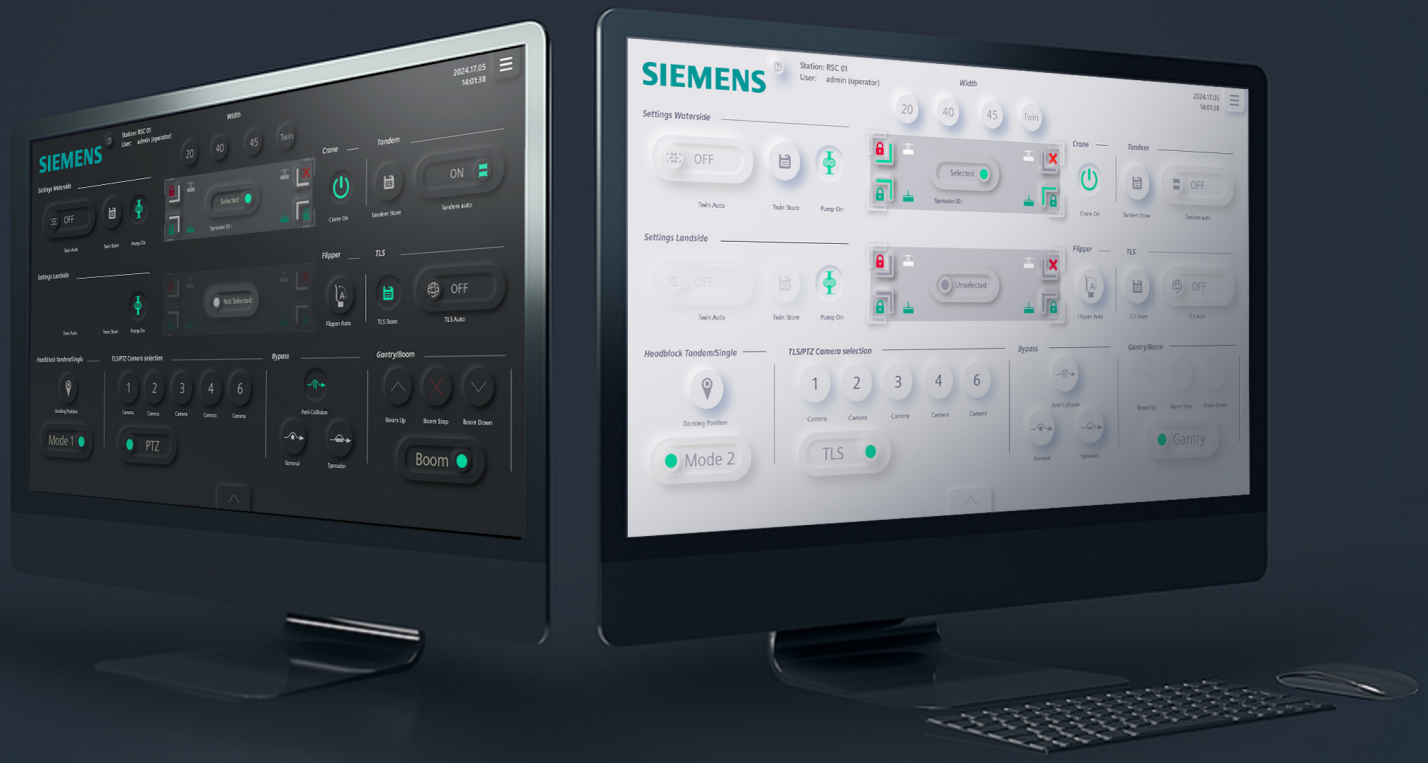

User Interface for Remote Control Operations System

An user interface with a focus on user friendliness and the concentration levels of the user

Master Thesis 2024
Jos van der Velden

SIEMENS | TU Delft

Colophon

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List of Definitions

Container spreader:
A container spreader is a tool used for lifting containers and unitized cargo. The spreader is placed between the container and the lifting machine.

Feature creep:
Feature creep is the excessive ongoing expansion or addition of new features in a product, especially in computer software, video games (not to be confused with Power creep) and consumer and business electronics. These extra features go beyond the basic function of the product and can result in software bloat and over-complication, rather than simple design.

High-fidelity (high-fi) prototyping:
A high-fidelity prototype is a polished simulation of your final product. Visual design details and real content show the look and feel of the end product. For testing, robust interactivity and functionality provide a more realistic user experience.

Gantry:
Gantry crane, a crane having a hoist fitted in a trolley for parallel movement. Rubber tyred gantry crane, a mobile gantry crane used in intermodal operations.

Harbor:
A place on the coast where ships may moor in shelter, where one protected from rough water by piers, jetties, and other artificial structures.

Jargon:
Special words or expressions used by a profession or group that are difficult for others to understand.

Low-fidelity (low-fi) prototyping:
A low-fidelity prototype is a simple diagram of an early-stage design concept. UX design teams use them to quickly test an idea, identify gaps and pitfalls, and discard product designs that don't resonate with users.

STS:
Ship to Shore

Style sheet:
Style Sheets are a powerful mechanism that allows customizing the appearance of widgets.

Remote Control Operator (RCO):
Operator behind the Remote Control Operation System desk station and end user of the user interface.

RCOS:
Remote Control OperationSystem

RCS:
Remote Control Station

User:
Refers to the end-user who will be interacting with the RCOS user interface.

User experience:
The overall experience of a person using a product such as a website or computer application, especially in terms of how easy or pleasant it is to use.

User friendliness:
Easy to learn, use, understand, or deal with user-friendly software.

User interface:
The means by which the user and a computer system interact, in particular the use of input devices and software.

Acknowledgment

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Thank you deeply!

Jos van der Velden

Executive Summary

Siemens possesses a comprehensive portfolio of digitalizing products or services. Their entrepreneurial mindset introduces the Remote Control Operation System (RCOS) to the crane industry. The vision of RCOS is to provide maximized production with security and safe crane operations. Siemens has emphasized more consistent crane usage, aiming to extend the equipment's lifespan and minimize damage. However, the interaction between the operator and the device has not been explored in depth.

Hence, the focus of this project was to create a viable proposal for a new RCOS user interface (UI) aimed at improving user-friendliness and enhancing user concentration levels. The project was performed on a human-centered design process, which can be divided into four main phases: initiation (understanding), market investigation (exploring), conceptualization (ideation), evaluation (integration). These phases include methods such as qualitative user interviews, quantitative surveys, field observations, low-fidelity (low-fi) prototyping, high-fidelity (high-fi) prototyping and usability testing.

Firstly, this report focuses on mapping the weaknesses and strengths of the existing iterations of RCOS, while simultaneously creating a better understanding of the RCOS system. Additional literary research provided insights in possible opportunities and threats within RCOS.

Through market research and interaction with stakeholders, previously unidentified problems with the RCOS were recognized. These issues, such as fatigue on the eyes during night shift or reflecting lights on wet containers, had not been discovered by Siemens and were not initially recognized as major problems.

Identifying these problems and areas for improvement provided a framework for the ideation phase, during which multiple concepts were developed, tested, and evaluated.

The final redesign features a soft UI style that addresses the lack of recovery and forgiveness, aligning with customer demands. It provides operators with various ways to perceive the state of elements beyond color, offering a more logical interaction and placement of elements.

