a parameter color it is easier to recognize to which trend line the parameter belongs.
- The colors are not easy to read from a distance because of the light background.
- The user does not get warned if the measured value is too high or too low, this is something what the other concepts do.
- The physio-relationship screen of concept 1 is better than this one.
- This way of changing the target value or parameter is much better than in the current interface.
- The background color makes it easier to read and almost makes it fun to use this interface.
- The physiology and physio-relationship screen still create too much noise. This might be the result of the extra parameter color.

Conclusion

This concept is liked by its style. However, there are still some doubts about whether the warnings are readable from a distance. Especially the trend line might be difficult to see from a distance. The zero & waveform process should have more intuitive buttons which make it more clear to the user where they have to press. Also the amount of confirming choices is an issue and should be done less in this interface.

11 | Concept choice

It is not possible to select one of the previous concepts out of the usability test survey and observation. Therefore, the final concept will contain the best aspects from every concept. On some of the aspects of the interface participants did not have a clear preference. By using the heuristics and list of requirements further decisions will be taken.

11.1 Style

The most preferred style by the participants is the Nexfin Blue concept. However, most of the participants selected the Nexfin Flat as most clear of the three concepts. A few participants mentioned that the readability of the graph would be bad from a distance. This is quite an important issue, because the requirement was that the screen should be readable from a 3 meter distance. Another issue that might occur with a light interface is that it is not desirable for the patient to have such a light source next to him/her at night. Because these two arguments are very important it might be better to choose for a darker background. The main style which will be used in the final concept is the flat design style of the concept Nexfin Flat (Figure 57). However, the huge color areas should be set to a minimum, because all of the participants rated this concept as too colorful.

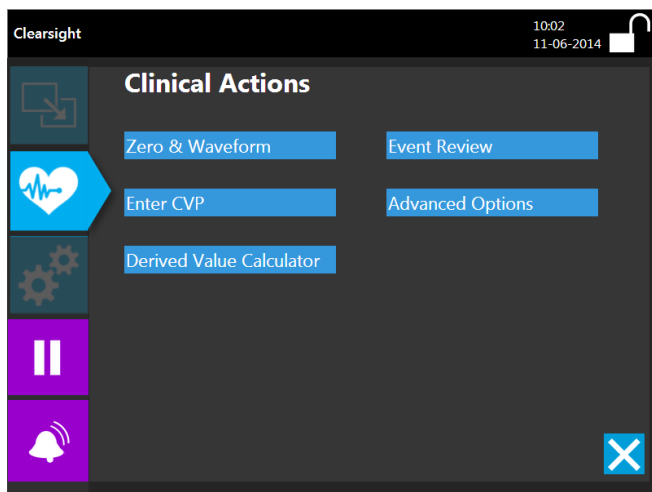


Figure 57. Nexfin Flat style

11.2 Zero & Waveform

Most of the participants preferred the zero & waveform menu of concept Nexfin Flat. Nexfin Blue ended on the second place. While using this interface for the first time it is useful to have an explanation step by step. However,

after using it a couple of times it might lead to irritation to go through all the steps. Therefore, it should be better to choose for Nexfin Blue concept (Figure 58) because it still has an overview for the beginner and it would not irritate the advanced user. Besides, it is better for the user to do as few actions as possible to reach a desired result.

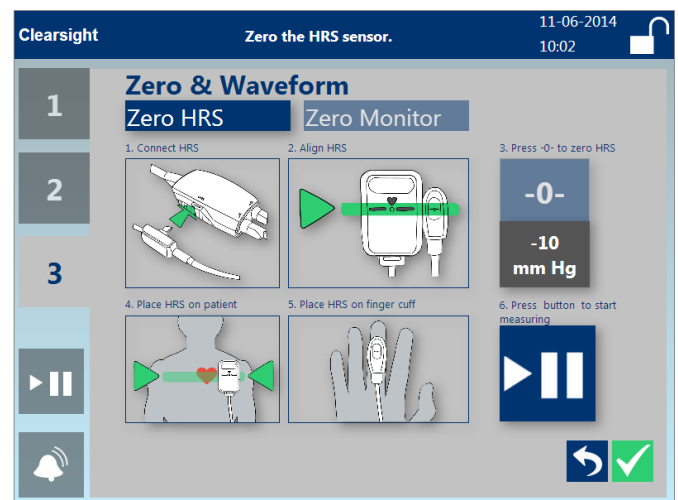


Figure 58. Zero & Waveform choice

11.3 Parameter selection

The participants liked the parameter selection of concept Nexfin Flat the most (Figure 59). The user is able to select its choice very quickly without confirming every choice. Despite, the contrast with the text of the deselected button should be better to improve the readability. Thereby, a solution has to be found for the globe selection problem.

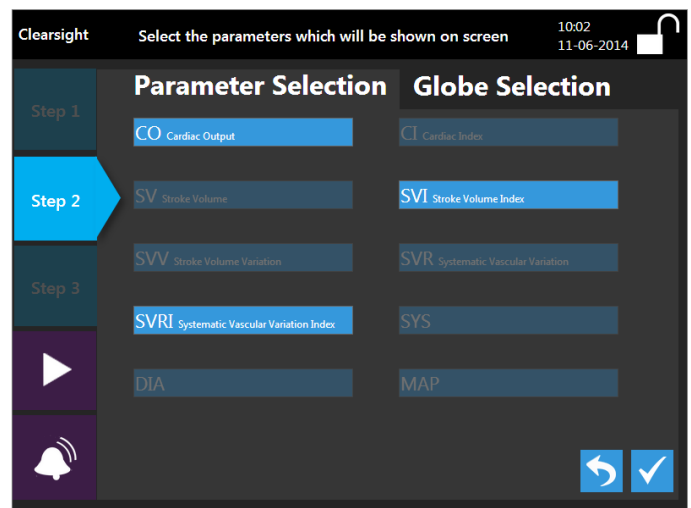


Figure 59. Parameter selection choice

11.4 Globe

Two kinds of globe visualizations were favorite by the participants: The arcs of concept Nexfin Black (Figure 60) and parameter color of concept Nexfin Blue. The most strong points of the arcs are that it gives an indication if a value is too high or too low. Even color blinds can indicate what the state is of the parameter. The only strong point of the Nexfin Blue globe is that it contains a parameter color. A possibility might be to integrate a parameter color in the arcs concept. Perhaps it should only be used in the tabular trend screen to prevent noise in other screens.

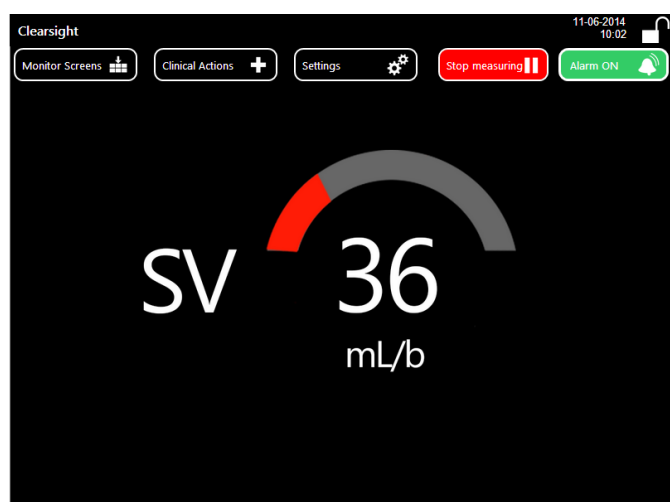


Figure 60. Globe choice

11.5 Physio-relationship screen

Most of the participants preferred the visualization of concept Nexfin Black for the physio-relationship screen (Figure 61). The value which is dangerously too high or too low comes very well to the front and less relevant information is sent to the background quite well. This situation is creating less noise and provides a focus point to the user.

11.6 Conclusion

After many considerations a choice for the final concept has been made. The final concept will contain a flat design style which should be less colorful than the current concept Nexfin Flat. The arrow/tab metaphor made the interface the most clearly and should be integrated in the final concept. The Zero & waveform menu contains an overview and should give enough information to the beginner and should not create irritation to the advanced user. The final concept will contain the parameter selection idea of concept Nexfin Flat. However, a few changes have to be made to create a higher amount of usability. The globes which will be used in the final concept are the arcs of concept Nexfin Black. These are better for color blinds and give more information to the user as the other globes. The physio-relationship screen will be visualized as in concept Nexfin Black. The placing of important information on the foreground and less important information on the background has been done the best in this concept.

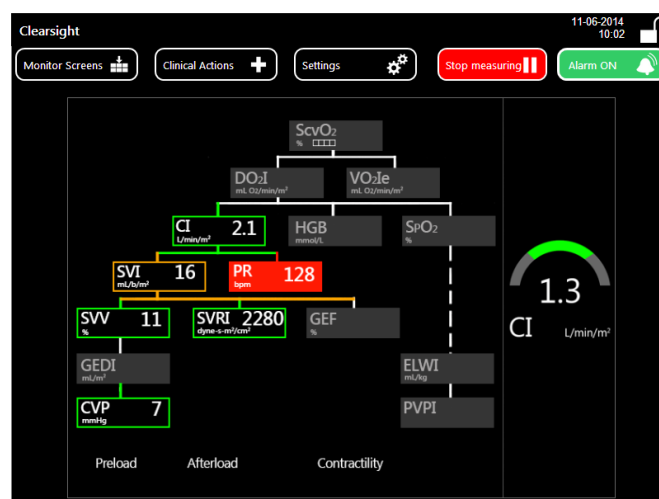


Figure 61. Physio-relationship choice



12

Finalization Phase

12 | Describing the final concept

This chapter explains the final concept which is generated out of the results of the last usability test. The previous chapter already explained what the final concept should contain from the generated concepts. The proportions of the user interface have been changed to fit on the presentation monitor screen. During generating the previous concepts this screen size was not known. An overview of all the different screens of the final concept can be seen in Appendix VI.

12.1 Structure

The structure of the final concept contains like the previous concepts a startup menu. This startup menu contains four steps where the user should give the needed input to the system. This startup menu contains one step more because this is clearer to the user. While most of the participants did not notice the globe selection tab in the Nexfin Flat concept. After following the startup steps the user is directed to the measurement stage.

The startup menu contains four tabs related to the four steps. These tabs are positioned on the left side of the screen. The measurement stage contains five tabs at the left side of the screen. The three grey tabs are menu

options. The two blue buttons beneath it do not contain a menu but should always be possible to use.

The user is notified by a blue arrow shape in which menu or step he/she is located. The other menu options are grey. This structure can actually be seen as a tab structure. The Zero & Waveform menu and monitor screens menu also contain this tab structure with arrows inside the main menu. This results in two arrows on screen which shows the user in which menu he/she is in and which submenu choice. This submenu tab structure is not used in the other menus because there are too many choices which will lead to a too crowded screen. In this case the screen contains a back button to choose another option in the previous menu.

A popup menu will be visible by pressing on a globe. The popup menu contains an arrow which points at the chosen globe. This popup menu allows the user to adjust the target value and to change the parameter. These options are divided into two tabs without the arrows; however the chosen tab is still blue.

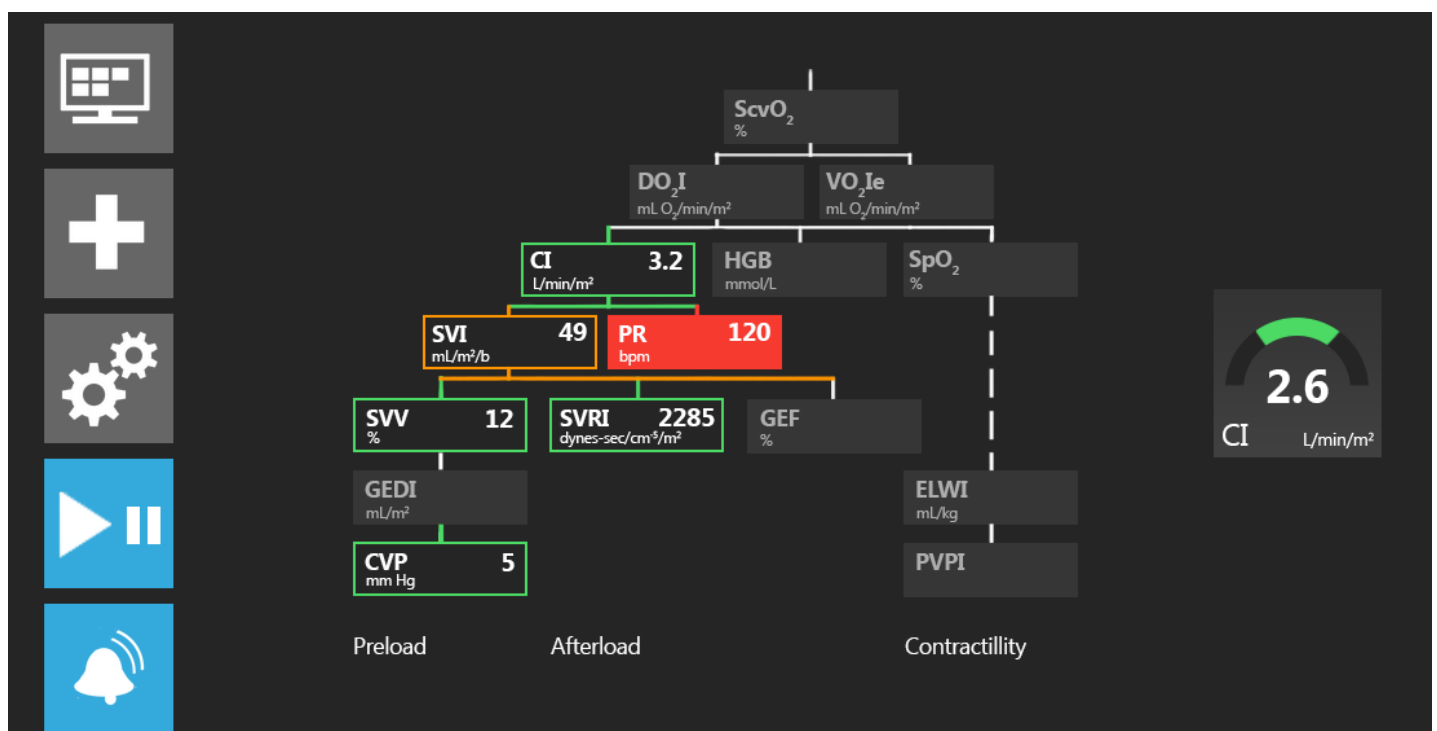


Figure 62. Physio-relationship screen

12.2 Style

The participants of the usability test thought that there was too many color in the Nexfin Flat concept. However it was selected as the clearest concept. This final concept contains the style of the Nexfin Flat but with less color areas which makes it easier to the eye.

The not selected menu tab options are grey instead of (low opacity) blue. In this way the menu buttons get less to the foreground and makes the user able to focus on the important measurement values.

The colors blue, green, orange and red are used to give information to the user. Blue is used because it comes forward very easily. Most of the color blinds are able to see blue colors and can therefore be used as a trend line color, menu notifications and menu options.

The green color is used to notify the user that the measured value is in a good range. The green color is used in a part on a circle on the globe, as a square in the physiology screen and as a contour around a tile in the physio-relationship screen. The same goes for the orange color notification. The red color notification however colors the whole tile in the physio-relationship screen. Because a red value is too dangerously high or low it is important that the user can identify this problem immediately.

A color blind user will see the green, red and orange color as brown to orange colors. By differentiating the visualization of these colors a cue is given to the color blind user to indicate if the value is good or dangerous.

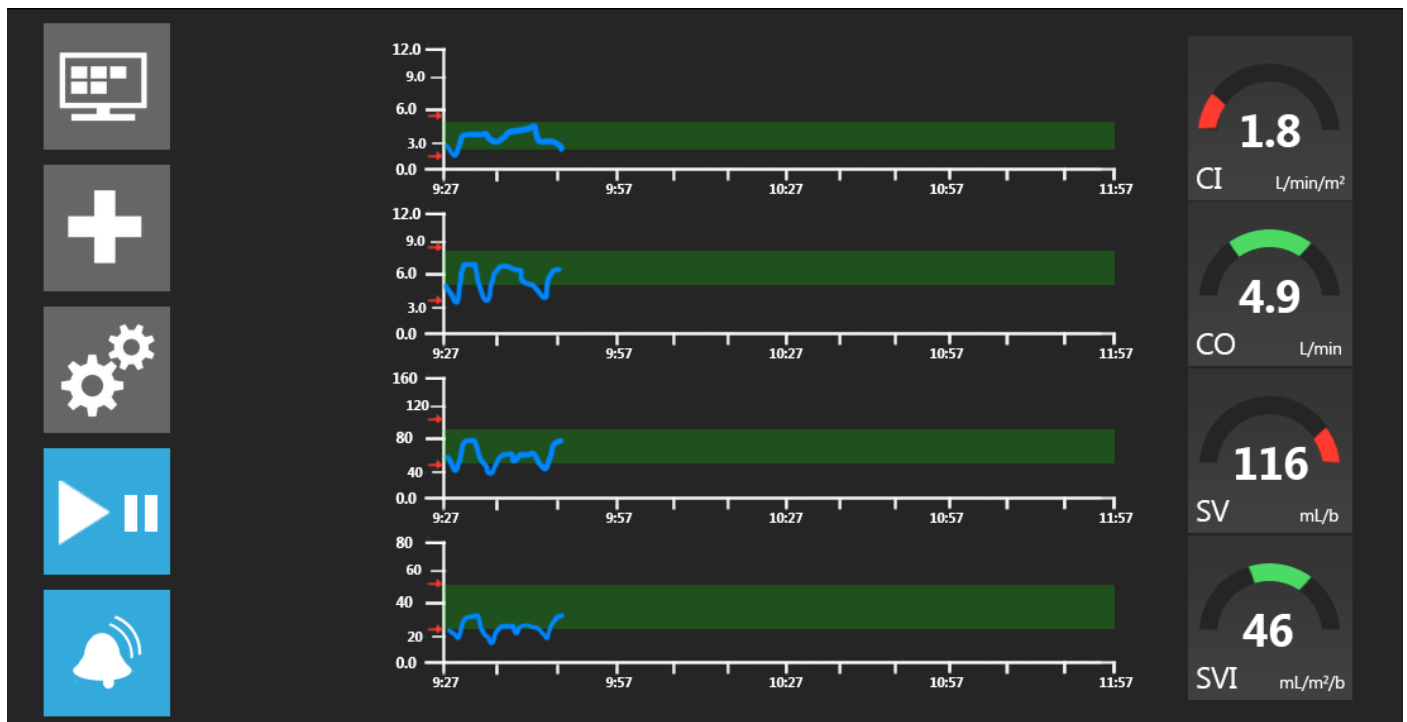


Figure 63. Tabular trend screen

12.3 Interaction

The user is able to do the following actions:

- Press on the ON/OFF button to start the device.

-Start screen appears.-

-The user gets directed to the startup menu.-

- **Step 1:** The user should fill in patient data. If there is still data from a previous patient the user can delete these data to choose for "New Patient".

- **Step 2:** The user can choose by pressing on the parameter tile which parameters will be on screen for this particular patient. In short: the user is able to delete unnecessary data of the screen to prevent noise.

- **Step 3:** The user can choose which parameter is shown in which globe. For example: the user chooses for the first globe parameter CI. This means that in every monitor screen the upper globe will be CI.

- **Step 4:** The user should zero the HRS. By following the steps the user is lead through this process. By pressing on the start button the user starts the measurement and the startup menu closes.

-The user is directed to the measurement stage.-

- By pressing on the first tab button the user opens the monitor screen selection menu. This menu allows the user to choose another amount of globes on screen and visualization of the measurement. The desired monitor screen visualization can be chosen by pressing on a picture of the visualization.

- By pressing on the second tab button the user opens the clinical actions menu. The user is able to zero the HRS and monitor again. Also other options are possible: enter CVP, derived value calculator, event review and advanced options.

- By pressing on the third tab button the settings menu opens. The settings menu allows the user to change the standard settings into their desired settings. The user can change the previous inserted patient data by going to the patient data menu. Also the parameter and globe settings can be changed again in this menu.

- By touching a globe in a monitor screen the user is able to change the target value for the parameter. The user is also able to change the parameter globe into another parameter. Besides the user is able to stop the measurement of one parameter by pressing on the target checkmark and disable the alarm by pressing on the alarm button.

- By pressing the fourth tab button the user pauses or starts the measurement. When the measurements are paused the globes get grey and no current values will be visualized. Previous measured values in the trend line and numeric value are still visible if the measurement is paused.

- By pressing on the fifth button the alarm can be set on and off again. This disabled alarm is for all the measured values.

- If a value of a measured parameter is in the red zone the globe starts blinking to get attention from the user.

- It is possible to change all the data which was setup during the startup stage in the measurement stage. This makes it possible to correct mistakes easily.

Summarized, this concept uses the flat design style which is characterized by simplicity and intuitiveness. The startup stage leads the user through the main menus which need to be setup before the measurement can be started. During the measurement stage the user is free to navigate through menus. Besides that, the user will get warned if a value is too high or too low.

13 | Conclusions and recommendations

13.1 Conclusions

The main goal of this project is: discovering what the guidelines for the ccNexfin user interface are which contributes to make the user interface more intuitive and more consistent to prevent possible disastrous failures. Several questions were answered during the previous chapters to reach this goal. Out of these answers of these questions and the design process and reviews the following guidelines are determined.

The navigation bar should contain as less choices as possible to prevent noise on screen.

During the first usability test two functions of the navigation bar were not necessary. Only menu options and important hotkeys such as Alarm and Start/stop measuring need to be in the navigation bar.

The user interface should be consistent.

Because the interface contains a complex measurement system it needs consistency. By using consistency the user can recognize situations more easily and would make fewer mistakes.

The user interface elements should not be focused on realism but on intuition.

Out of the visual design trend analysis can be concluded that the trend for this year is flat design. Flat design tries to make the user feel more comfortable, the graphical interface starts focusing more on intuition instead of focusing on realism. Instead of adding to the design, the designer should remove unnecessary elements.

Instructions of difficult/important actions should be divided into smaller steps with pictures and/or text where possible.

An example is the Zeroing process. Every step contains a picture or a button with an instruction text. These steps will help the beginner user to learn the process and helps the advanced user to remind him for not forgetting a step.

Users should be able to set up their own preferences for a patient before they start the measurement.

Noise can be canceled on screen by providing preference settings of parameters. Important parameters differentiate from patient to patient.

The user should be informed in which step they are in the startup process and how many steps they still need to go through.

Users want to stay informed and want to know when they have finished the startup phase and can actually start measuring.

The user should always be informed in which menu he/she presently is.

Add cues for the user such as arrows or tabs to make clear to the user in which menu he/she is.

The user should always be able to change mistakes made during giving input.

Users can make a mistake by giving the wrong input. If they detect it they should be able to change this very easily.

Errors should be given in a clear language.

The user should be able to understand what is wrong and how they should fix this error.

Hotkeys should have a logical place, otherwise no one will find these.

Situations like in the current interface with pressing inside the globe for the target value menu and outside the globe for changing the globe parameter should be prevented.

Do not ask for confirming data too much since this will irritate the user.

The sequence of actions should not be too high for every action and decision the user makes. Only important data should be confirmed.

Use high contrasting colors for important data and background.

Because clinicians need to see information on the screen from a distance of 3 meter, clear bright colors should be used for this information with a dark background. Important information can be described as the trend graph and the parameter status.

Add not only color cues for important information while color blinds experience fewer colors.

Color blinds have difficulties with seeing green and red colors, blue colors are for most of the color blinds recognizable. Especially in this interface the red and green colors are very important and therefore a clear distinction should be made.

Use as little as possible colors to prevent noise on screen.

Too many colors give noise on screen. Only use a color if information is important or should warn the user.

Use icons instead of text in the navigation bar, because icons are stronger as text.

Text might be useful for beginner user, however good icons give way more information as text to the advanced and beginner user.

During the second usability test several participants said that the new concepts were clearer and easier to use in comparison with the current interface. Especially the function of changing the globe targets and parameters in the popup screen is seen as more intuitive. This illustrates that the goal of designing a more intuitive and consistent user interface is reached.

At last, it should be helpful to make an instruction mode in the interface which goes through all the menus to make clear to the user what is possible in a menu and how they can reach this menu.

13.2 Recommendations

The concept interfaces were seen as more intuitive and consistent; however there are still some recommendations for further research to improve the intuitiveness of the user interface.

First, a point of improvement which did not get so many attentions is the errors. Especially during patient data input it is still possible to set up values which probably do not match with each other. An example is filling in 35 kg by a male patient with a height of 185 cm.

Second, the keypad design stopped after the ideation phase. This was done because it was a lot of work to put this function in a prototype. It is not necessary in this prototype but it would be preferable for the completeness of the prototype.

Third, not all functionalities of the current user interface have been analyzed and used in the redesign. It might be interesting to see how the user interface redesign handles the complexity of more functions.

Additionally barely any attention is given to the possibilities of touch screen interactions. Another research might be interesting to investigate touch screen interaction possibilities for this specific medical device.

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I/VI | Appendices

I | Hemodynamic parameter definitions

Parameter	Description
Cardiac output (CO)	Continuous assessment of the volume of blood pumped by heart measured in liters per minute.
Cardiac Index (CI)	Cardiac output relative to body surface area (BSA)
Stroke Volume (SV)	Volume of blood pumped with each heart beat.
Stroke Volume Index (SVI)	Stroke volume relative to body surface area (BSA)
Systematic Vascular Resistance (SVR)	The resistance that the left ventricle must overcome to eject stroke volume with each heart beat.
Systematic Vascular Resistance Index (SVRI)	SVR relative to body surface area.
Stroke Volume Variation (SVV)	The perfect difference between SV min, max and mean.
Cardiac Function Index (CFI)	CFI is provided by transpulmonary thermodilution and serves as an indicator of left ventricular systolic function.
Cardiac Output (iCO)	Intermittent assessment through thermodilution of the volume of blood pumped by the heart measured in liters per minute.
Cardiac Index (iCI)	Intermittent assessment through thermodilution of cardiac output relative to body service area.
Extravascular Lung Water (EVLW)	Extravascular water content of the lung tissue.
Extravascular Lung Water Index (ELWI)	Extravascular water content of the lung tissue relative to predicted bodyweight (PBW)
Global Ejection Fraction (GEF)	Estimated injection fraction using GEDV
Global End-Diastolic Volume (GEDV)	Estimated combined volume of the RAEDV, RVEDV, LAEDV, and LVEDV.
Global End-Diastolic Volume Index (GEDI)	Estimated combined volume of the RAEDV, RVEDV, LAEDV, and LVEDV relative to body service area.
Intrathoracic Blood Volume (ITBV)	Estimated combined volume of the heart and the pulmonary blood volume (PBV).
Pulmonary Vascular Permeability Index (PVPI)	Ratio of the extravascular lung water and the estimated volume of pulmonary blood.
Stroke Volume (iSV)	Intermittent assessment through thermodilution of the volume of blood pumped with each heart beat.
Stroke Volume Index (iSVI)	Intermittent assessment through thermodilution of the stroke volume relative to body service area.
Systematic Vascular Resistance (iSVR)	Intermittent assessment through thermodilution of the resistance to flow that must be overcome to push blood through the circulatory system
Systematic Vascular Resistance Index (iSVRI)	Intermittent assessment through thermodilution of the SVR relative to body service area.
Central Venous Oximetry (ScvO2)	Venous oxygen saturation as measured in the superior vena cava.
Mixed Venous Oximetry (SvO2)	Venous oxygen saturation as measured in the pulmonary artery.

Parameter	Description
Oxygen Consumption (VO2)	The amount of oxygen used by body per minute.
Estimated Oxygen Consumption (VO2e)	An estimate of the amount oxygen used by body per minute.
Oxygen Consumption Index (VO2I)	The amount of oxygen used by the body per minute indexed against body service area.
Estimated Oxygen Consumption Index (VO2Ie)	An estimate of the amount of oxygen used by the body per minute indexed against body service area.

Usability test/expert review current user interface

Het hoofddoel van dit gebruiksonderzoek is het identificeren van mogelijke verbeterpunten van de interface met betrekking op interactie en vormgeving van het ccNexfin system om de gebruiksvriendelijkheid van het apparaat te vergroten.

Vragen die beantwoord dienen te worden om het hoofddoel te behalen zijn:

- Waar liggen problemen op gebied van interactie tussen de gebruiker en de Nexfin?
- Hoe ernstig wordt dit probleem ervaren door de gebruiker?
- Treden er irritaties op met betrekking tot de vormgeving?
- Wat voor mogelijke verbeteringen brengt de gebruiker zelf naar voren?

Hypothese

De testpersonen beschouwen de interface als intuïtief door het gebruik van iconen. (intuïtief als de taken gemiddeld genomen normaal of sneller worden doorlopen)

De testpersonen zien de zeer uitgebreide grafisch realisme als storend.

Karakteristieken van de testpersonen

De testpersonen die nodig zijn voor deze test moeten een medische achtergrond hebben om een mening te kunnen vormen over de aspecten die worden weergegeven in de interface. Wenselijk is dat een aantal testpersonen eerdere ervaringen hebben gehad met soortgelijke medische apparaten om de Nexfin te kunnen vergelijken om mogelijke punten voor verbetering te zien.

Protocol

Afhankelijke variabelen

- Tijdsduur van de taak
- Aantal fouten bij het uitvoeren van de taak
 - o Verkeerd gekozen menu
- Tevredenheid met het apparaat
- Begrijpelijkheid van het apparaat

Onafhankelijke variabelen

- Ervaring met dergelijke apparaten van de gebruiker
 - o Gebruik van smartphone of tablet
 - o Gebruik van medische apparaten
 - o Gebruik van elektronische apparaten met display

Omgevings variabelen

- Man/vrouw
- Leeftijd

Evaluatie methoden

- Directe observatie
- Bijhouden van tijd
- Waarnemen van acties van proefpersoon
- Gesprek met proefpersoon

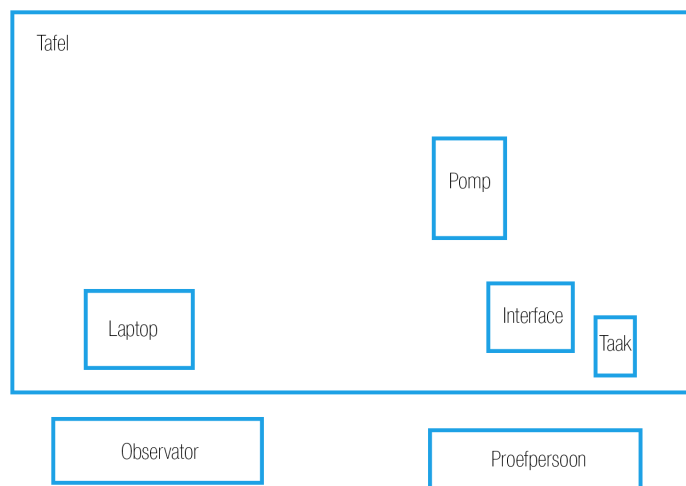
Tijdsindicatie

Introductie: 5 minuten

Aansluiten van apparatuur bij de persoon: 1 minuut.

Taak uitvoering: 20 minuten

Interview: 15 minuten



Beschrijving voor tester

Inleiding

De interface die u gaat testen is van het ccNexfin systeem, een systeem wat continu de hart- en vaattoestand van patiënten meet. Dit systeem monitort hemodynamische parameters die de arts kunnen helpen met onder andere strategie bepaling voor het behandelen van de patiënt. Het systeem bestaat uit een monitor, pomp, polsband, vingermanchet en een hartreferentiesysteem. Om deze test uit te voeren is het van belang dat al deze componenten zijn aangesloten.

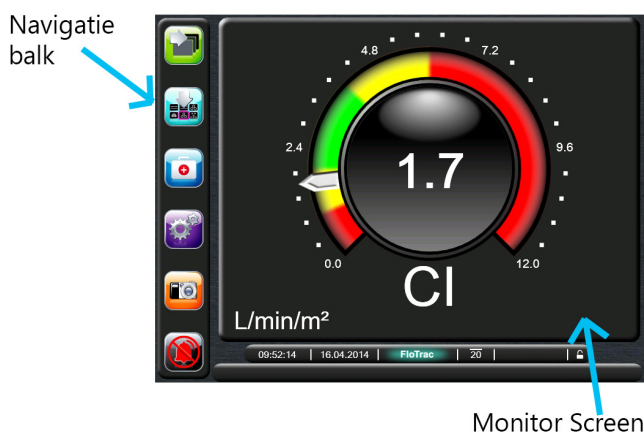
Doel

Het doel van deze gebruikstest is om te achterhalen wat mogelijke verbeterpunten zijn van het huidige ontwerp van de interface van het ccNexfin systeem. U wordt zelf niet getest, dus het is niet erg als een bepaalde taak niet lukt. Als een taak niet lukt ligt dit aan de interface en niet aan u.

U krijgt een aantal taken die u moet uitvoeren op de interface. Tijdens deze taken mag u hardop denken wat u opvalt tijdens het gebruik. De opmerkingen die u maakt kunnen helpen om goede of juist slechte aspecten uit de interface naar voren te halen. Nadat u de taken heeft uitgevoerd zal ik u nog een aantal vragen stellen over de interface.

Om de interface optimaal te laten werken is het nodig dat er een persoon zit aangesloten op de apparatuur. U mag ervoor kiezen of u zelf aan de apparatuur wilt worden aangesloten of dat ik deze taak op mij neem.

Hieronder ziet u het hoofdmenu met daarbij de benodigde termen die zullen worden genoemd in de taakomschrijving. Met parameter worden bijvoorbeeld CI en SVR bedoeld.



Takenlijst

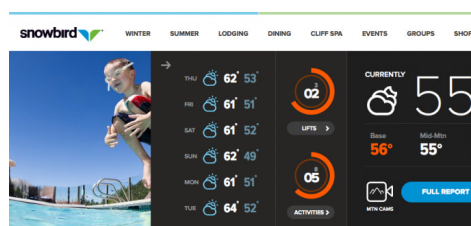
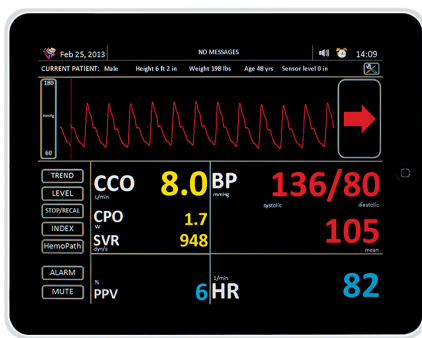
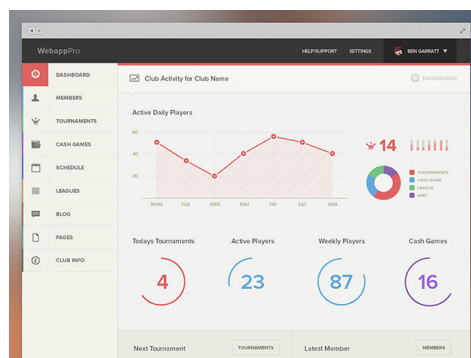
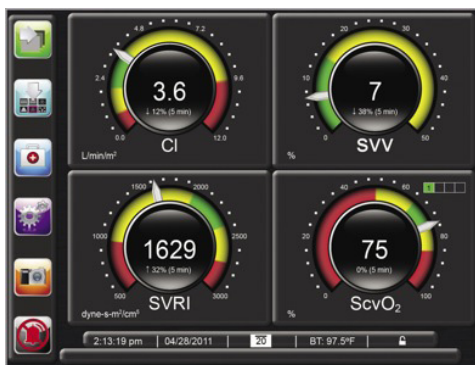
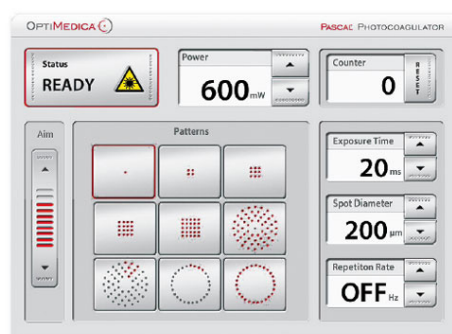
- Zet het apparaat aan en voer vervolgens de volgende patiënt gegevens in en sla deze op.
 - o Jaap de Jong
 - o Lengte: 185 cm
 - o Gewicht: 75 kg
 - o Leeftijd: 33
- Navigeer naar het menu Zero & Waveform en voer de instructies gegeven op het scherm uit en start de meting.
- Scroll door alle verschillende Monitor Screens. Is dit wisselen van schermen ook mogelijk in een ander menu?
- U wilt een ander aantal aan parameters die worden weergegeven op de Monitor Screens veranderen, hoe zou u dit aanpakken?
- Verander een van de parameters die wordt weergegeven in het hoofdscherm in een andere parameter naar keuze.
- Verander de "Target Value" van een parameter naar keuze. Is dit volgens u mogelijk om dit ook via een ander menu te doen?
- Verander de eenheid van temperatuur van Celcius (°C) naar Fahrenheit (°F) en sluit vervolgens het menu.
- Maak een Snapshot (Foto). Wat krijgt u te zien?

Dit is het einde van de taken lijst. Momenteel heeft u ongeveer alle menu's doorlopen.

Vragen achteraf

1. Wat is uw algemene indruk van de interface? (Was het makkelijk of juist moeilijk om bijvoorbeeld het goede menu te vinden?)
2. Mist u bepaalde hoofdfuncties in het navigatie menu?
3. Zijn er volgens u functies overbodig in het navigatie menu?
4. Vindt u de plaatsing van het navigatiemenu aan de linkerkant van het scherm prettig of heeft u voorkeur voor een andere plek op het scherm?
5. Zijn de gebruikte iconen duidelijk? (hierbij is een lijst met plaatjes van iconen gegeven)

6. Zou u liever de keuze hebben uit tekst in plaats van iconen?
7. Wat vindt u van de manier van weergave van de parameters in de Monitor Screens?
8. Mist u nog manieren van weergaven van parameters?
9. Zijn er volgens u schermen van de monitor screens die u als overbodig ziet?
10. Hoe heeft u het kleurgebruik en indeling van de interface ervaren?
11. Denkt u dat de verschillende kleuren in het navigatie menu de interface gebruiksvriendelijker maakt?
12. Vindt u de stijl van de interface passen bij het doel van het apparaat?
13. Als u de keuze had welke van de volgende stijlen heeft uw voorkeur als interface stijl voor de Nexfin en wat voor stijl vindt u het minst aantrekkelijk?



Aantekeningen bij taken

1. Zet het apparaat aan en voer vervolgens de patiënt gegevens in en sla deze op.

Tijd: Gemiddeld tot snel

Fouten:

- Tikken op scherm om aan te zetten
- Op home button drukken die niet selecteerbaar is.

Opmerkingen:

- Het is geen querty toetsenbord
- Er is iedere keer een groene enter knop om te bevestigen, maar de laatste knop is blauw en heeft een huis symbool.

2. Navigeer naar het menu Zero & Waveform en voer de instructies gegeven op het scherm uit en start de meting.

Tijd: Zeer traag

Fouten:

- Drukt op melding onderin: zero HRS
- Proberen te zeroen met de twee onderdelen naast elkaar te houden. Zij hebben niet door dat op 0 gedrukt moet worden.

Opmerkingen:

- De instructies op het scherm zijn niet duidelijk wanneer de persoon voor het eerst alles gaat aansluiten.
- De plaatjes zijn niet duidelijk dat de HRS sensor op hart hoogte moet worden geplaatst.