Table of Content

Chapter 01.

The Project

This chapter provides an introduction of this thesis setup, including the context behind RCOS, the involved stakeholders through-out the entire design process, the objectives and aims for both my client and myself, and what kind of structure is provided in order to realize a suitable result.

8. | *Image 1: RMG Crane using RCOS (Siemens, n.d.)*

1.1 Introduction

It is well-known that the attention to user interfaces (UI) and user experiences (UX) has been growing over the last few years, due to the increase in digitalization. Nowadays, people interact with technology, UI and UX, throughout most of their day, in personal and professional spheres. Labor markets and work processes have transformed enormously since these information and communication technologies have emerged. Hence, it is important to understand how to optimize the interaction between the technologies and the users.

Today, Siemens engineers developed the Remote Control Operation System (RCOS) for the automatization of cranes, including the system's UI Here, people can control the cranes from the comfort of their own office, rather than working 50 meters up and experiencing discomfort like G-forces. Since we are working with industrial machines with extreme powers, it is crucial to optimize both the concentration of the user while performing tasks on the crane and the user- friendliness of the overall UI. Hereby reducing mistakes, which can cause tons worth of damage.

Siemens wishes that the UI improvements focus on optimizing the concentration levels of the remote operators. If the UI runs more effectively for the user and they can concentrate for a longer period, more containers can be replaced in a shorter time. This will eventually lead to an increase in profit and a better UI to sell to third parties.

1.2 Background

Siemens developed RCOS to provide a new environment for their clients, enhancing productivity and enabling automated crane operations. The system allows Remote Crane Operators (RCO's) to control cranes from an RCOS station, as shown in image 2. By creating these digital twins of reality, Siemens can express their core values: responsibility, excellence, sustainability, and innovation. Ideally, cranes equipped with RCOS can automatically pick up containers using their spreaders. However, if an issue arises, the system requires Manual Intervention (MI). In such cases, the RCO must take control of the crane to resolve the problem.

Siemens recognizes that each terminal has unique processes and requirements, allowing every project to be customized to meet the specific needs and requirements of that terminal. RCOS offers a complete end-to-end crane control solution from operator login, carrying out operations, to operator log-out (Siemens AG, 2022).

Image 2: Operator behind desk station (Siemens, n.d.)

The user interface is designed for four types of cranes: Ship to Shore (STS), Rubber Tyred Gantry (RTG), Rail-Mounted Gantry (RMG), and Overhead Bridge Crane (OHBC). The remote operator controls the cranes using two physical controllers, with the settings and controls displayed across four screens, including one touch screen. These screens provide the operator with feedback, including data and live footage. The UI is designed for 24/7 global use, ensuring it is accessible and user-friendly for people of all genders and nationalities.

At the start of the UI, you can select a role, which determines the features available for you in the RCOS. The four roles are: operator, administrator, maintenance and supervisor. Operator is the role who is most frequently used; hence we are focusing on the UI of the operator mostly for this project scope.

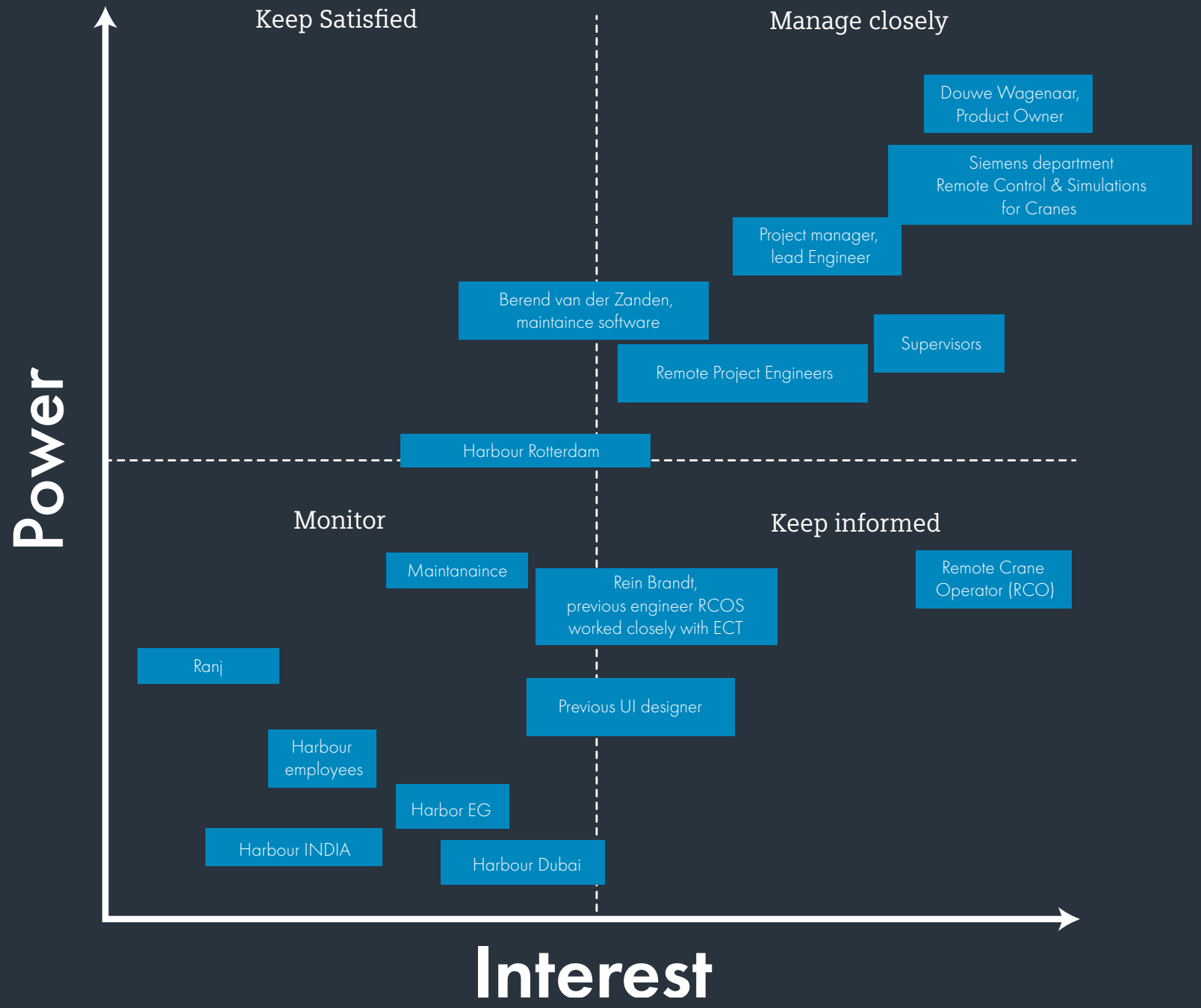
1.3 Stakeholder analysis

The primary stakeholder for this project is Siemens, specifically the Cranes department. This department is responsible for and actively engaged in the creation, sale, and execution of the RCOS, including its user interface. To visualize all relevant stakeholders, a power-interest matrix is created, see graph 1 on the next page.