3. Scroll door alle verschillende Monitor Screens. Is dit wisselen van schermen ook mogelijk in een ander menu?

Tijd: Zeer traag

Fouten:

- Proberen te swipen
- Op de knop voor intervention drukken
- Op globe drukken
- Kan het vorige menu niet makkelijk sluiten

Opmerkingen:

- Het is nog niet helemaal duidelijk wat monitor screens zijn.

4. U wilt een ander aantal aan parameters die worden weergegeven op de Monitor Screens veranderen, hoe zou u dit aanpakken?

Tijd: Snel tot zeer traag

Fouten:

- Direct naar het settings menu gaan bij monitor screens.
- Op een nummer drukken en dan zien ze vervolgens dat het aantal parameters veranderd en drukken vervolgens op het kruisje waardoor er geen verandering optreed.
- In het intervention menu zoeken.
- Drukken op parameter metertje zelf.

Opmerkingen:

- Vaak gaan ze eerst naar het goede menu, maar hebben ze niet door dat ze in het goede menu zitten.
- Als men weet dat het op deze manier moet is het wel duidelijk.

5. Verander een van de parameters die wordt weergegeven in het hoofdscherm in een andere parameter naar keuze.

Tijd: Zeer traag tot totaal niet kunnen vinden.

Fouten:

- Drukken op de globe, maar komen in het target value screen terecht.
- Gaan zoeken bij monitor settings
- Drukken op clinical actions

Opmerkingen:

- Wordt niet als logisch beschouwd.
- Werd toevallig gevonden door verkeerd drukken.
- Er werd gedacht dat er per se in een bepaalde hoek moest worden gedrukt om het menu te krijgen.
- Mogelijk aangedragen oplossing is een knop vorm onderin wat impliceert dat daar op gedrukt kan worden.
- Het moet ook mogelijk zijn om dit bij monitor settings aan te passen.

6. Verander de "Target Value" van een parameter naar keuze. Is dit volgens u mogelijk om dit ook via een ander menu te doen?

Tijd: Gemiddeld tot snel

Fouten: voor de andere optie zoeken bij clinical actions

Opmerking:

- Het Target menu hadden ze al eerder gevonden tijdens een andere taak.

7. *Verander de eenheid van temperatuur van Celcius (°C) naar Fahrenheit (°F) en sluit vervolgens het menu.*

Tijd: Zeer traag

Fouten:

- Monitor screens doorlopen om vervolgens een parameter te veranderen.
- Naar clinical menu navigeren
- Bij instellingen zoeken bij parameter settings in plaats van General

Opmerkingen:

- Er wordt gedacht dat dit ook een parameter is waardoor zij deze zoeken onder parameter settings.

8. *Maak een Snapshot (Foto). Wat krijgt u te zien?*

Tijd: Zeer snel

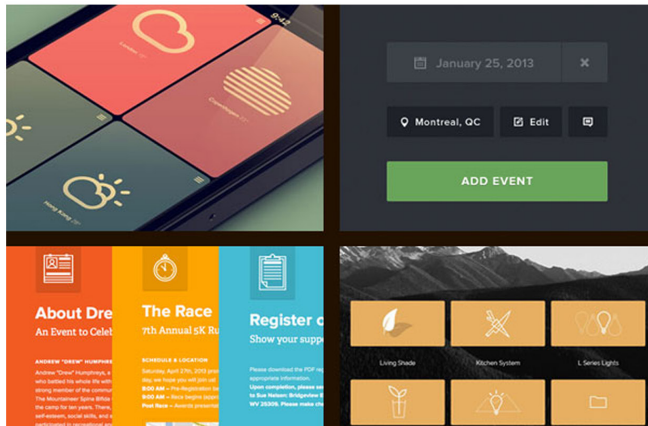
Fouten: Geen

Opmerkingen: Het is hen totaal niet duidelijk wat het nut is van deze functie.

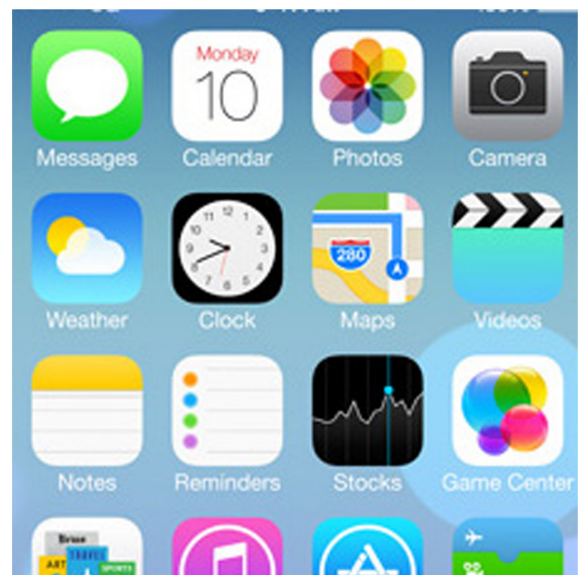
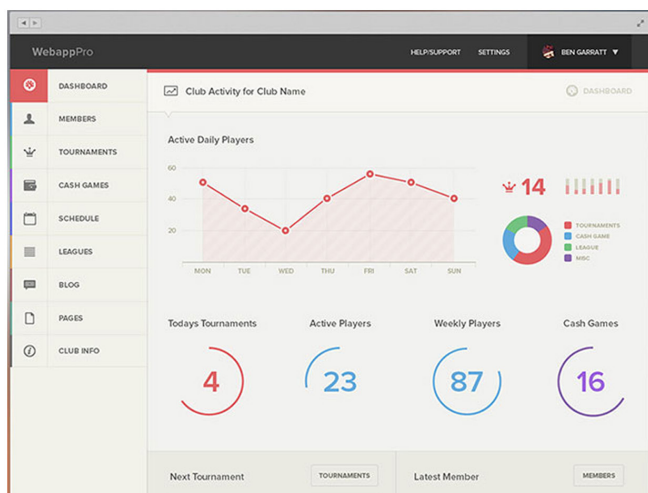
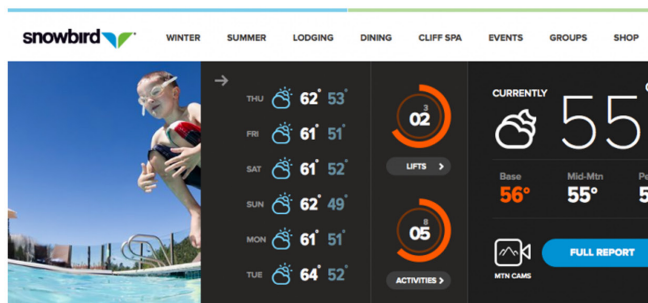
Algemeen veel voorkomende fouten:

- Wanneer een menu open staat op een globe op de achtergrond drukken.
- Naar een ander menu willen navigeren voordat het menu gesloten is.
- In het settingsmenu wordt vaker op het huisje gedrukt dan op het pijltje terug.

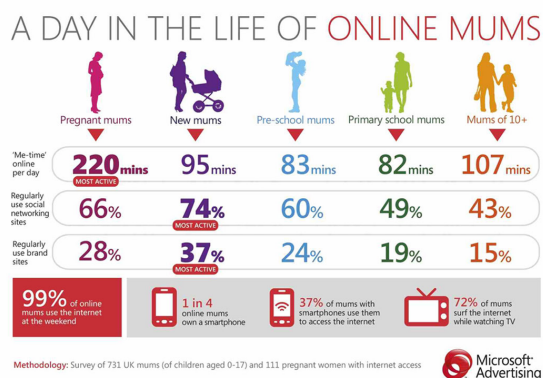
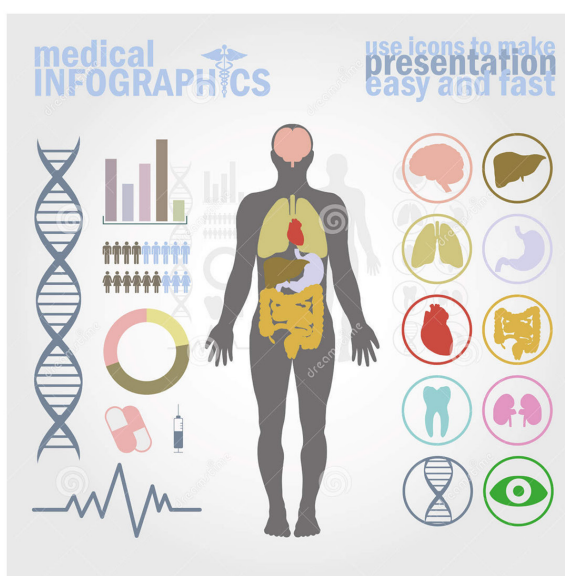
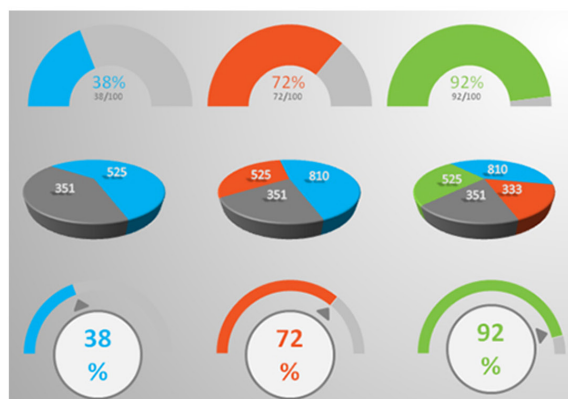
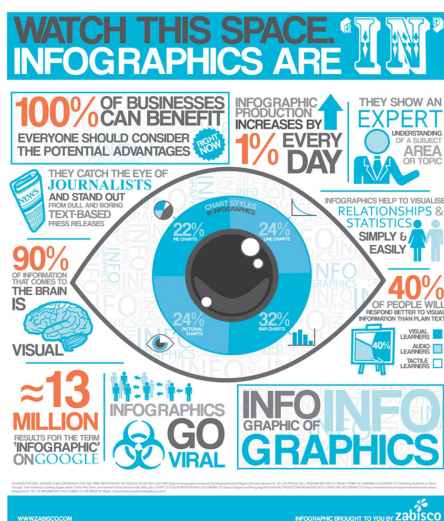
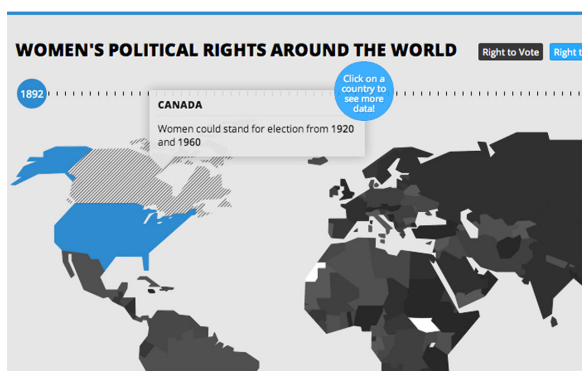
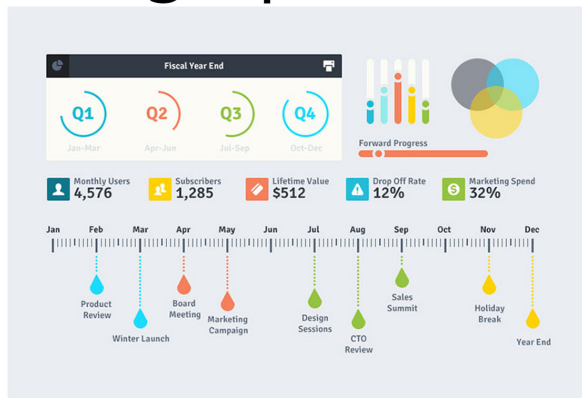
III | Visual design trend collage

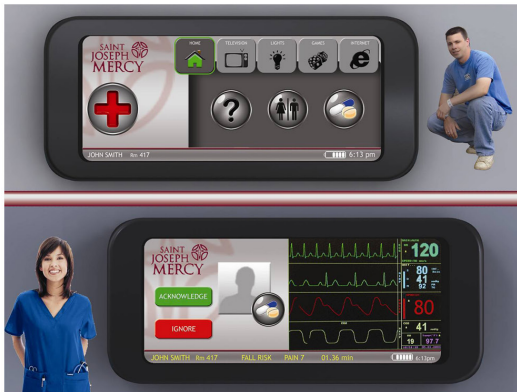


Flat Design

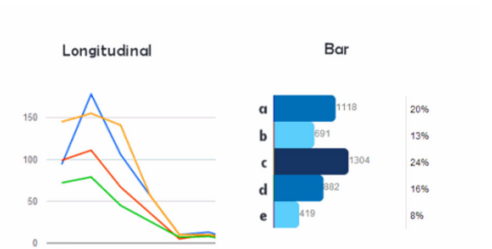
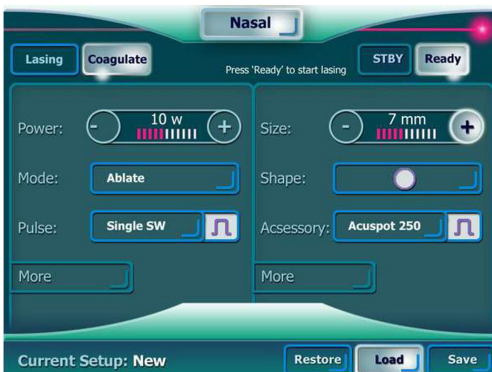
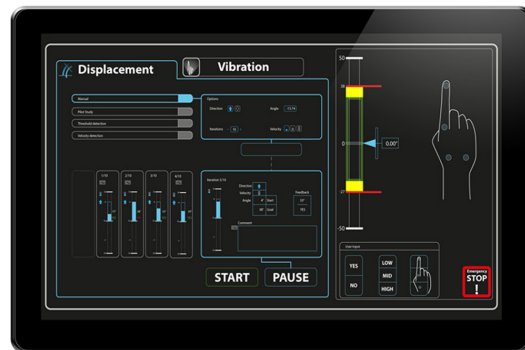
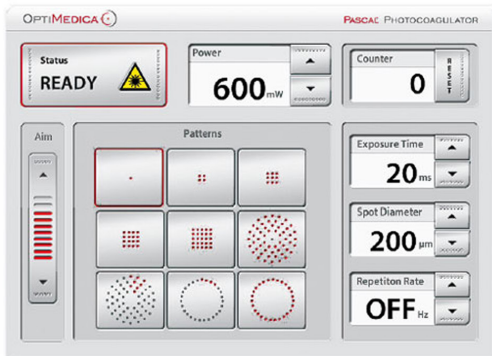


Infographics





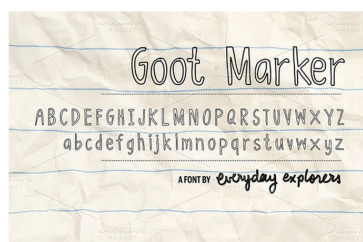
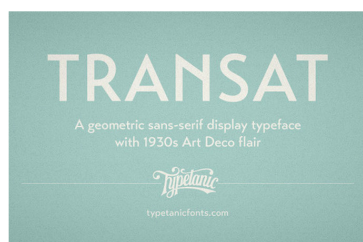
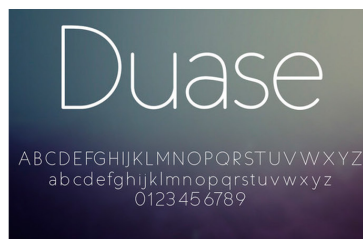
Medical Interfaces



Graphs



Typography Trends 2014

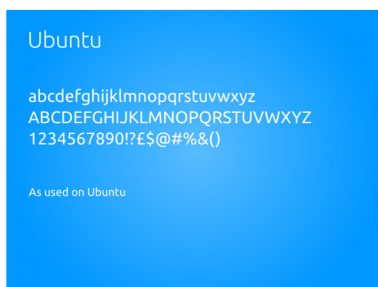
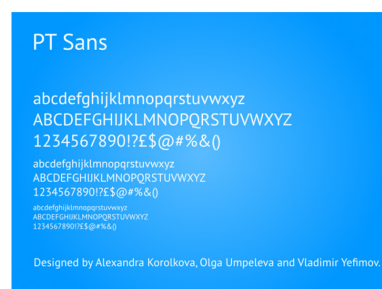
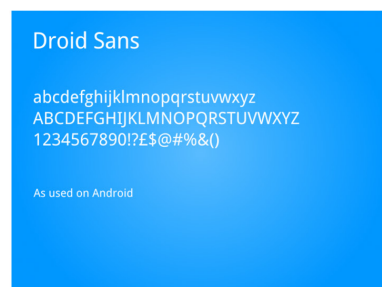


Flat Design

Handwritten Fonts

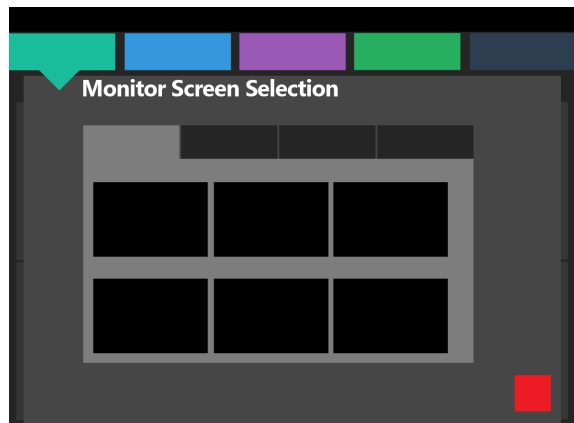
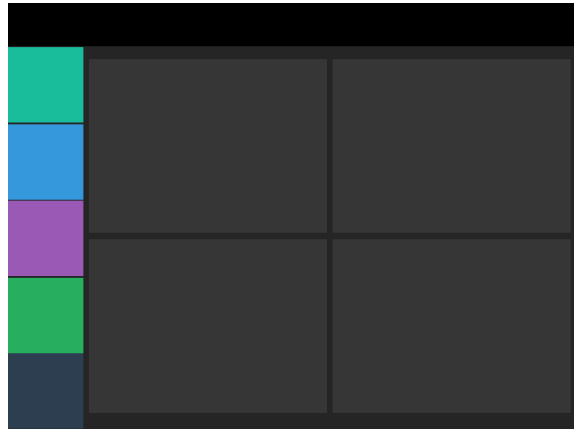
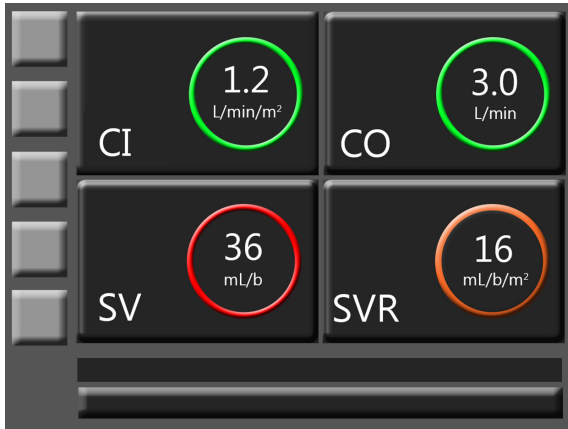
Mix & Match

User Interface Fonts

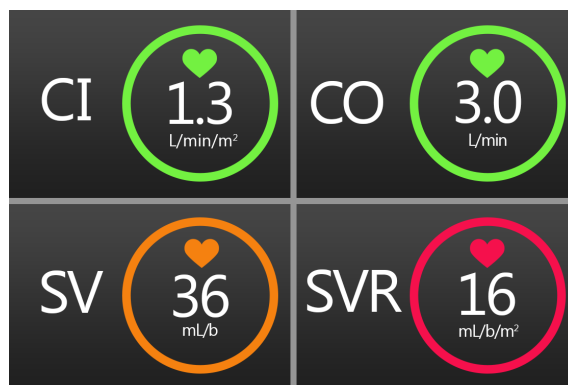
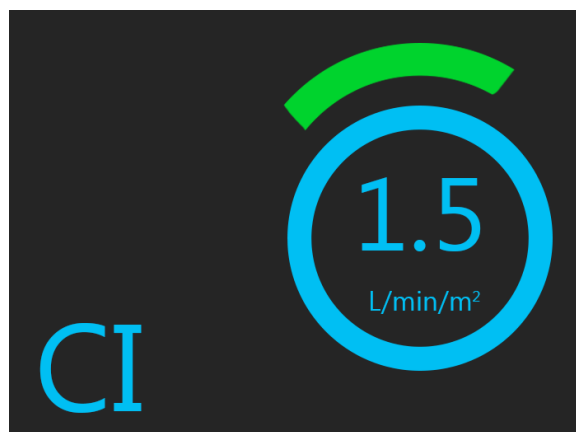


IV | Ideation material

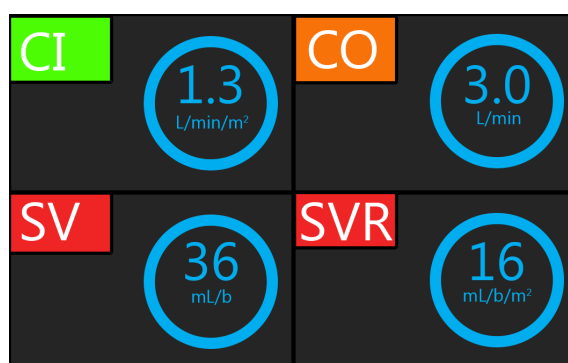
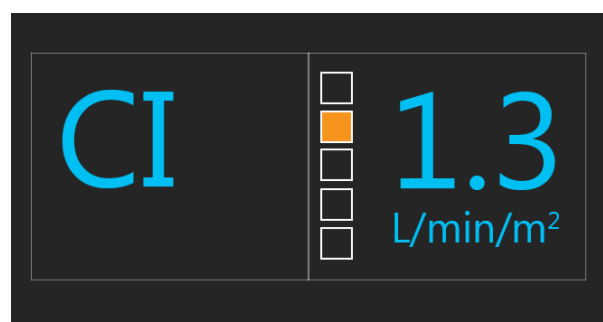
Screen Structure

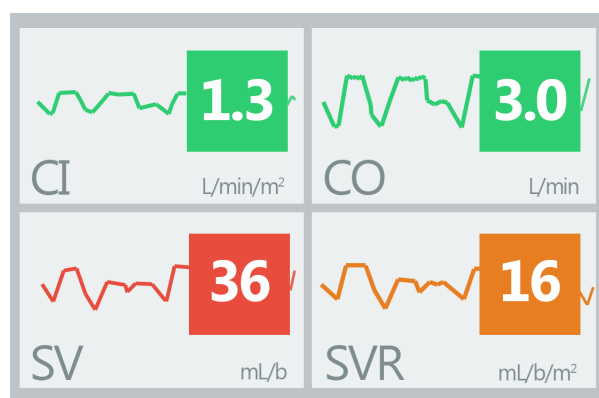
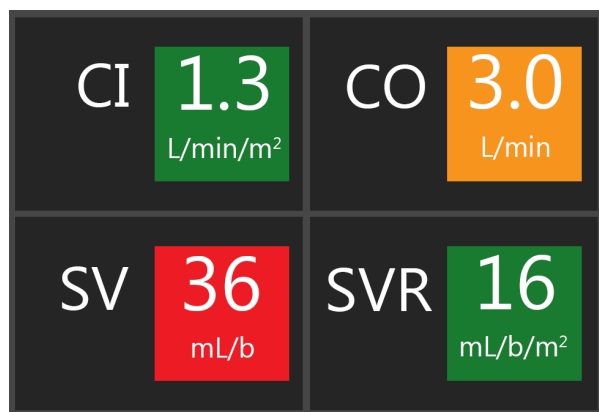
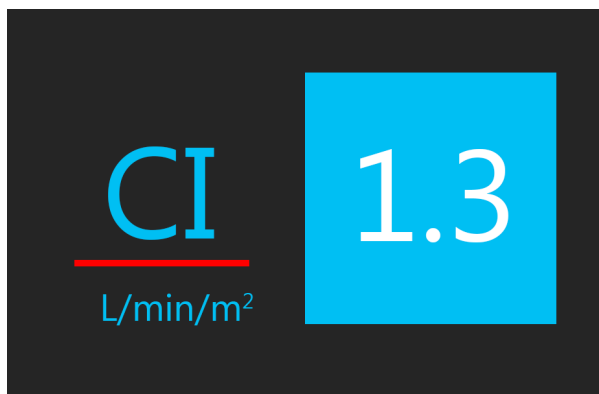
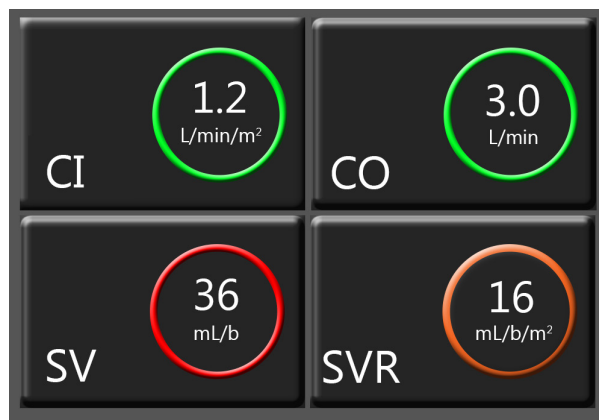
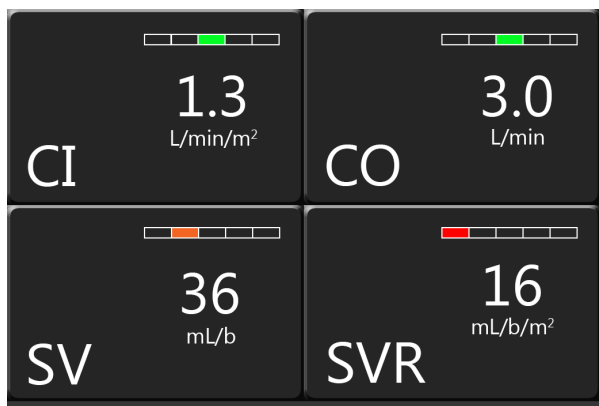


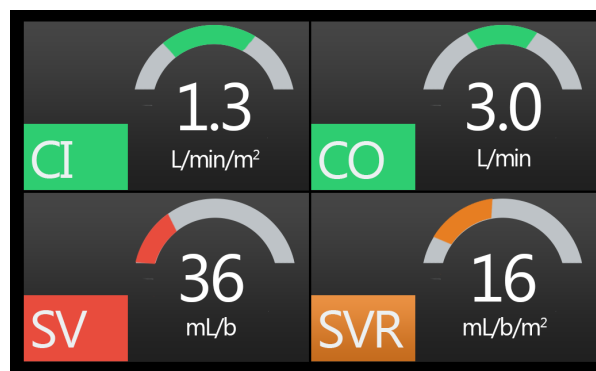
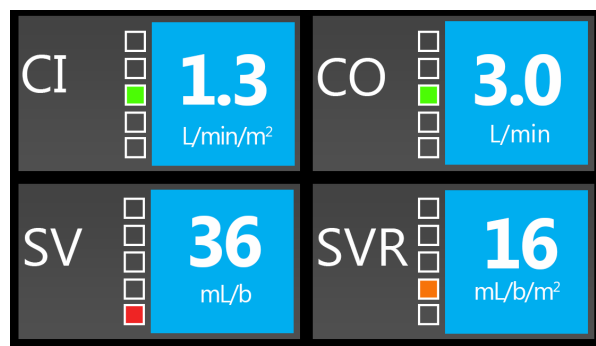
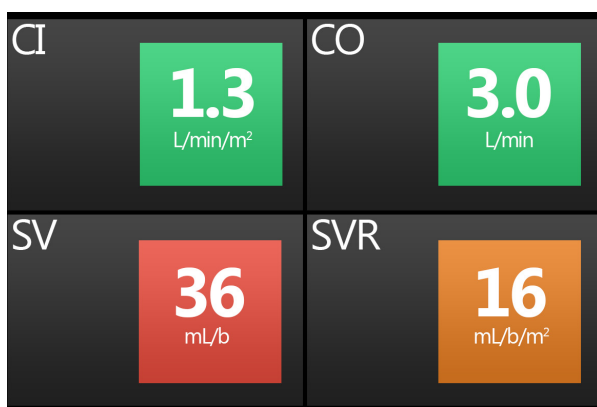
Big number screen



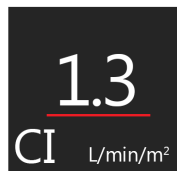
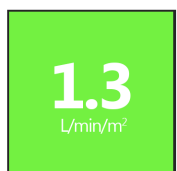
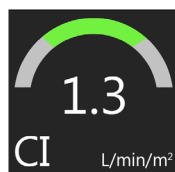
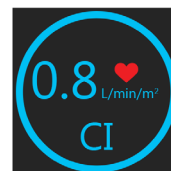
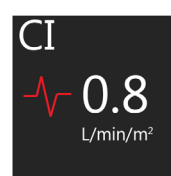
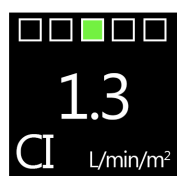
CI	1.3 L/min/m ²
SVR	20 mL/b/m ²
SV	36 mL/b
CO	30 L/min
Clearsight Warning	



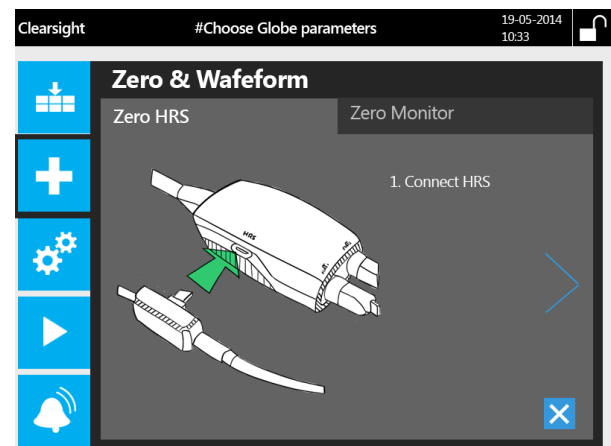
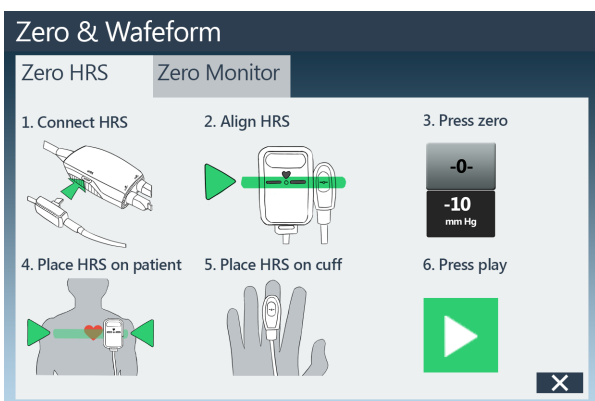
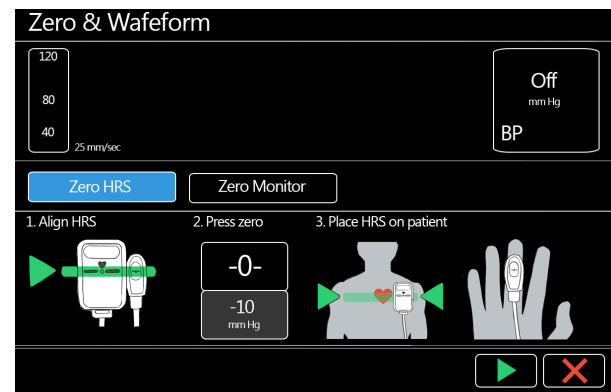
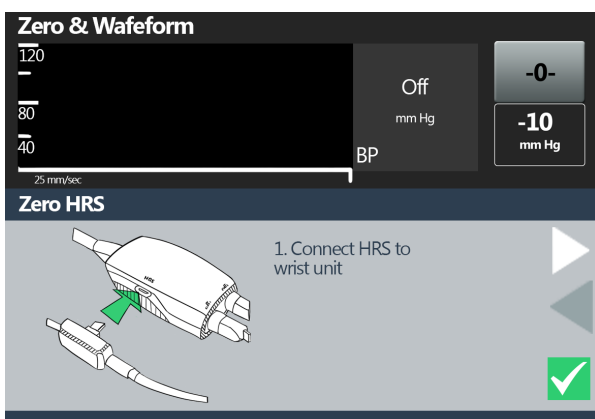
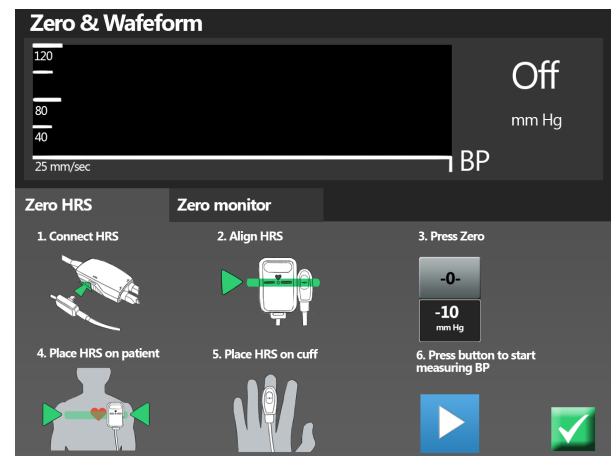
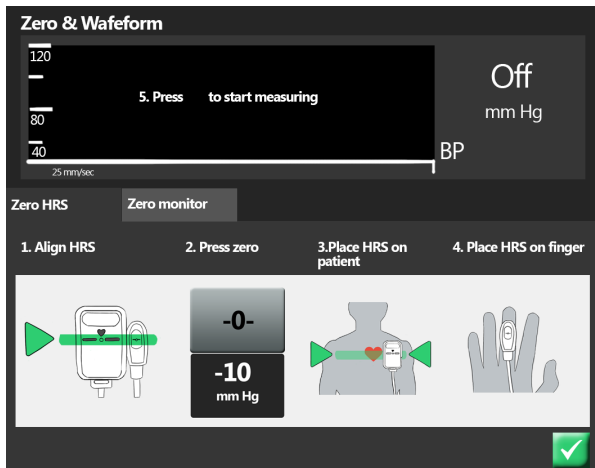




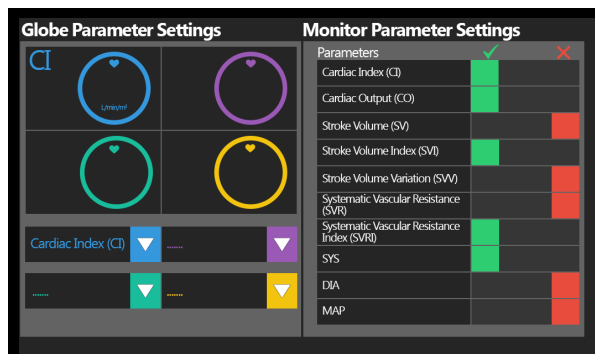
Small globes



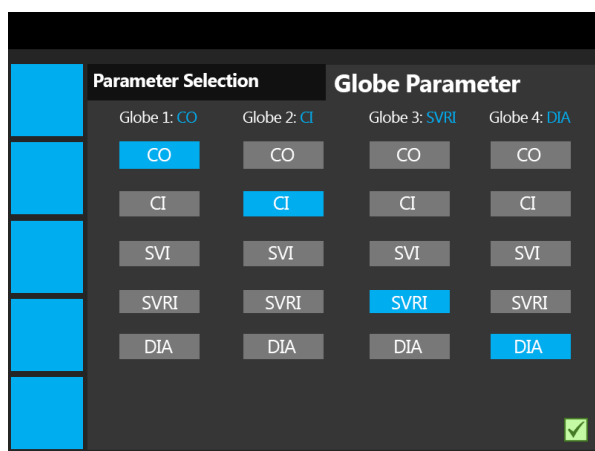
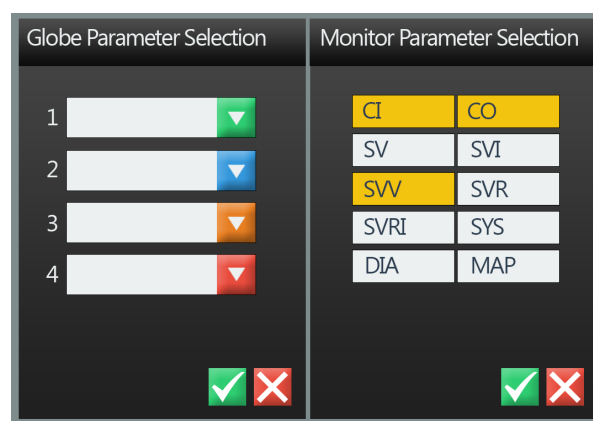
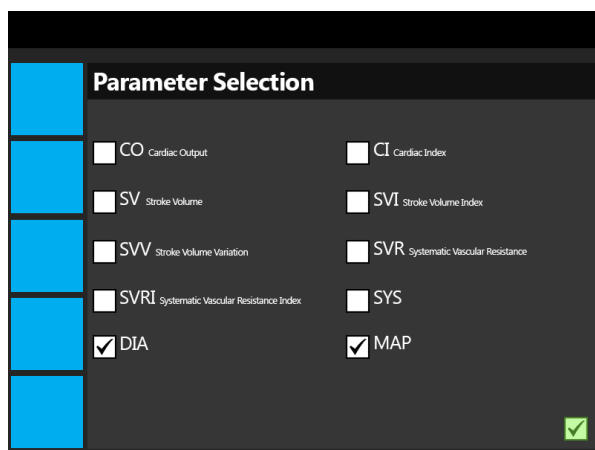
Zero & Waveform



Parameter selection



Parameters		
Cardiac Output (CO)	✓	✗
Cardiac Index (CI)	✓	✗
Stroke Volume (SV)	✓	✗
Stroke Volume Index (SVI)	✓	✗
Stroke Volume Variation (SVV)	✓	✗
Systematic Vascular Resistance (SVR)	✓	✗
Systematic Vascular Resistance Index (SVRI)	✓	✗
SYS	✓	✗
DIA	✓	✗
MAP	✓	✗
	✓	✗



V | Usability test of the generated concepts

Gebruikstest

Het hoofddoel van dit gebruiksonderzoek is het identificeren welke van de drie gegenereerde concepten het meest geschikt is om aan te leveren als ontwerpvoorstel. Daarnaast moet het duidelijk worden welke aspecten het beste naar voren komen en is het uiteindelijke ontwerpvoorstel verwerkt dienen te worden.

Vragen die beantwoord dienen te worden:

- Waar liggen nog problemen met betrekking tot het gebruik?
- Welke voorkeur brengen de personen naar voren?
- Welke stijl wordt het meest aantrekkelijk gevonden?
- Welke iconen worden als het duidelijkst geïdentificeerd?
- Aan welke manier van weergave wordt de voorkeur gegeven?
- Welke manier van parameter selectie wordt het duidelijkste gevonden?

Hypothese

- De test personen beschouwen concept 3 als meest overzichtelijk.
- De bignumber weergave van concept 1 wordt als beste big number screen beschouwd.
- Het zero HRS proces van concept 3 wordt als meest duidelijk beschouwd.
- De velle waarschuwings kleuren van concept 1 worden als meest duidelijk beschouwd.
- Het zero HRS proces van concept 1 wordt als het moeilijkst beschouwd.
- Tekst bij de iconen wordt niet als nuttig beschouwd.
- Het kleuren schema van concept 2 is het meeste gewenst.

Karakteristieken van de testpersoon

Zij moeten kennis hebben van medische apparaten of eerdere ervaringen met vergelijkbare apparaten die op de IC worden gebruikt. Zij moeten inzicht hebben over de parameters die worden weergegeven om daarover een mening te kunnen vormen.