Moreover, Douwe Wagenaar is project owner of the RCOS and the person who is guiding the department, meaning he has both interest and power. The UI provides various initial roles for users, each role determining the accessible features and how the user interacts with the interface. Among these roles, the RCO has the most intensive interaction with the UI.

Furthermore, the UI can be customized to meet the specific needs of each terminal. Different clients often request various features and test different UI layouts simultaneously. These iterations serve as reference points for developing improvements to the current UI. Although these iterations are implemented in a matrix format, clients may not always be interested in the new UI or have no influence over current decision-making processes.

The most relevant client of the RCOS for this project is Harbor Rotterdam. Due to their proximity, field research can be conducted, and qualitative interviews can be held with the RCO's to gain more knowledge about experience and identify problem areas. Harbor Rotterdam is also the only company who changed to UI by hiring a third party, Ranj.



Graph 1: Power-Interest stakeholder matrix

1.4 Objectives & Aims

The goal of this project is to provide Siemens with an improved proposal compared to their current RCOS. The interface should offer the operators multiple options to make their work more accessible. To realize these improvements, the following objectives are established:

- Investigate the UI's of previous clients to gain knowledge about the user and their current scenario.
- Gain knowledge about the future wishes of both Siemens and the clients.
- Generate multiple features to improve the UI.
- Optimize the flow inside the UI.
- Creating a clear hierarchy of tasks regarding relevance and importance.
- Lower the cognitive burden of the operator by day and night.

To improve the UI overall, the following research questions will be answered:

- How can we redesign the user interface so the user will not lose concentration and stay in the working flow?
- How can we optimize the usability and user-friendliness of the UI both tested in the field and academically?
- How can we create flow in a non-leisure software?

1.5 Project Scope

The master thesis project is carried out during a 22 weeks' time frame of full-time work at the Siemens location in the Hague from February to July. The project is limited to a viable proposal for the UI of the RCOS program which is both founded in research and testing. Due to limited manpower and time constraints, creating a fully functional UI within this period is not feasible. Additionally, the improvement of the redesign cannot be fully tested till the point only to the point where Siemens feels comfortable implementing the improvements in the UI. The prototype and iterations will need further user testing after the completion of the project.

This human-centered project will not involve coding or an in-depth examination of the ergonomic aspects of the four screens and physical controllers. Instead, it will focus primarily on qualitative user interviews, observations, prototyping, and testing. Fortunately, potential iterations can be tested in the test room located at Siemens, with additional field research conducted at the Harbor of Rotterdam.

Chapter 02.

Context Analysis

The context chapter provides a comprehensive understanding of both the current and past situations, serving as a base of the thesis. This chapter includes an in-depth analysis of all the custom UI's Siemens has offered to clients in recent years. Ending this chapter with the current house style of Siemens.

2.1 Hardware RCOS

The UI's all share a similar layout but differ when it comes to details, besides the UI from Harbor Rotterdam. The UI from Harbor Rotterdam differs both in layout, color scheme, functionality, and task hierarchy. For the hardware, the default set up for the operators is one touch screen and three monitors. Companies do have the option to add monitors to the setup, e.g. Harbor Rotterdam is working with five screens. However, Siemens desired to design for the default set up, hence the focus for this project is on the following set up, see image 3.

The desk can adjust its height to meet the user's ergonomic preferences. That station includes hardware controls in the form of joysticks and buttons. The joysticks and movements correlate with the real look and function of the hardware joysticks and buttons in the crane. The main difference is the number of buttons on the joysticks. In the crane, the operators use foot pedals to control the crane instead of multiple buttons on the joystick. Additionally, the buttons can be customized to meet the client's needs. The RCO has an explanation sheet on the desk for further details about the hardware, see image 3.

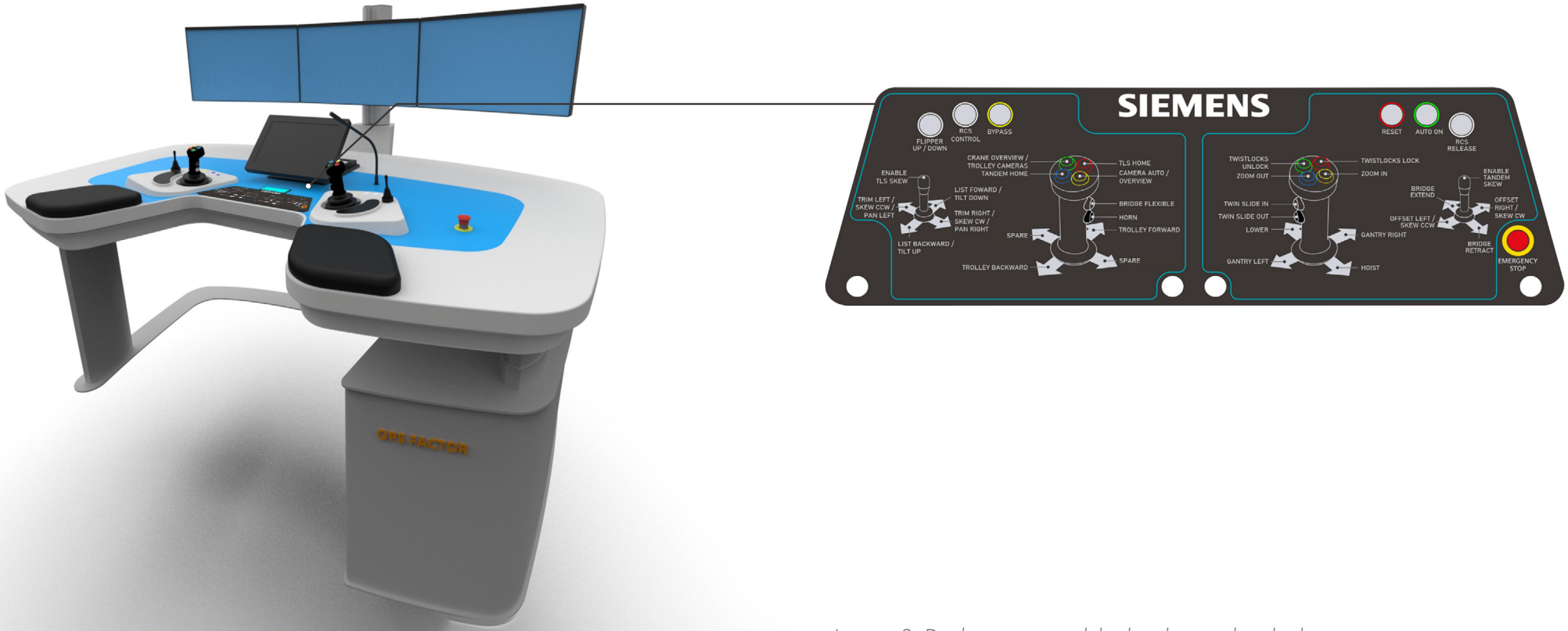


Image 3: Desk stations and the hardware details sheet

2.2 Login Screen

At the start, the RCO will see a login screen on the touch panel. The RCO's can enter their personal username and password. When selecting any entry field, an on-screen keyboard will appear. If available, a hardware keyboard can also be used. If the user decides to change his/her password he can tab on the gear in the password field and a pop up will appear, see image 5. The password is initially provided by an administrator. All the UI's have the exact same functionality and appearance, besides the Harbor of Rotterdam UI. Upon analyzing this screen, the main insights can be categorized into strengths and weaknesses.

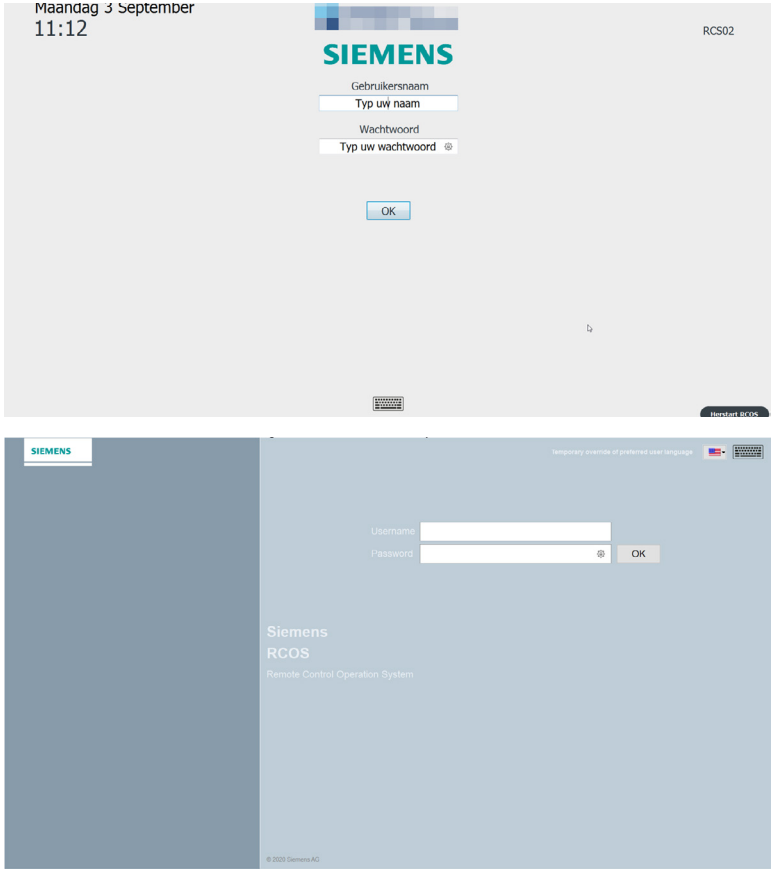


Image 4: Login screens of Siemens and Harbor Rotterdam (Siemens, n.d.)

Strengths:

- System requests personalized data and recognizes the RCO controlling the station.
- RCO has the option to change the language in the Siemens UI.
- A RCO can change their password, displayed by a gear icon.

Weaknesses:

- Lack of clear indications for the interactive buttons.
- Inconsistency in the Harbor Rotterdam UI: the OK button indicates its interactivity with a blue hue, but this indication is absent for the 'Herstart RCOS' button.

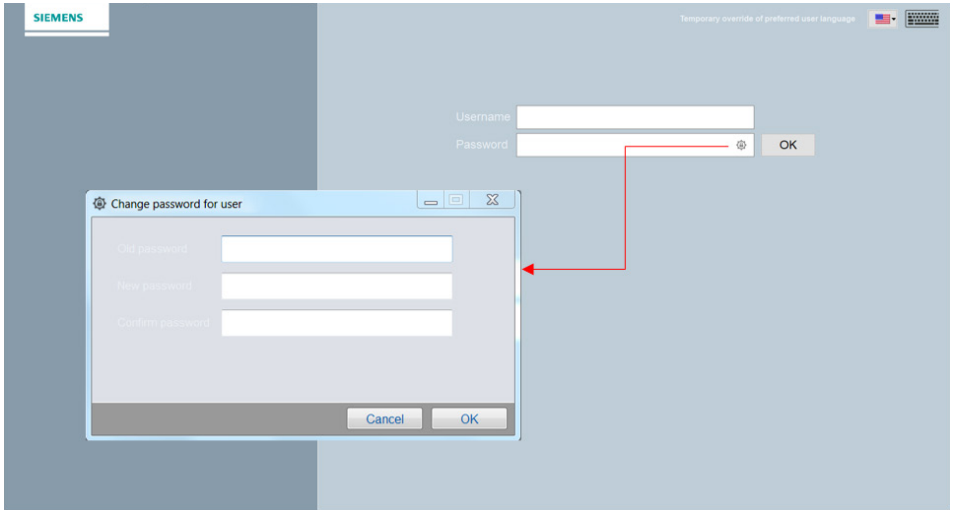


Image 5: Pop up to change password (Siemens, 2024)

2.3 Role selection

After successful authentication, the user must select a role, see image 6. An administrator configures the available roles for each user. If only one role is configured for a user, they are automatically assigned that role and skip the role selection step. This ensures that not everyone can choose the supervisor role; it must be specifically available to the user. The same layout and functionality apply for the Request for the type of crane screen, see Appendix A

Upon analyzing this screen, the main insights can be categorized into strengths and weaknesses.

Strengths:

- Screen automatically skips if only role is available for the operator. Resulting in a lower cognitive burden.
- If the RCO has 2 options, the third option lowers its proximity. Resulting in a lower chance of mistapping.
- An operator can change their password, displayed by a gear icon.

Weaknesses:

- From this moment on, the UI of Siemens changes its color scheme, for no clear reason. Resulting in a less coherent overall appearance.
- Lack of clear indications for the interactive buttons.
- Siemens' UI uses the same icons for different functions.

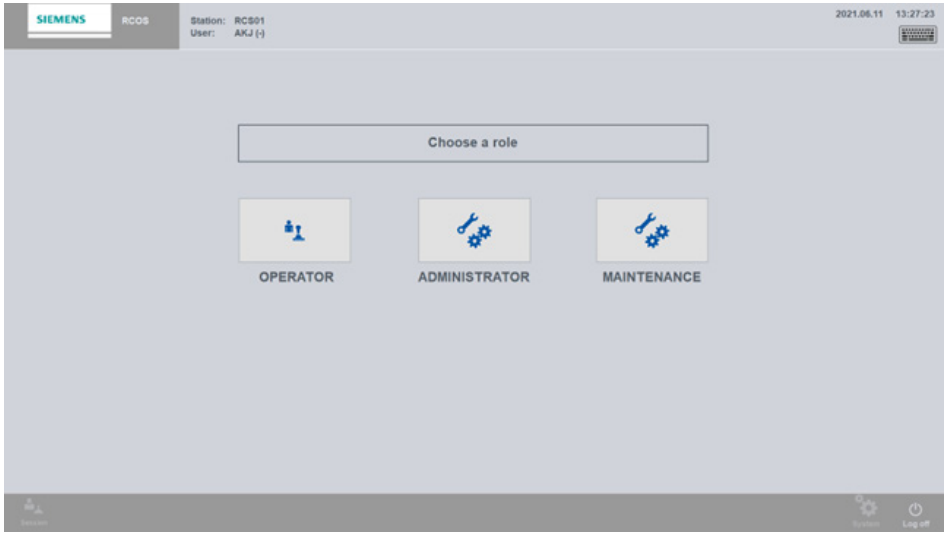


Image 6: Role selection (Siemens, 2024)

Image 7: Harbor Rotterdams role selection (Siemens, 2024)

2.4 Crane Session

To select a crane in the UI, the operator must tap on the crane's name in square 1 or on the crane itself in square 2, see figure 8. The cranes indicate their status with an icon or by displaying a color, see figure 9. A green highlighted square over the entire crane and name indicates that the crane is selected, while a gray square indicates that the crane is offline. When a crane's color switches between green and blue, it means manual intervention is required.