Protocol

Persoon 1	Concept 1	Concept 2	Concept 3
Persoon 2	Concept 2	Concept 3	Concept 1
Persoon 3	Concept 3	Concept 1	Concept 2
Persoon 4	Concept 1	Concept 3	Concept 2
Persoon 5	Concept 2	Concept 1	Concept 3
Persoon 6	Concept 3	Concept 2	Concept 1

Afhankelijke variabelen

- Tijdsduur van de taak
- Aantal fouten bij het uitvoeren van de taak
 - o Verkeerd gekozen menu
- Tevredenheid met het apparaat
- Begrijpelijkheid van het apparaat

Onafhankelijke variabelen

- Ervaring met dergelijke apparaten van de gebruiker
 - o Gebruik van smartphone of tablet
 - o Gebruik van medische apparaten
 - o Gebruik van elektronische apparaten met display

Omgevings variabelen

- Man/vrouw
- Leeftijd

Evaluatie methoden

- Directe observatie
- Waarnemen van acties van proefpersoon
- Enquete proefpersoon

Tijdsindicatie

Introductie: 5 minuten

Aansluiten van apparatuur bij de persoon: 1 minuut.

Taak uitvoering: 15 minuten

Enquete: 10 minuten

Tekst voor test personen

Gebruikstest user interface concepten van het ccNexfin systeem

Tijdens deze gebruikstest gaat u drie verschillende interfaces testen. Deze drie interfaces zijn nieuwe ideeën gebaseerd op de huidige interface van het ccNexfin systeem. Het ccNexfin systeem monitort hemodynamische parameters die de arts kunnen helpen met onder andere strategie bepaling voor het behandelen van de patiënt.

Een eerdere gebruikstest heeft een aantal aspecten naar voren gebracht die beter zouden kunnen in een nieuwe interface. In deze test zal naar voren moeten komen of de gevonden oplossingen beter zijn en welke oplossing de voorkeur heeft bij de gebruiker.

Tijdens deze test krijgt u een aantal taken die u bij ieder concept uit moet voeren. Met behulp van deze taken wordt u door de interface geleid en krijgt u een beeld van hoe deze werken. Het is niet erg wanneer u fouten maakt

of dat een taak niet lukt. Tijdens de taken mag u hardop denken wat u opvalt tijdens het gebruik. Deze opmerkingen worden genoteerd en kunnen zeer nuttig zijn. Nadat u alle taken heeft volbracht krijgt u een enquête die u in moet vullen met onder andere vragen over stijl en interactie.

De interfaces zijn niet in zijn geheel uitgewerkt. Het kan voor komen dat het laden van een nieuwe pagina wat langer duurt. Daarnaast worden ingevoerde gegevens niet opgeslagen en zijn niet alle opties selecteerbaar. De interface is daarnaast ook in het Engels. Het uiteidelijke product zal worden bediend door middel van touchscreen maar tijdens deze test zullen muis en toetsenbord worden gebruikt.

U mag gerust vragen stellen tijdens deze test als u iets niet duidelijk is.

Termen

Parameter: Parameters zijn meetwaarden die worden gemeten door het systeem. Voorbeelden van parameters zijn: CI, CO, SV, SVR.

Globe: Een globe geeft de gemeten waardes aan van de parameter dit kan bijvoorbeeld in de vorm van een metertje zijn.

HRS sensor: De HRS sensor bestaat uit twee delen die meet wat de afstand is tussen de patiënt zijn vinger en zijn hart.

Target Value: De target value is de range van waarden waartussen de gemeten waarden van de parameter horen te liggen.

Taken lijst

1. Zet het apparaat aan.

Momenteel bevindt u zich in het start menu. In het start menu moeten alle essentiële gegevens van de patiënt worden ingevoerd voordat de meting kan starten.

2. Vul de volgende gegevens in op het startscherm bij stap 1 Patient Data:

Patient ID: Rutger Ennes

Height: 185 cm

Weight: 83 kilo

Age: 54

Gender: Male

De volgende taak is alleen mogelijk bij de concept interfaces.

3. Navigeer naar het volgende scherm (stap 2 Parameter Selectie)

- o Wanneer dit een mogelijke optie is; zet de volgende parameters actief: CI, CO, SV en SVR.

- o Selecteer voor de eerste globe dat parameter CI moet worden weergegeven.

- o Bevestig de gemaakte selectie.

4. Navigeer naar stap 3 Zero & Wafeform en volg de instructies op het scherm. Gebruik hierbij de HRS sensor.

Als het goed is heeft u de meting gestart en ziet u een grafiek met meetwaarden.

5. Selecteer dat er 4 parameters in beeld komen en ga vervolgens bladeren tussen de 5 verschillende schermen.

6. Ga weer terug naar 1 parameter in beeld en open het target value menu. Bekijk beide tabbladen. Wat kunt u hier instellen? Sluit vervolgens het menu.

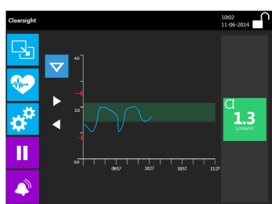
7. Schakel het alarm uit.

8. Schakel het apparaat uit.

Enquete



1. Welke stijl vindt u het meest aantrekkelijk en welke het minste?

Zet de meest aantrekkelijke op 1 en de minst aantrekkelijke op 3.










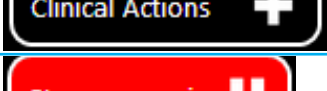

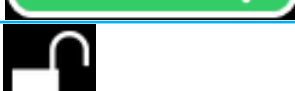


1	2	3	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	 ⏻
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	 ⏻
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	 ⏻

2. Welke concept vindt u het meest overzichtelijk en welke het minste?

Zet de meest overzichtelijke op 1 en de minst overzichtelijke op 3.



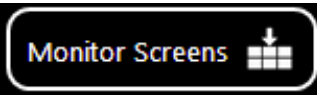
1	2	3	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	 ⏻
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	 ⏻
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	 ⏻

3. Geef van de volgende iconen aan of u deze duidelijk of onduidelijk vindt met betrekking tot hun functie:




Ze er on dui delijk	Onduidelijk	Neutraal	Duidelijk	Ze er dui delijk	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	

4. Geef van de volgende navigatie elementen aan welke u het duidelijkste vindt (1) en welke u het minst duidelijk vindt (3).



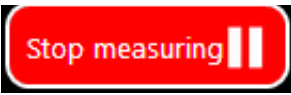
Monitor Screen Selection

1	2	3	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	

Clinical Actions

1	2	3	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	

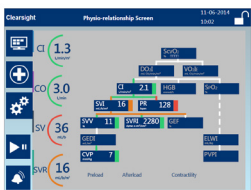
Start/Stop measuring BP

1	2	3	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	

5. Hoe heeft u het kleurgebruik ervaren per concept? Er zijn meerdere antwoorden mogelijk.

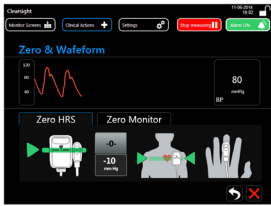
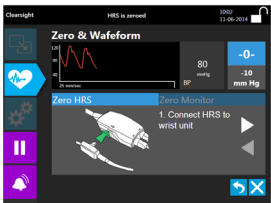
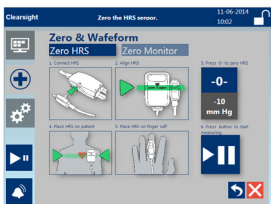
	<input type="radio"/> Goed
	<input type="radio"/> Te fel
	<input type="radio"/> Te licht
	<input type="radio"/> Te druk
	<input type="radio"/> Te rustig
	<input type="radio"/> Anders Namelijk:

	<input type="radio"/> Goed
	<input type="radio"/> Te fel
	<input type="radio"/> Te licht
	<input type="radio"/> Te druk
	<input type="radio"/> Te rustig
	<input type="radio"/> Anders Namelijk:

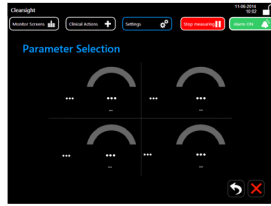
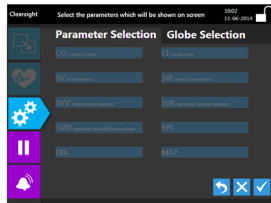
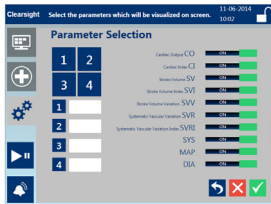
	<input type="radio"/> Goed
	<input type="radio"/> Te fel
	<input type="radio"/> Te licht
	<input type="radio"/> Te druk
	<input type="radio"/> Te rustig
	<input type="radio"/> Anders Namelijk:

Interactie

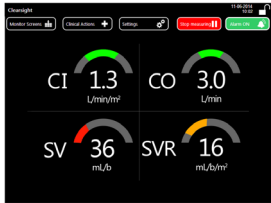

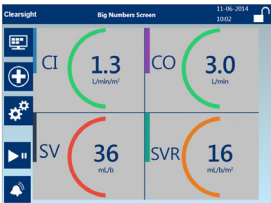
6. Welke manier van instructie tijdens het Zero proces heeft uw voorkeur en waarom? Zet op 1 uw eerste voorkeur en op 3 uw minst favoriete voorkeur.

1	2	3	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	 <input type="radio"/>
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	 <input type="radio"/>
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	 <input type="radio"/>

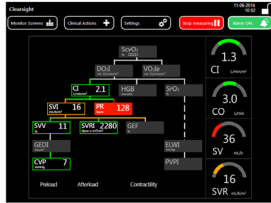
7. Welke manier van parameter selectie heeft uw voorkeur en waarom? Zet op 1 uw eerste voorkeur en op 3 uw minst favoriete voorkeur.

1	2	3	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	 <input type="radio"/>
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	 <input type="radio"/>
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	 <input type="radio"/>

8. Welke manier van globe weergave heeft uw voorkeur en waarom? Zet op 1 uw eerste voorkeur en op 3 uw minst favoriete voorkeur.

1	2	3	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	 ⏻
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	 ⏻
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	 ⏻

9. Welke weergave van dit diagram heeft uw voorkeur en waarom? Zet op 1 uw eerste voorkeur en op 3 uw minst favoriete voorkeur.

1	2	3	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	 ⏻
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	 ⏻
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	 ⏻

10. Wanneer u gebruik heeft gemaakt van de hulp tekst in de bovenste balk van het scherm, vond u deze informatie nuttig? (Denk aan schermnaam en instructie bij enkele menu's.)

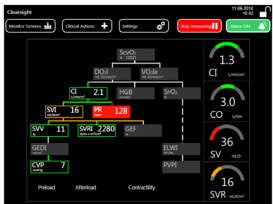
11. Heeft u de tekst bij de iconen als prettiger ervaren dan zonder tekst bij de iconen?


12. Zijn er nog manieren van interactie die u niet logisch vindt per concept?


13. Zijn er nog punten in de interface die u mist of anders zou willen zien?

14. Heeft u verder nog opmerkingen?

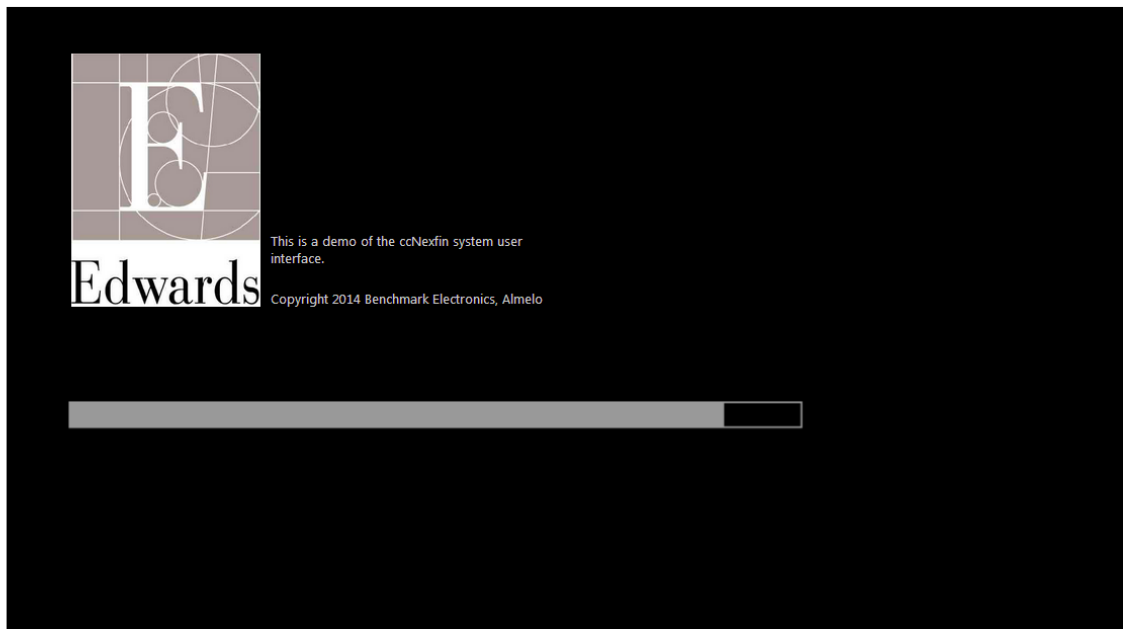
Einde van deze enquête

	<input type="radio"/> Ja namelijk
	<input type="radio"/> Nee

	<input type="radio"/> Ja namelijk
	<input type="radio"/> Nee

	<input type="radio"/> Ja namelijk
	<input type="radio"/> Nee

VI | The final concept screens



Startup screen

The image shows a form titled 'Step 1 Patient Data' within a software interface. The form is divided into four steps: Step 1 (Patient Data), Step 2, Step 3, and Step 4. Step 1 is currently active and highlighted with a blue arrow. The form contains the following fields: Patient ID (a long text input), Height (a text input followed by 'cm'), Age (a text input followed by 'Years'), Weight (a text input followed by 'kg'), Gender (two radio buttons labeled 'Male' and 'Female'), and BSA (a text input followed by 'm2'). There is a 'New patient' button next to the BSA field. A 'Next' button is located at the bottom right of the form. The top of the interface shows the time '10:02', the date '9-7-2014', and a lock icon. The title 'Clearsight' is in the top left corner, and the instruction '1. Fill in all patient data' is in the top center.

Step 1 Patient Data

Clearsight 2. Choose the parameters which will be visualized on screen 10:02 9-7-2014

Step 1 **Parameter Selection**

Step 2 **CO** Cardiac Output **CI** Cardiac Index

SV Stroke Volume **SVI** Stroke Volume Index

Step 3 **SVV** Stroke Volume Variation **SVR** Systematic Vascular Variation

Step 4 **SVRI** Systematic Vascular Variation Index **SYS**

DIA **MAP**

Previous **Next**



Step 2 Parameter Selection

Clearsight 3. Choose the globe parameters 10:02 9-7-2014

Step 1 **Globe Selection**

Step 2 **Step 3**

Globe 1: CO Globe 2: CI Globe 3: SVV Globe 4: SVI

CO **CI** **CO** **CI** **CO** **CI** **CO** **CI**

SV **SVI** **SV** **SVI** **SV** **SVI** **SV** **SVI**

SVV **SVR** **SVV** **SVR** **SVV** **SVR** **SVV** **SVR**

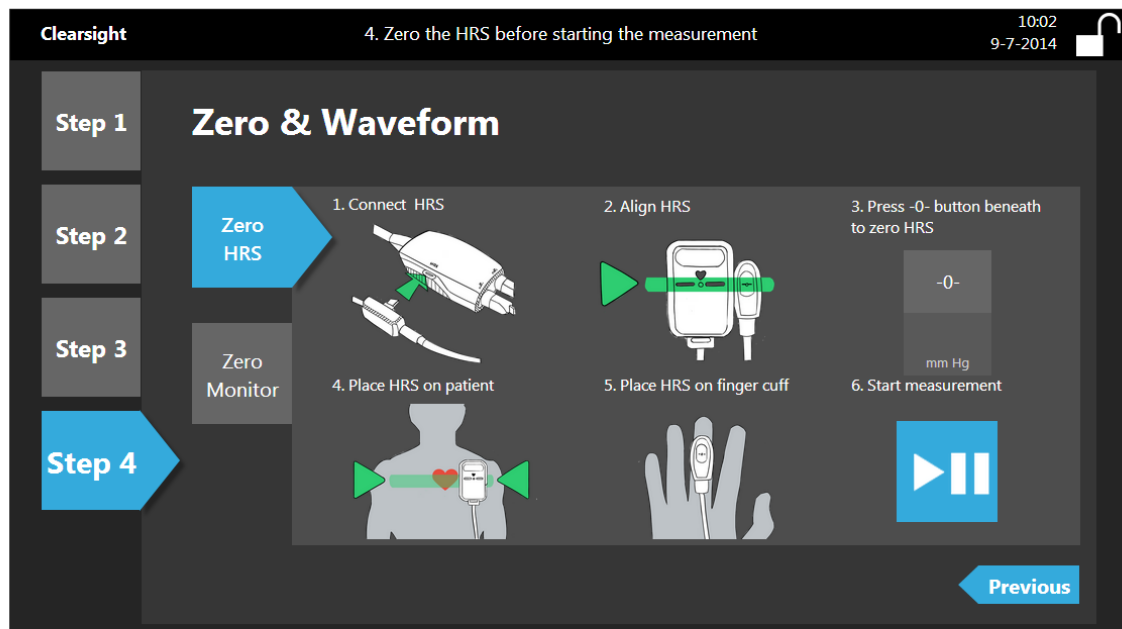
SVRI **SYS** **SVRI** **SYS** **SVRI** **SYS** **SVRI** **SYS**