To accept or release an MI, the RCO can press the hardware RCS button on the desk station. An MI can be assigned to an operator based on their measured idle time or skill level in the system.

RCO's can choose between four different cranes: OHBC, RMG, RTG, and SHS. Only an STS crane in Siemens UI can differ in appearance. An STS crane is always displayed next to water, while other cranes are displayed on land, see Appendix B. In both cases, the distance and location of the cranes indicate the actual distance. For Harbor Rotterdam, their UI uses a completely different appearance, displaying different icons, colors, and additional information, see Figure 9.

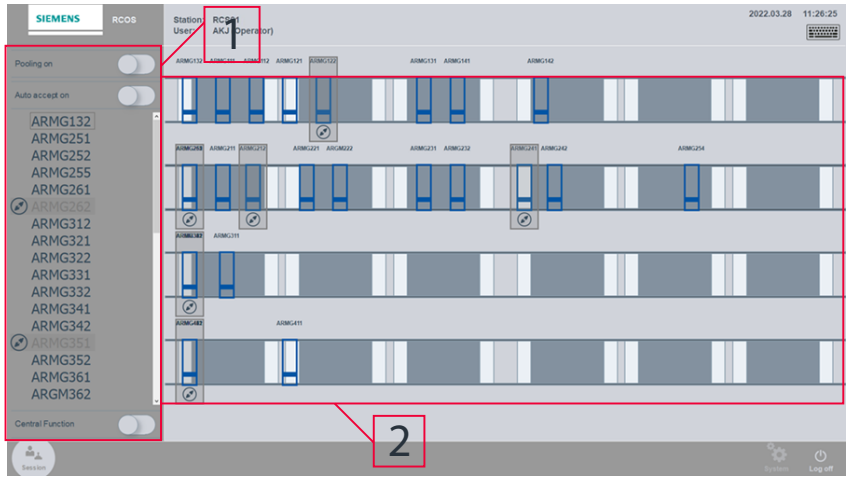


Image 8: Crane selection screen (Siemens, 2024)

For more details regarding the functionality and appearance of the 'Pooling On' and 'Auto Accept' functions, which are displayed in square 1, see Appendix C. Upon analyzing this screen, the main insights can be categorized into strengths and weaknesses.

Image 9: Crane selection icons

Image 10: Harbor Rotterdams crane visualization.

2.5 Crane/Default

The crane screen displays the most critical information for the crane on a single screen, see image 11. When a crane session is selected, this screen automatically becomes the default screen for the RCO. A button will display a green color when enabled and return to gray when disabled. While the buttons on this screen indicate interactivity, their use is inconsistent. From this point, the operator can use the menu bar to navigate between screens. However, the operator role does not have access to all the options displayed on the menu bar. Additionally, there is no option on the menu bar for the operator to seek further explanation about the functionality of elements. If the operator needs more information, they must refer to the manual or, in the worst-case scenario, call Siemens. This results in lower efficiency and fewer containers relocated.

Strengths:

- Making the text less visible when a crane cannot be selected.
- Real life indication of the distance between cranes.
- Map shows real life location of the crane.
- Both text and cranes are highlighted when selected.
- Use of icons to indicate the crane's status.
- The crane's appearance indicates what kind of crane it is and which side the landside is.
- Measured skill level and idle time of operator show opportunities for feedback system.

Weaknesses:

- Confusing color use when the crane is demanding a MI. Blue and green show little contrast and can be overseen. Moreover, green is used here to indicate an active state or that the crane is already connected
- Lack of clear indications for the interactive buttons.
- Compared to Harbor Rotterdam, the crane shows very little additional information.
- Harbor Rotterdam uses yellow to indicate availability, which normally means warning.

Image 11: Crane/Default screen (Siemens, 2024)

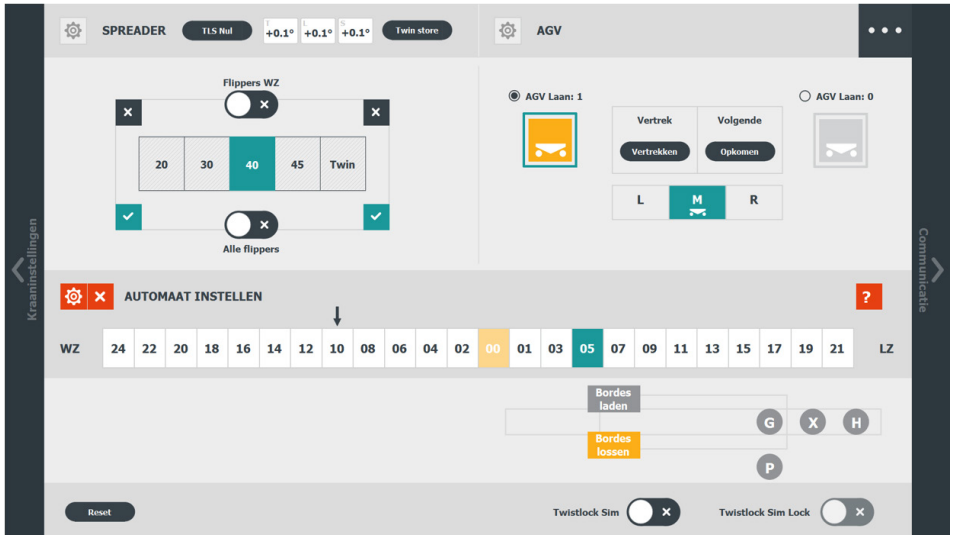


Image 12: Harbor Rotterdams Default screen (Siemens, 2024)

Harbor Rotterdam's crane screen differs significantly in appearance, functionality, and workflow. Their use of icons provides additional information about button functionality, and the default screen features color indications to signify task urgency. However, accessing detailed information requires tapping the gear icon to open a pop-up menu, adding extra steps for the RCO before starting the proces, see Appendix D. Since they use a flat design, there is no clear indications for the operator how to navigate through the screen.

Although there is a help desk option designed to assist the RCO efficiently, operators still frequently call Siemens with UI questions, indicating that the help desk is not as effective as it should be. Both UI shows strengths and weaknesses regarding the most important screen. Upon analyzing this screen, the main insights can be categorized into strengths and weaknesses.

Strengths:

- Clear distinguishment between enabled and disabled buttons.
- Siemens UI needs one tap to navigate through the menu bar.
- Use of groups by borders.
- Use of proximity.
- Buttons display small shadows to indicate interactivity
- Harbor Rotterdam uses color indications to signify the urgency of tasks.

Weaknesses:

- Titels of groups show low readability.
- No clear hierarchy of tasks, implying everything is equally prioritized.
- Siemens' icon of hardware details is extremely vague.
- The same icons are used in the menu bar for different screens.
- No clear alignment between elements
- Siemens' visual of spreader is not interactive
- No consistent use of interactivity indications, the width buttons don't display shadow.
- Siemens offers no additional help service. Harbor Rotterdam does, but not effectively.
- Harbor Rotterdam needs more additional taps to navigate through the entire system of pop ups and the menu bar, see Appendix D.

2.5 Control

The control screen handles less critical crane functions, using different widgets but sharing the same strengths and weaknesses as the Crane screen. A key issue is that the RCO is missing important information when switching to the control screen. An improvement could be combining both screens to provide a comprehensive overview. Upon analyzing this screen, the main insights can be categorized into strengths and weaknesses.

Strengths:

- Use of different widgets.

Weaknesses:

- Important data may be overlooked by the RCO due to the necessity of switching between screens.

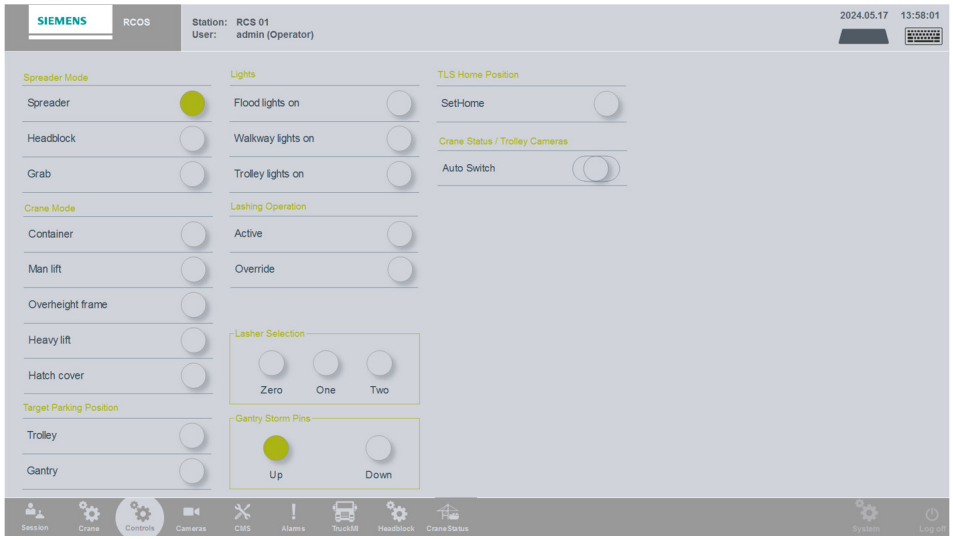


Image 13: Control screen (Siemens, 2024)

2.6 Camera selection

If an RCO desires more dimensional information about the surroundings or spreaders, they can select a camera stream by tapping a number in the 2D visualization of the crane or the name of the camera. The numbers pinpoint the crane's locations, helping the RCO connect names with locations, improving clarity and guessability. However, the names are not fully readable at first glance, and selecting a camera causes a pop-up to cover the entire screen. For each camera a red border is shown to indicate high latency and/or low frame rate alert.

In contrast, Harbor Rotterdam's system displays the pop-up in a smaller portion of the screen. Additionally, Harbor Rotterdam has included extra controls, such as the 'Crane On' button and lights, on this screen.

Upon analyzing this screen, the main insights can be categorized into strengths and weaknesses.

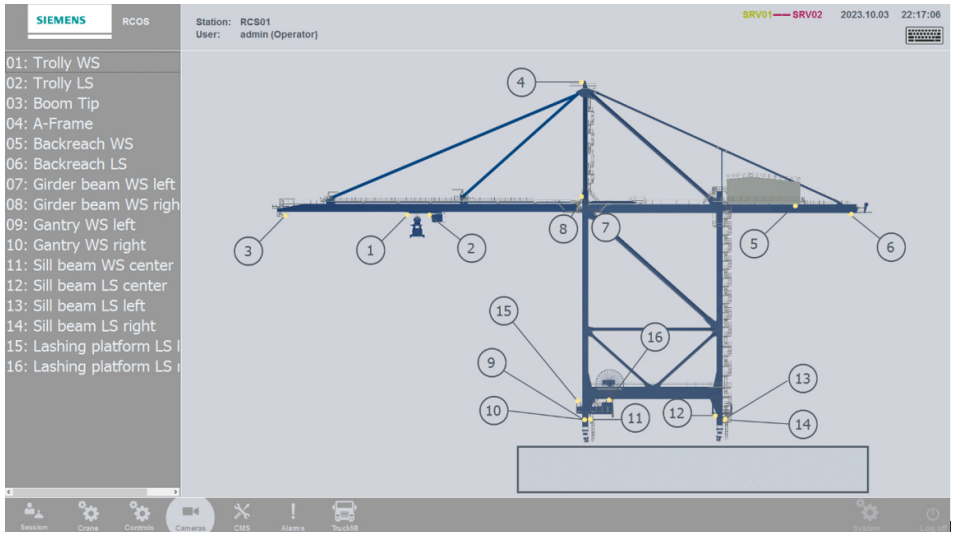


Image 14: Camera screen (Siemens, 2024)

Strengths:

- Pinpoint indications of camera placement
- Both name and number can be used to select a camera.
- Harbor Rotterdam implemented the light controls in the camera selection screen.
- Harbor Rotterdam has a separate part of the screen dedicated to the camera screen.
- The name of a camera is displayed and highlighted when selected.
- Indication high latency and/or low frame rate by red frame.

Weaknesses:

- Names are not fully readable at first sight.
- Siemens' camera stream almost covers the entire screen without a clear indication of how to return to the normal screen, see image 15.
- Lack of clear indication for interactive buttons.
- Red frame can have a double meaning. People can associate it with recording.
- When the camera stream occupied the whole screen, there was no clear way to return to the normal view.

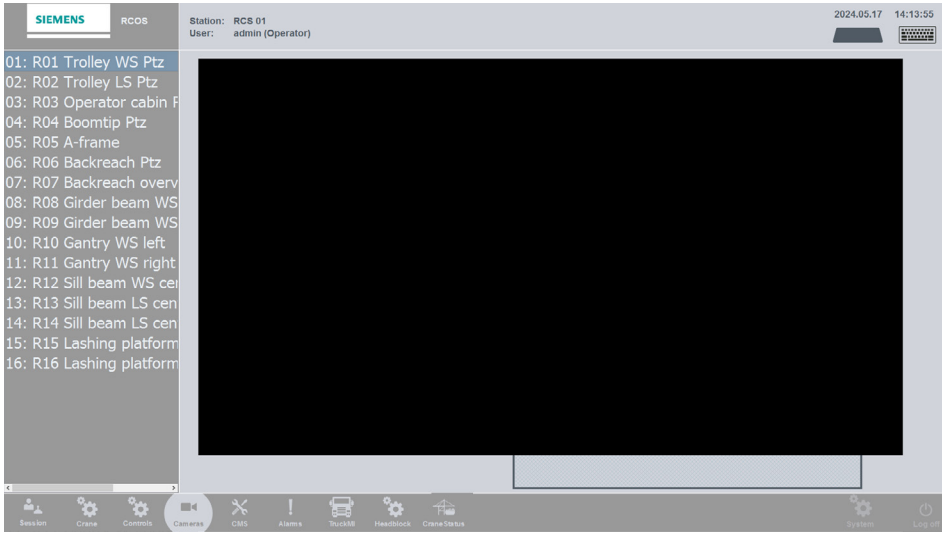


Image 15: Pop-up camera screen (Siemens, 2024)