DIA **MAP** **DIA** **MAP** **DIA** **MAP** **DIA** **MAP**

Previous **Next**



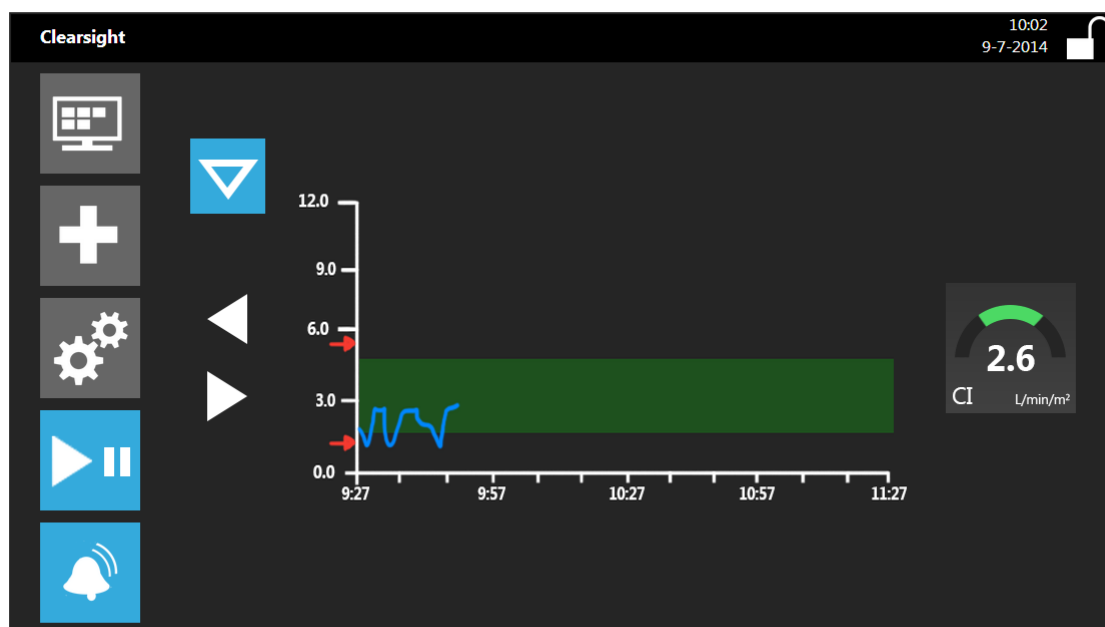
Step 3 Globe Selection



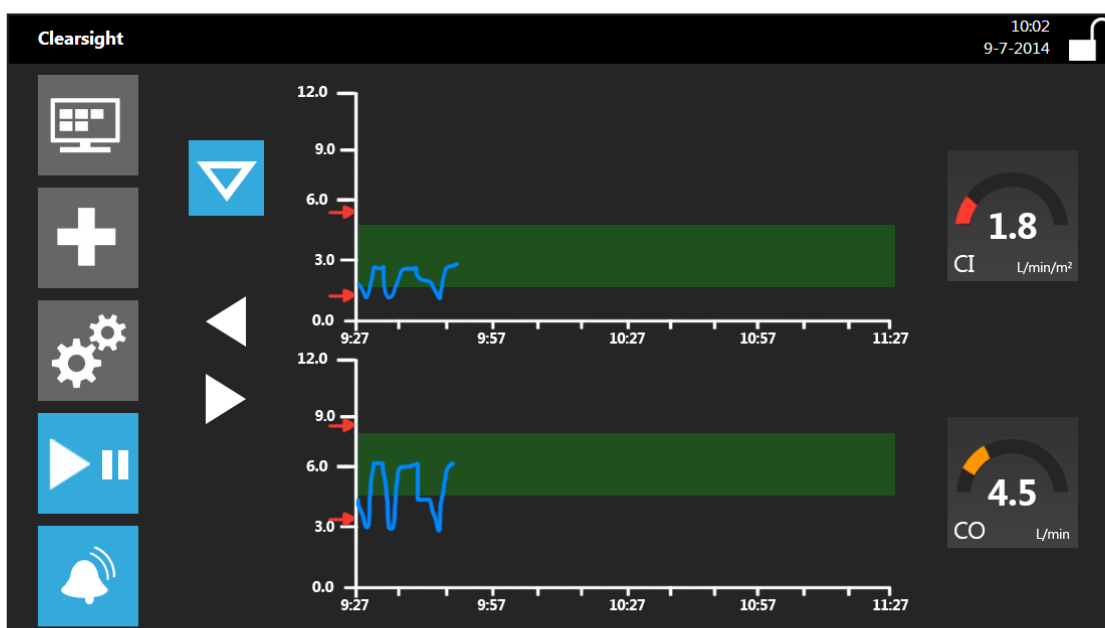
Step 4 Zero & Waveform



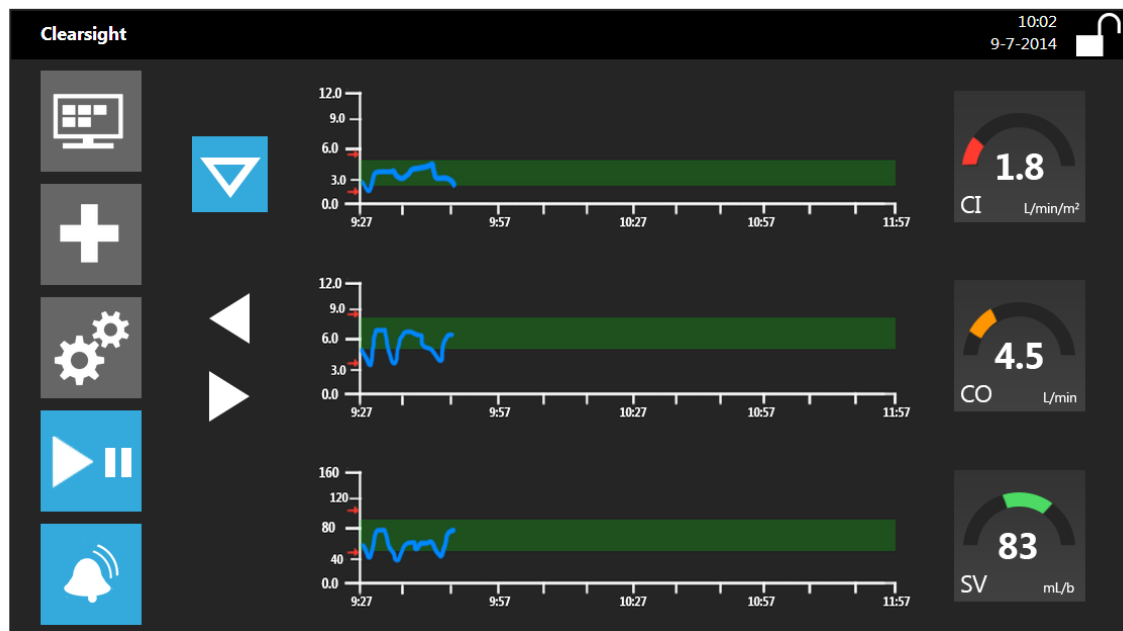
Target value menu popup



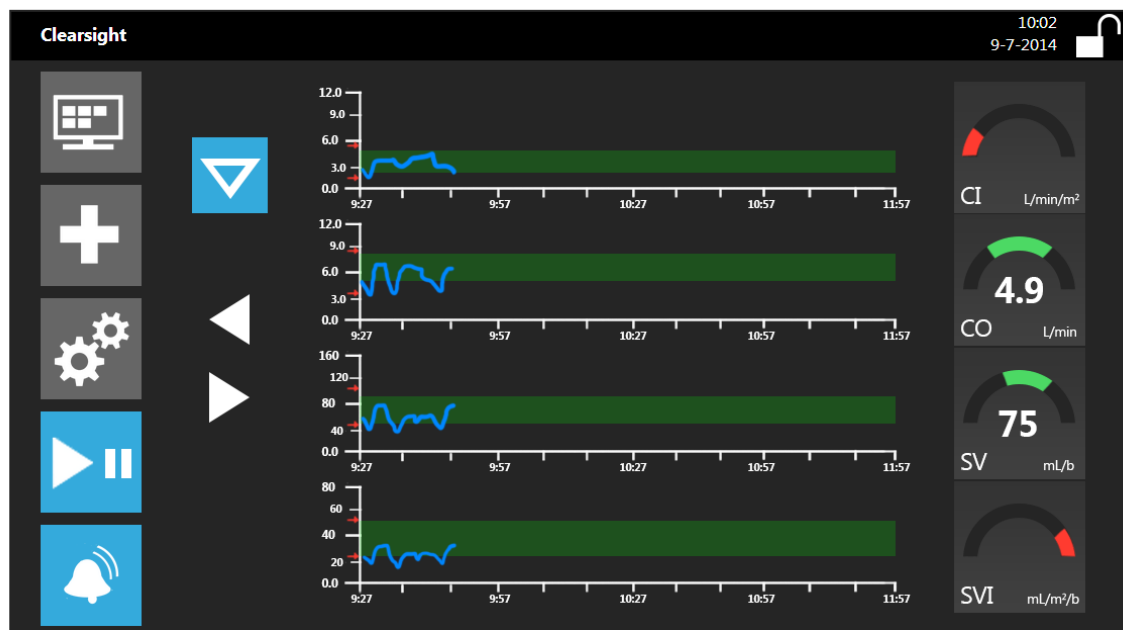
Tabular Trend Screen 1



Tabular Trend Screen 2



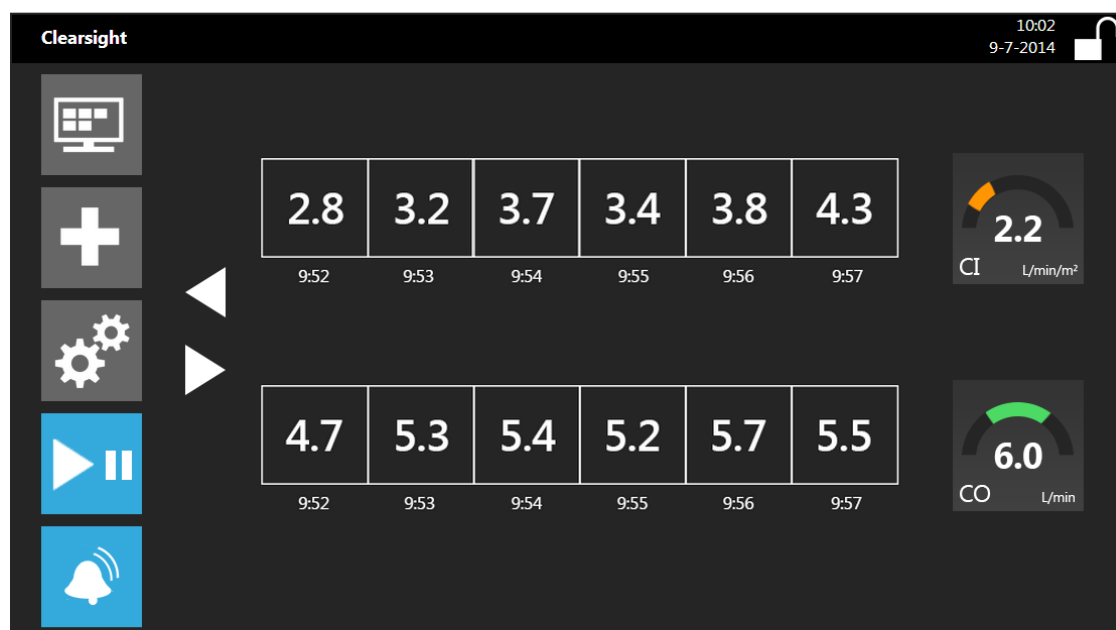
Tabular Trend Screen 3



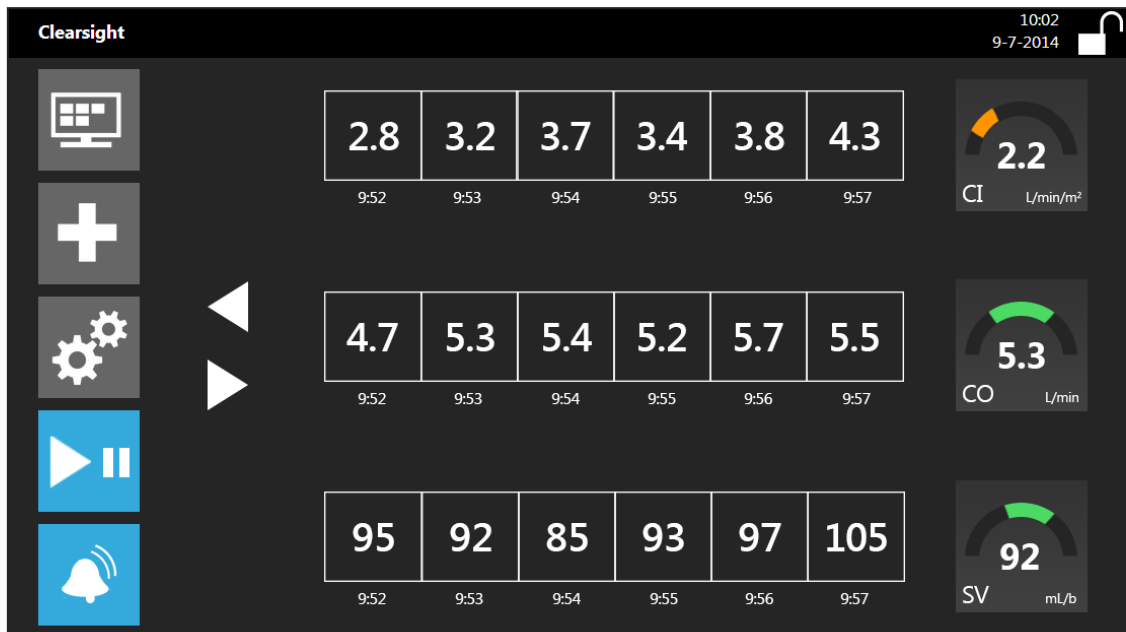
Tabular Trend Screen 4



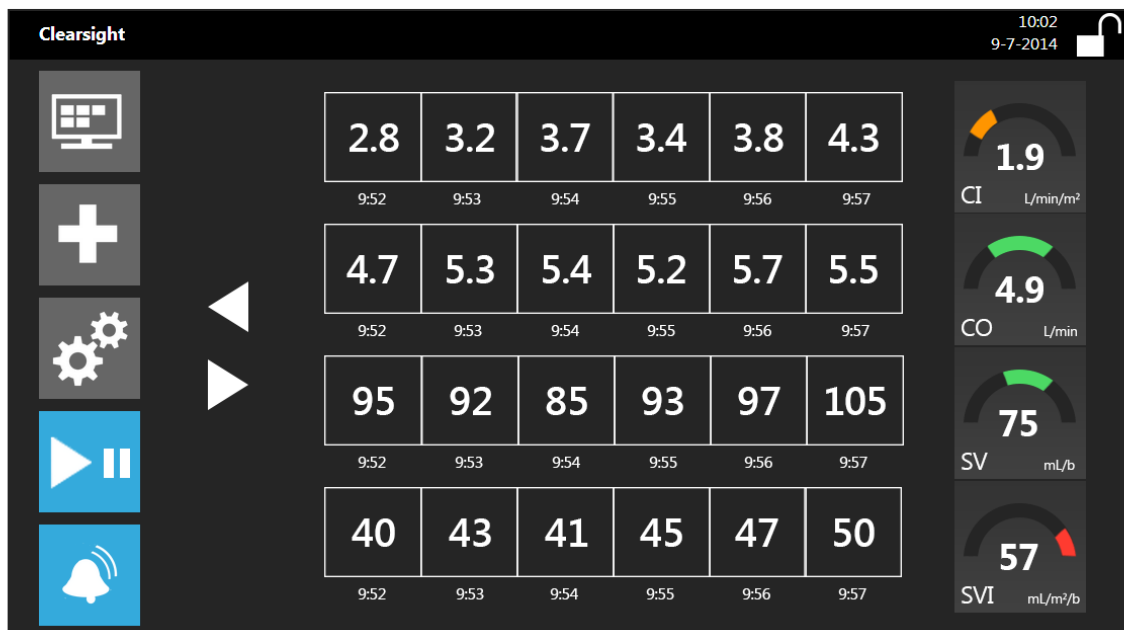