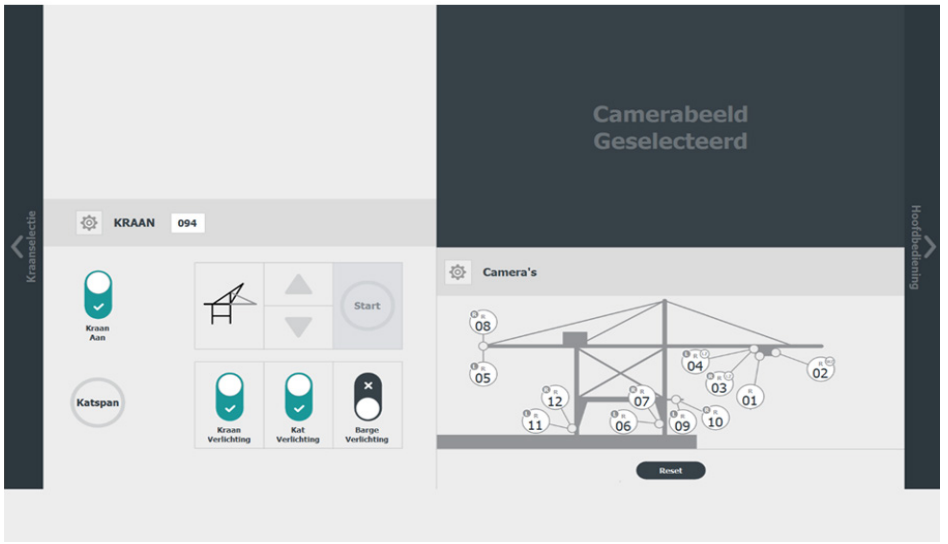


Image 16: Harbor Rotterdams Camera screen (Siemens, 2024)

2.7 Alarm

The alarm panel displays the latest seven active messages. Each message is accompanied by an alarm icon indicating the urgency of the task with the following color codes: red for urgent alarms, yellow for warnings, and green for informational messages. The icon blinks until the message is addressed. Once addressed, the RCO can delete the message by tapping on it. Upon analyzing this screen, the main insights can be categorized into strengths and weaknesses.

Strengths:

- Use of color to indicate alarm urgency.
- Blinking alarm icons until handled.
- Simple deletion of handled alarms by tapping on them.

Weaknesses:

- Inconsistent color coding: Siemens' standard color code designates red for errors/urgent alarms, yellow for warnings, and green for active state/enabled. Here, green is used for informational messages.
- Lack of clear indicators for interactive buttons.
- Rows are too small, making them difficult to read and tap.
- No clear indication to scroll down the page when there are too many alerts.

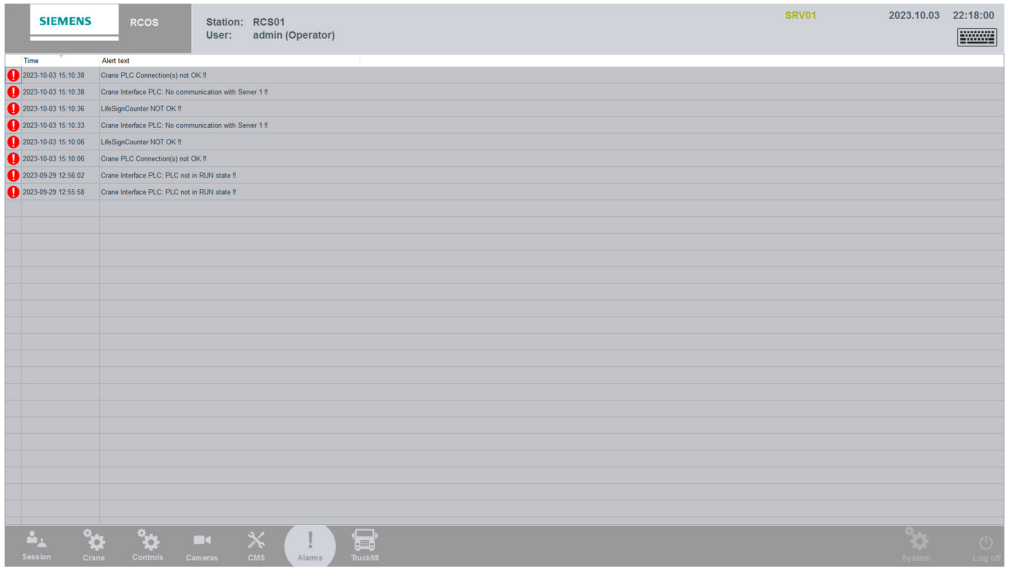


Image 17: Alarm screen (Siemens, 2024)

2.8 Truck MI

The Truck MI page automatically opens to alert the operator when the 'Expected truck ID' does not match with 'Actual truck ID'. After receiving this message, the operator can take the necessary action and continue operations. Since the page opens automatically and does not require action if the IDs match, there is little need for interaction. This is the sole purpose of the screen, and because none of the features are interactive, there is minimal need for redesign, see image 18. Upon analyzing this screen, the main insights can be categorized into strengths and weaknesses.

Image 18: Truck MI screen (Siemens, 2024)

Strengths:

- Screen automatically goes to the screen. Only when necessary. Resulting in a lower cognitive burden.

2.9 CMS & System

Since the CMS is unavailable for the operator role, selecting CMS on the menu bar results in an empty screen. Similarly, only the operator and administrator have access to the System screen. If the operator presses the System button, nothing will happen. Therefore, the CMS and System pages will not be analyzed any further.

2.10 Logout

The Logout option does not currently have its own screen. When an operator chooses to log out, the only requirement is that RCOS must be disconnected from the cranes. If this condition is not met, the operator will not be logged out. Currently, the RCO does not receive a reminder to check if the cranes are disconnected if the logout attempt fails. This presents an opportunity to provide more guidance to the RCO throughout the system. If the logout is successful, the RCO is returned to the login screen.

2.11 Left Monitor

This monitor allows the RCO to gain extra dimensional information through four different angles. The camera can switch between three states: Automatic (A), Manual (M), Overview (O). All camera angles are pre-set and cannot be changed by the RCO, adjustments must be made by Siemens. For all these camera images, if there is a high latency and/or a low frame rate from a certain camera angle, the RCO will be alerted by a red border around that camera angle. Same as for the middle monitor and the camera screen. Moreover, RCOS will send a message to alert the RCO for pressing RCS control after requesting a session. It also includes messages to assist operators during the session.

For Siemens, the lower bar alerts the RCO to press the hardware button after requesting a session. The Harbor Rotterdam UI uses five angles instead of four. Appendix E provides more details about the left monitor's entire functionality

Image 19: Left monitor (Siemens, 2024)

Strengths:

- RCOS system assists RCO with messages during session.
- Indication high latency and/or low frame rate by red frame.

Weaknesses:

- Camera streams are pre-set and cannot by changed by the RCO.