Numeric Value Screen 1



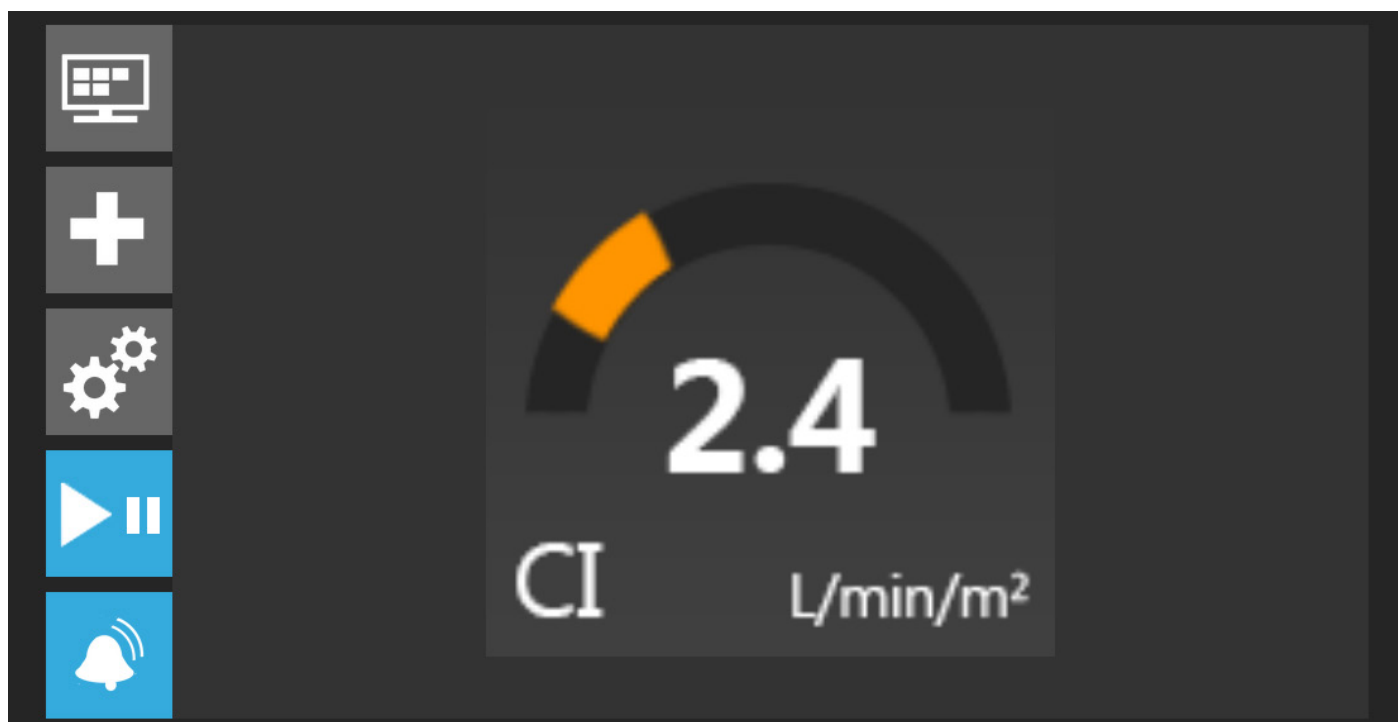
Numeric Value Screen 2



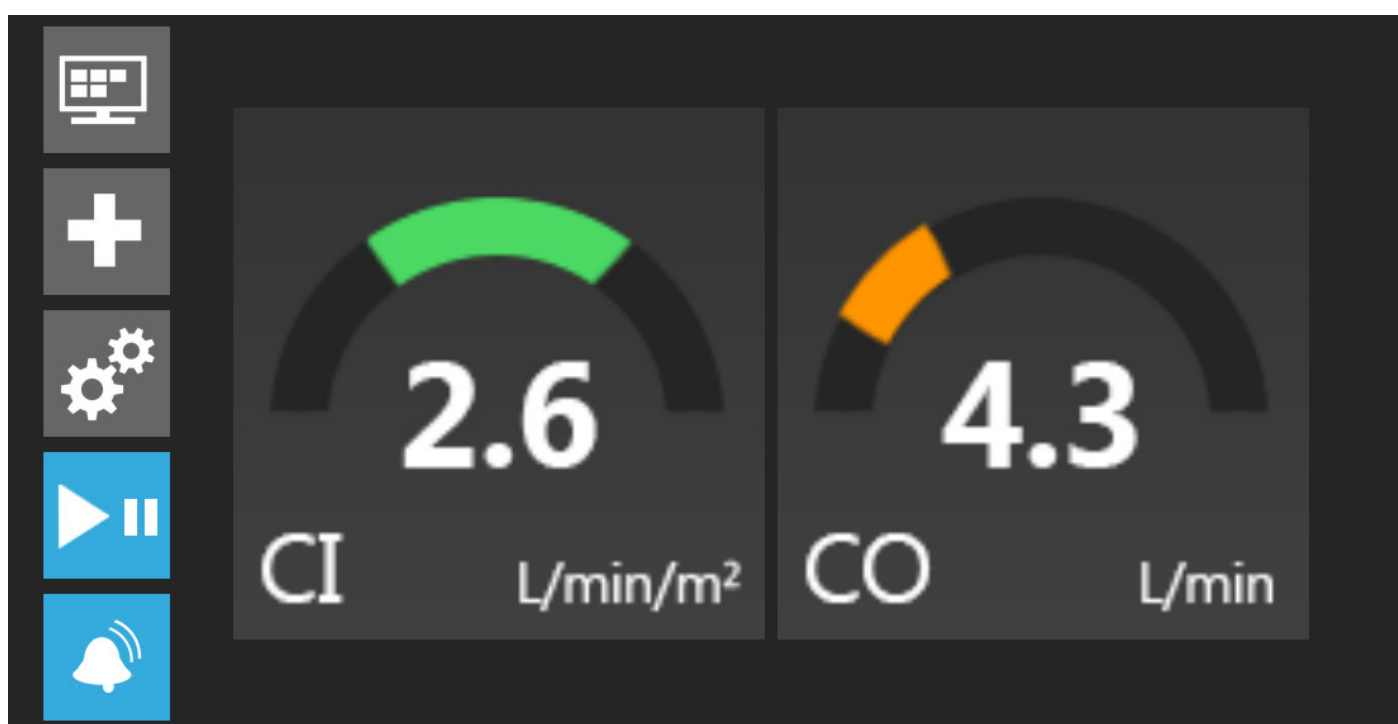
Numeric Value Screen 3



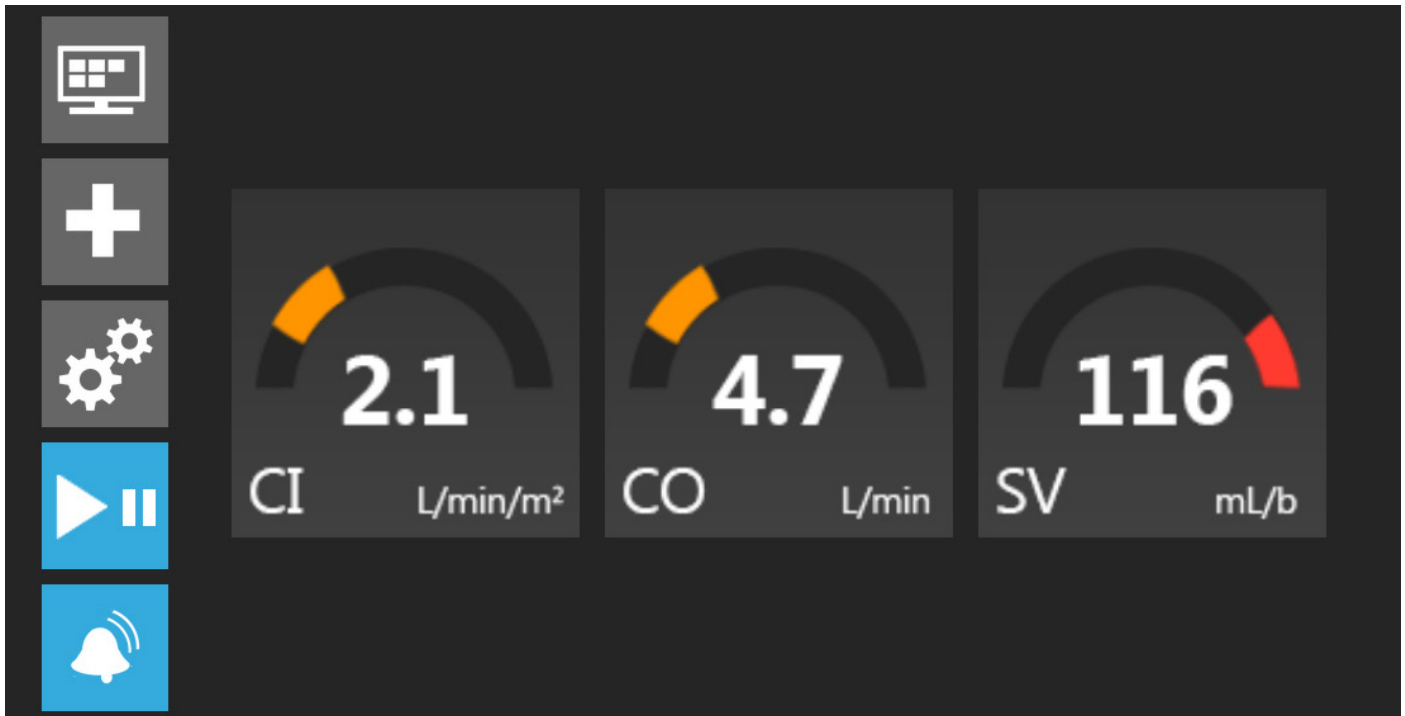
Numeric Value Screen 4



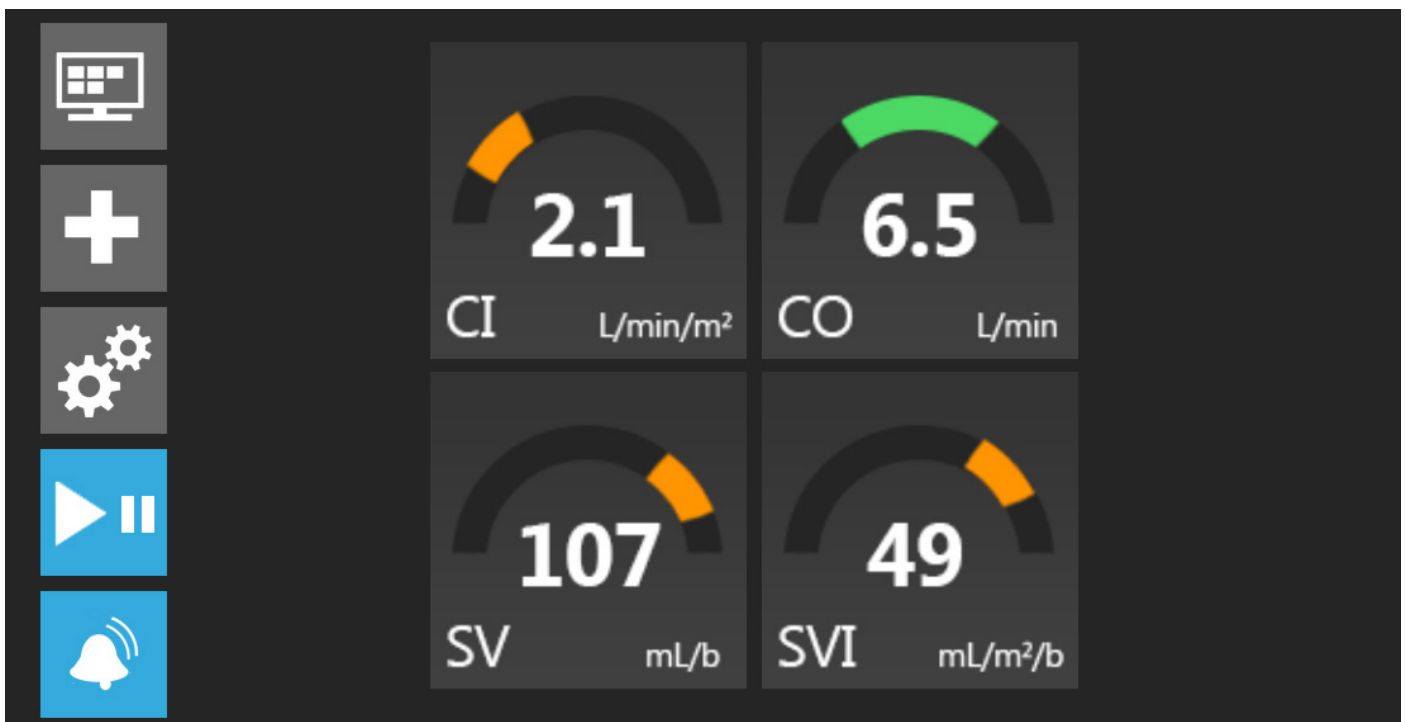
Big Number Screen 1



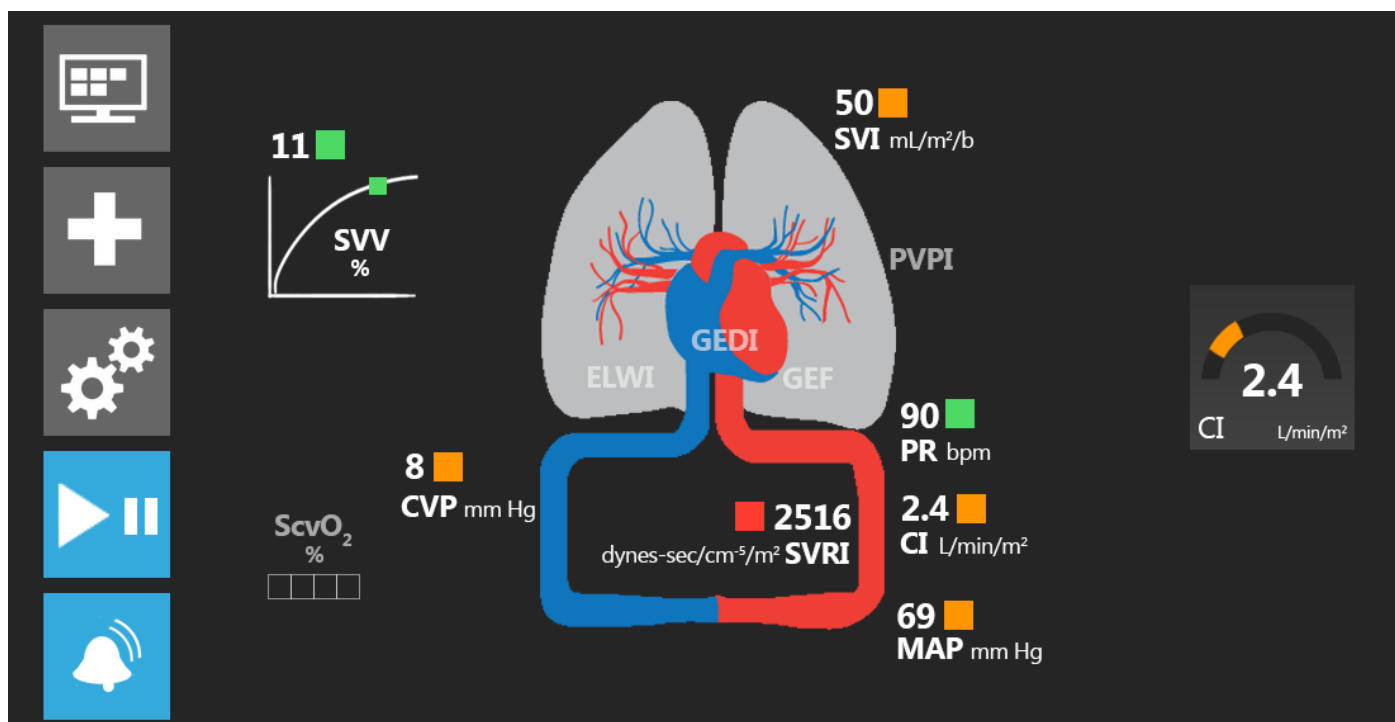
Big Number Screen 2



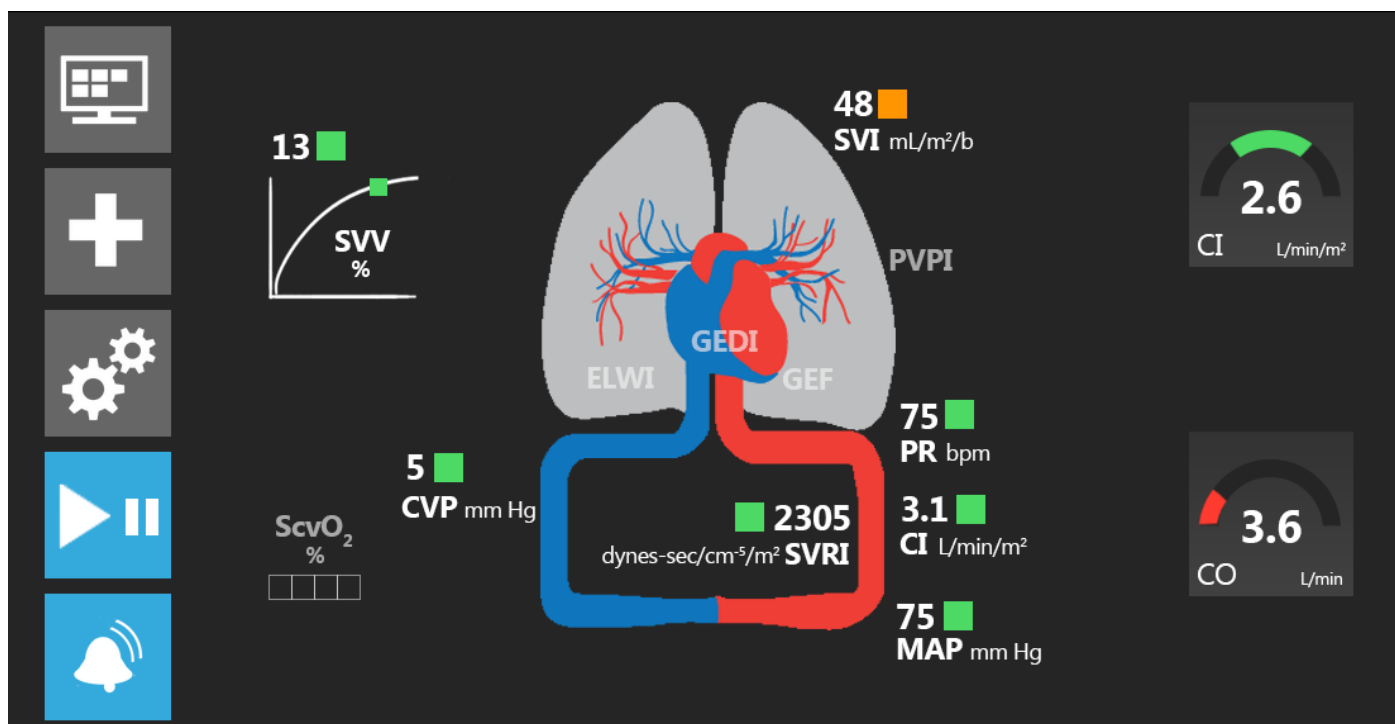
Big Number Screen 3



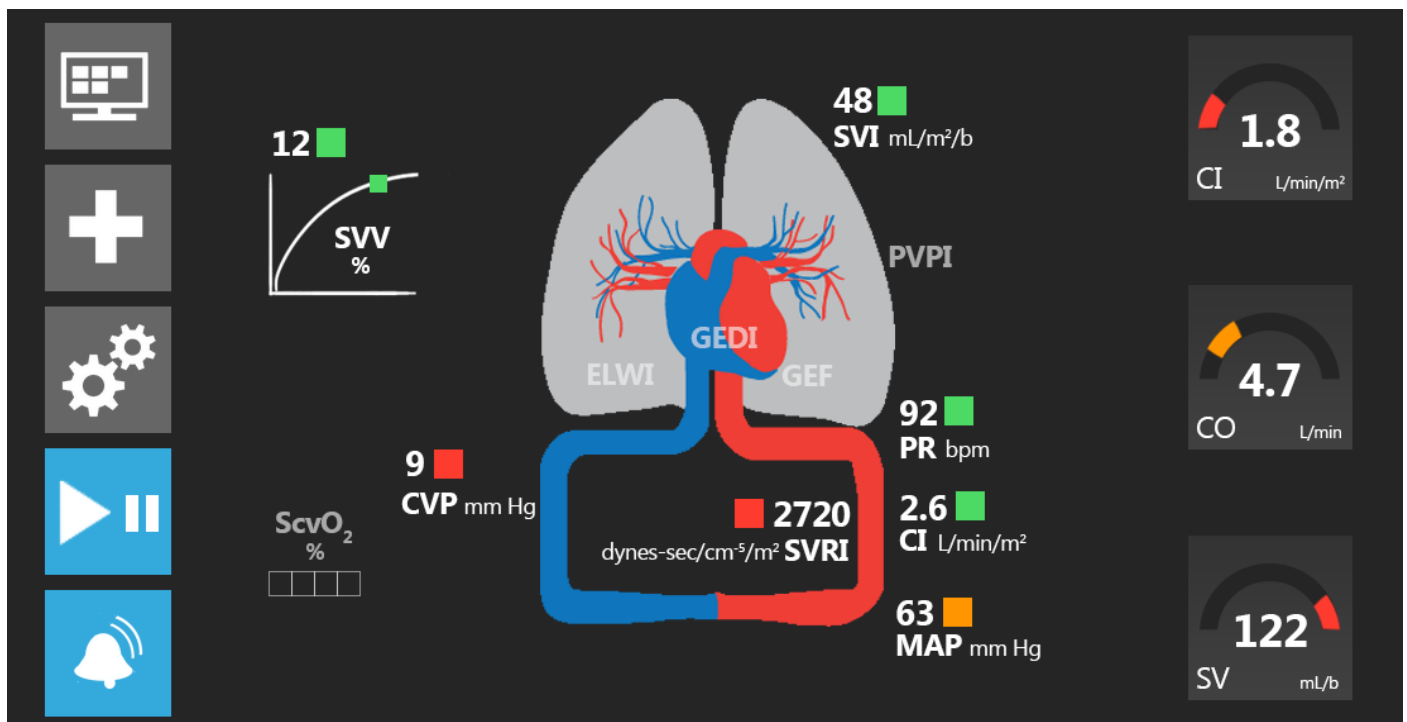
Big Number Screen 4



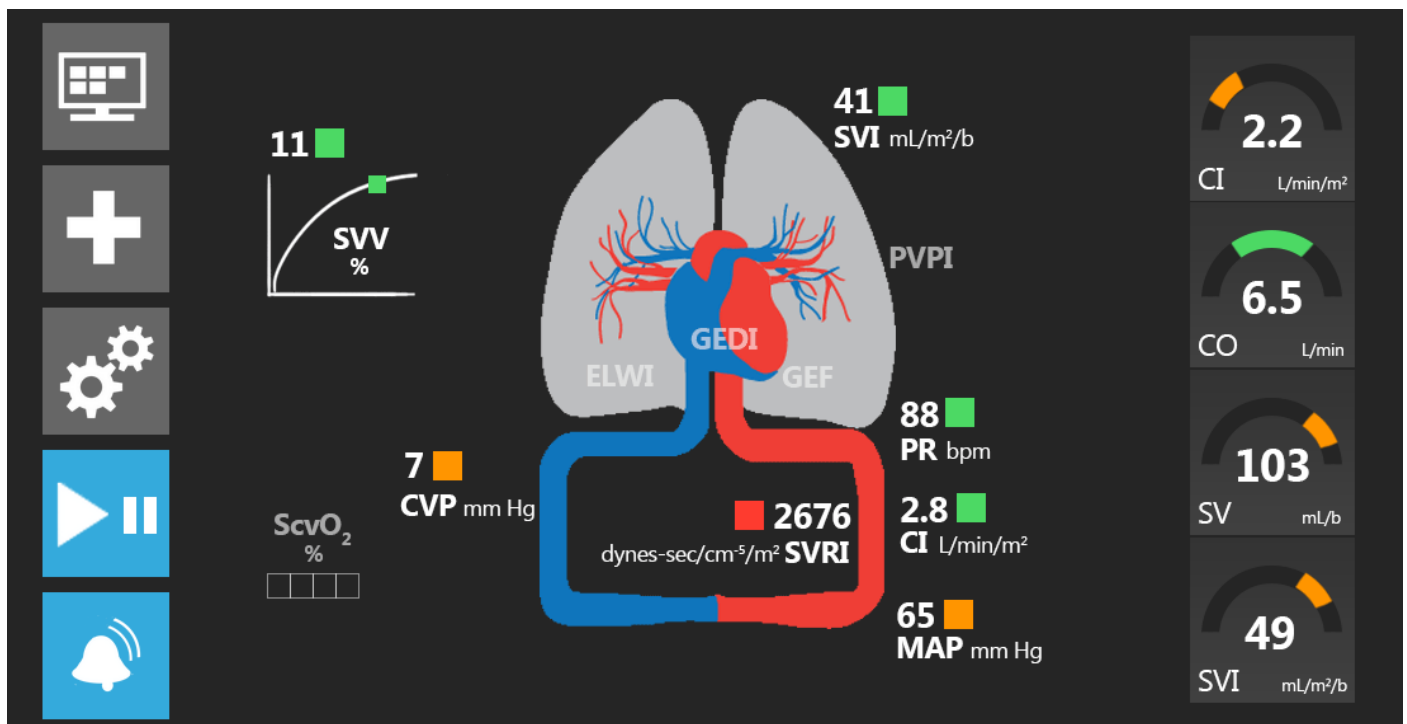
Physiology Screen 1



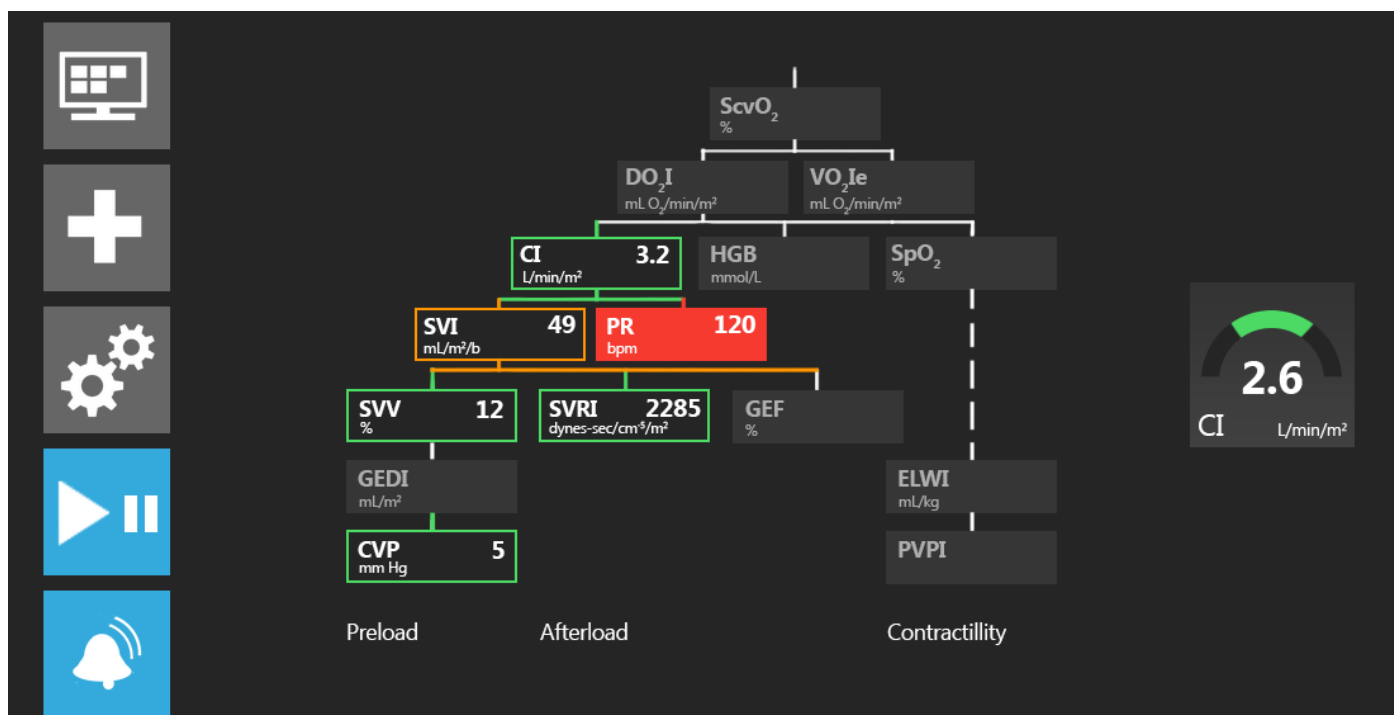
Physiology Screen 2



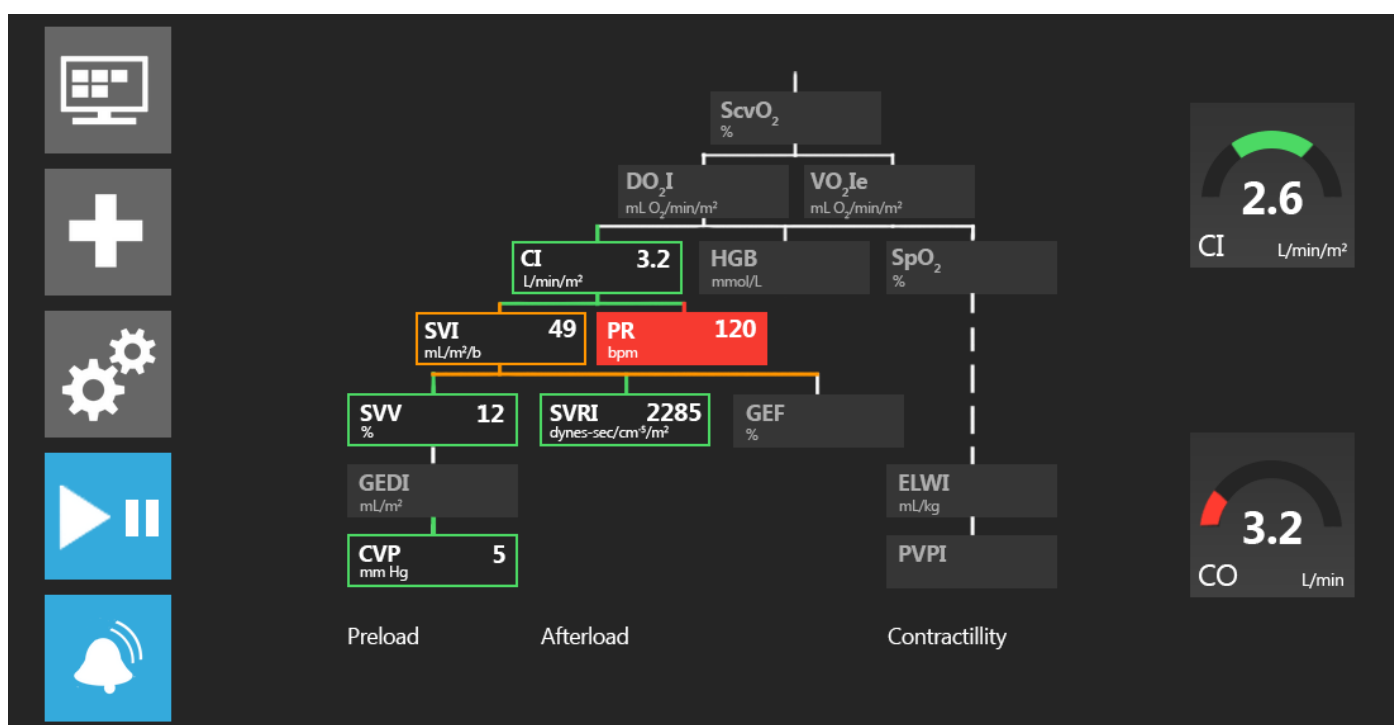
Physiology Screen 3



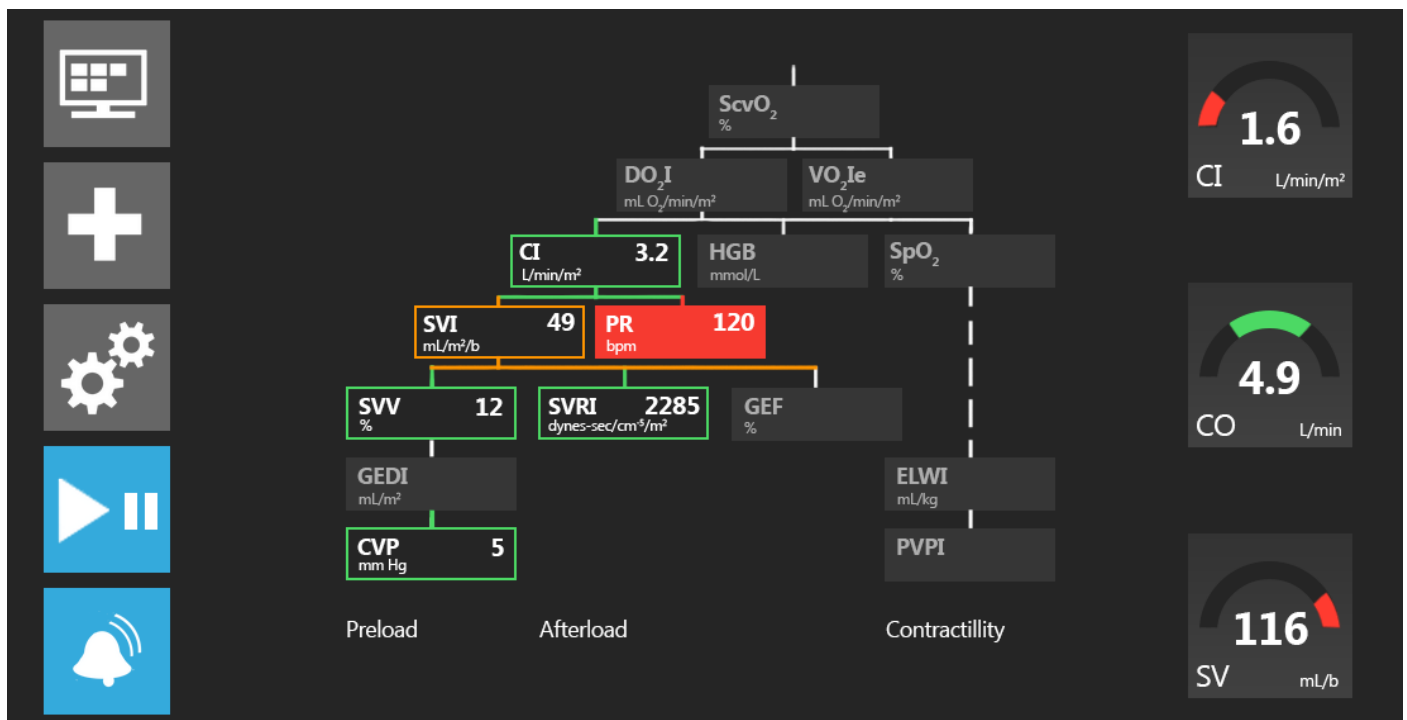
Physiology Screen 4



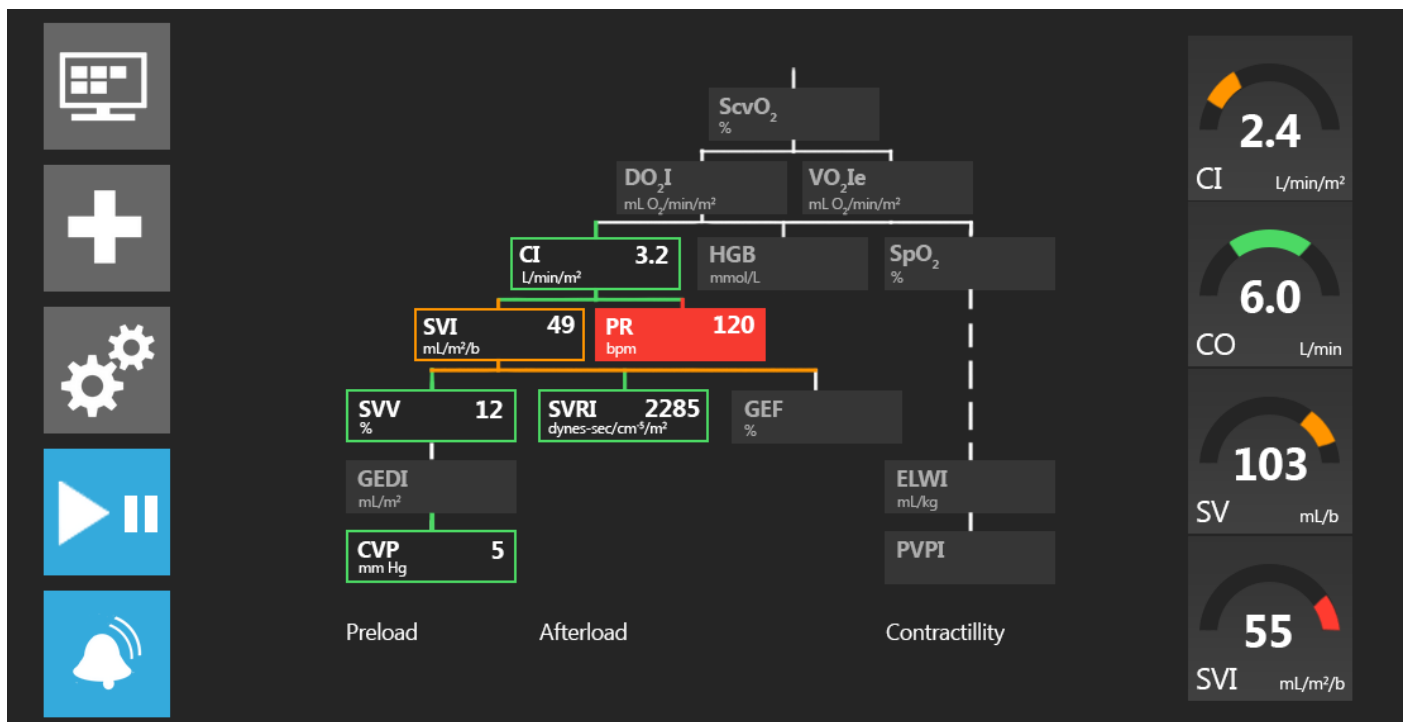
Physio-relationship Screen 1



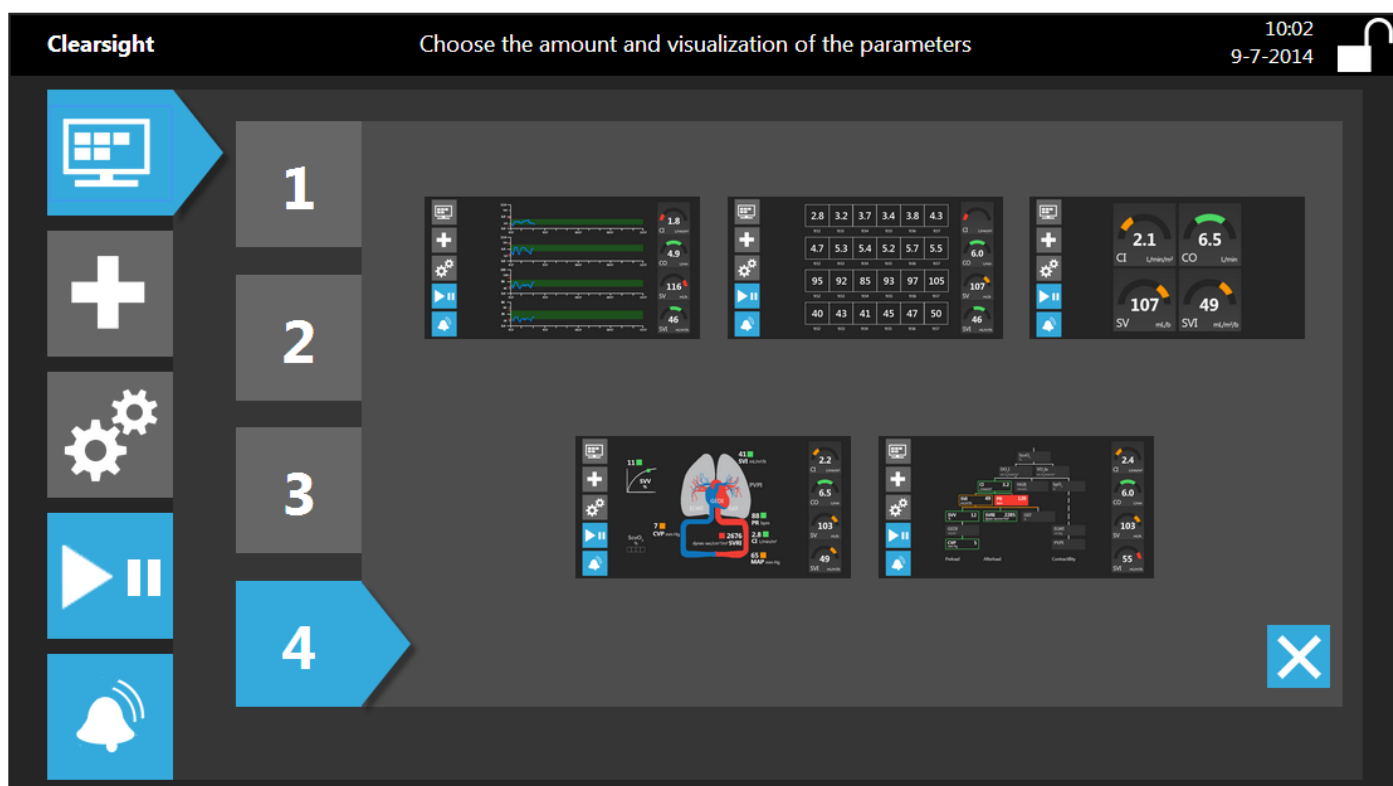
Physio-relationship Screen 2



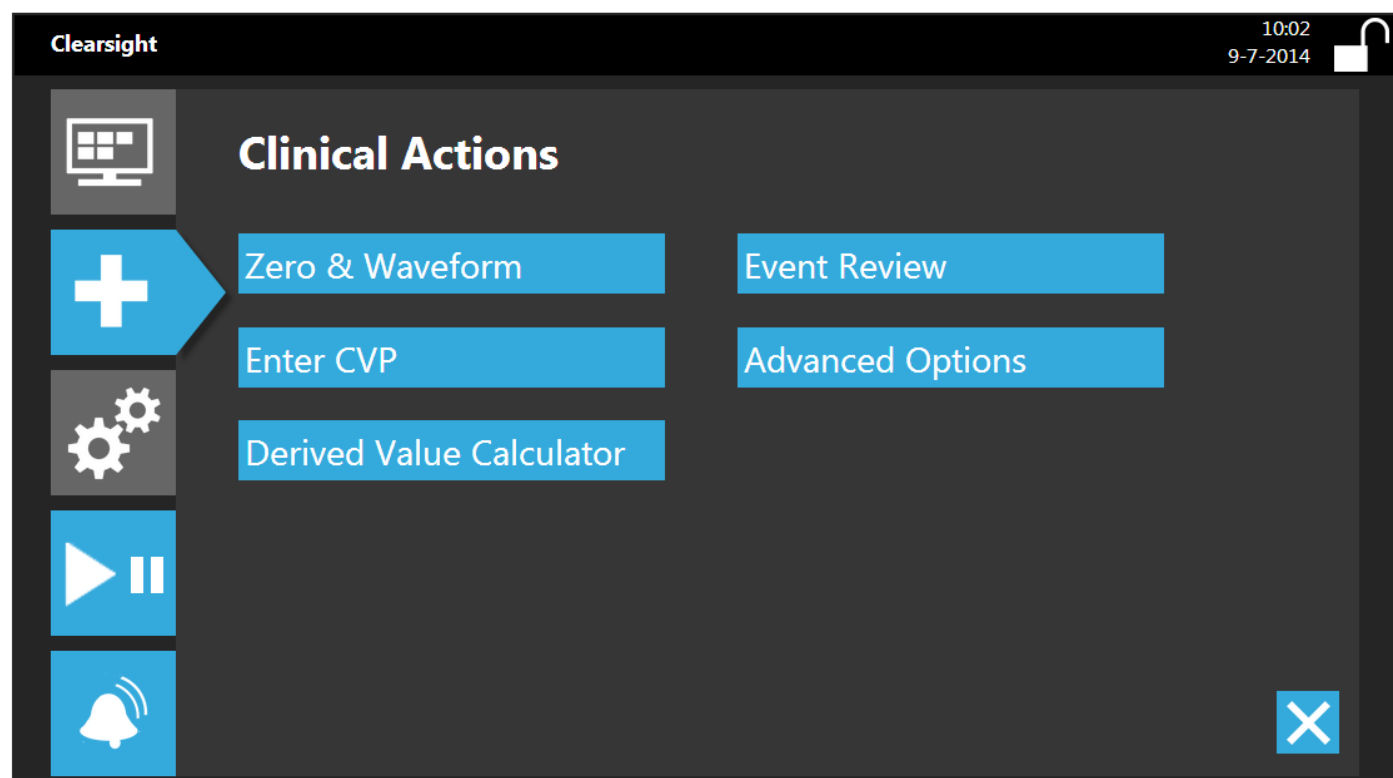
Physio-relationship Screen 3



Physio-relationship Screen 4



Monitorscreen Selection Menu



Clinical actions menu