2.11 Middle Monitor

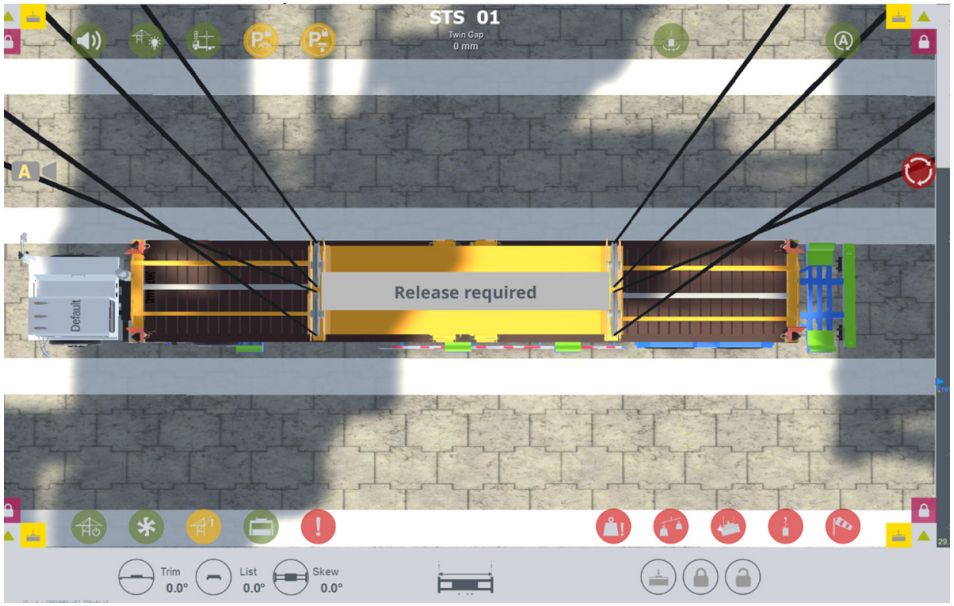


Image 20: Middle Monitor (Siemens, 2024)

The middle monitor serves as the main screen, drawing the most attention from the RCO. This screen features icons as overlays that indicate the crane's status or issues, displayed only when relevant. The overlay uses Siemens' color code to indicate the type of alert: green is enabled, yellow is alert, red for warning. This color code is used inconsistently throughout most of the RCOS UI. When the camera screen is experiencing a low frame rate, it displays the same red frame around the camera stream as for the camera screen. When the camera stream of Harbor Rotterdam experiences a low frame rate or high latency, only the corners around the image turn red. The Siemens' UI includes a bar located on the right side of the screen indicating the height of the hoist, showing only one height measurement. In contrast, Rotterdam Harbor displays four different height measurements. More details about the entire functionality of the middle monitor can be found in Appendix F.

Weaknesses:

- The contrast of the red bezel against the white background in Rotterdam's design is higher and of bigger size compared to Siemens' red frame, which makes it more dominant.
- Icons do not have names.
- Chance of icon being overseen when the background behind the icon is the same as the icon itself.
- Harbor Rotterdam provides the user with more information regarding the heights.

Strengths:

- The middle monitor provides overlays about the crane's status, only when relevant.
- The overlays use the correct Siemens' color code.
- Indication of high latency and/or low frame rate by red frame.

2.11 Right Monitor

The right monitor can display two different pages: one providing crane information and the other showing an additional camera view. By default, the crane information page is displayed, see image 21. To switch to the camera page, the RCO can press a hardware button on the physical joystick. Alternatively, if auto-switching is enabled, the monitor will automatically switch to the camera page when the spreader enters predefined locations where extra views are mandatory. It is also possible to display both the camera view and crane status simultaneously. This is the default screen for the Harbor Rotterdam UI.

The monitor provides a 2D live visualization of the crane's movements, allowing the RCO to track the trolley's speed and current operational status. The crane mimics real-life movements, with one component moving at a time. Moreover, a key feature of this monitor is the controller vs. drive display, which shows the power input from the RCOS compared to the actual power being used by the crane. For the RCO, it is crucial to be aware of any delay between the system input and the crane's actual movements. Without this information, the RCO might experience a false sense of the system's responsiveness.

Additionally, the panel below indicates possible manual interventions, errors, or status updates of the crane. This feature is also missing in the Harbor Rotterdam UI. For more detailed information on all the monitor's features, refer to Appendix G.

Strengths:

- Mimicking real life movements positively impacts the RCO, as it enables him to predict the required distance and the power needed for the movement.
- Only screen which can be on a monitor and the touch screenpanel.
- Comparison between controller and drive power.

Weaknesses:

- No clear hierarchy regarding the importance of displayed information.

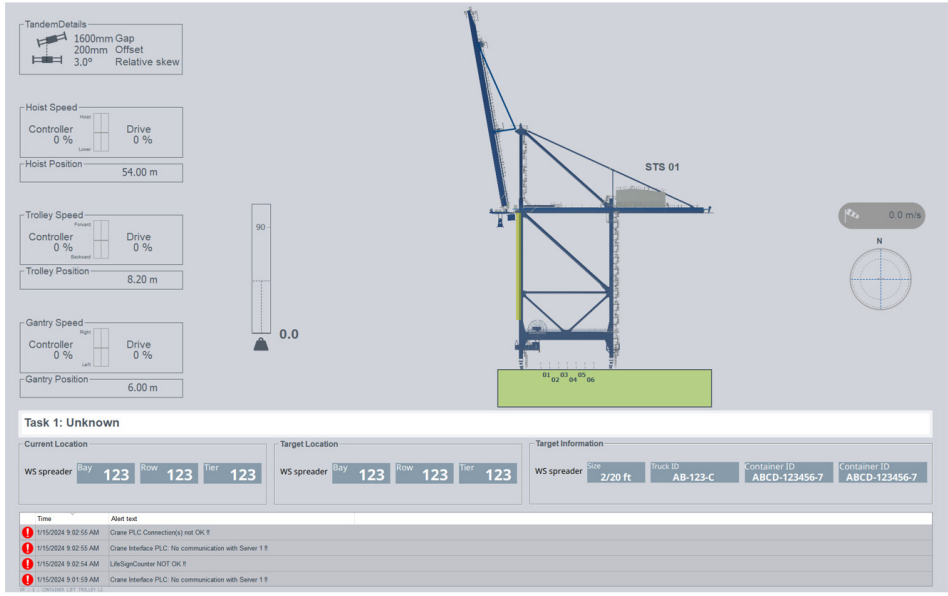


Image 21: Control screen (Siemens, 2024)

2.12 Housestyles

This chapter provides an overview of the current house style used for RCOS and the house style of Siemens itself.

2.12.1 RCOS Housestyle

The RCOS UI is designed by the Engineers of the Crane department by making choices they thought would be logical. During the process of making the UI, the user friendliness between the device and human was not taken into consideration. Some general guiderules for RCOS would be:

- No coherent use of visible interactive buttons.
- No fixed framework for alignment or placements
- Limited use of icons
- No dark Mode
- Color code for warnings green is enabled, yellow is alert, red for warning
- Primary colors used throughout UI:

aab537 d1d5db 989898 475a67

2.12.1 Siemens Housestyle

Siemens has a fixed house style with guidelines and dos and don'ts for working with its components, but this style was not applied to RCOS due to the time required for full implementation. The color scheme and detailed guidelines can be found in Appendix FIXME.

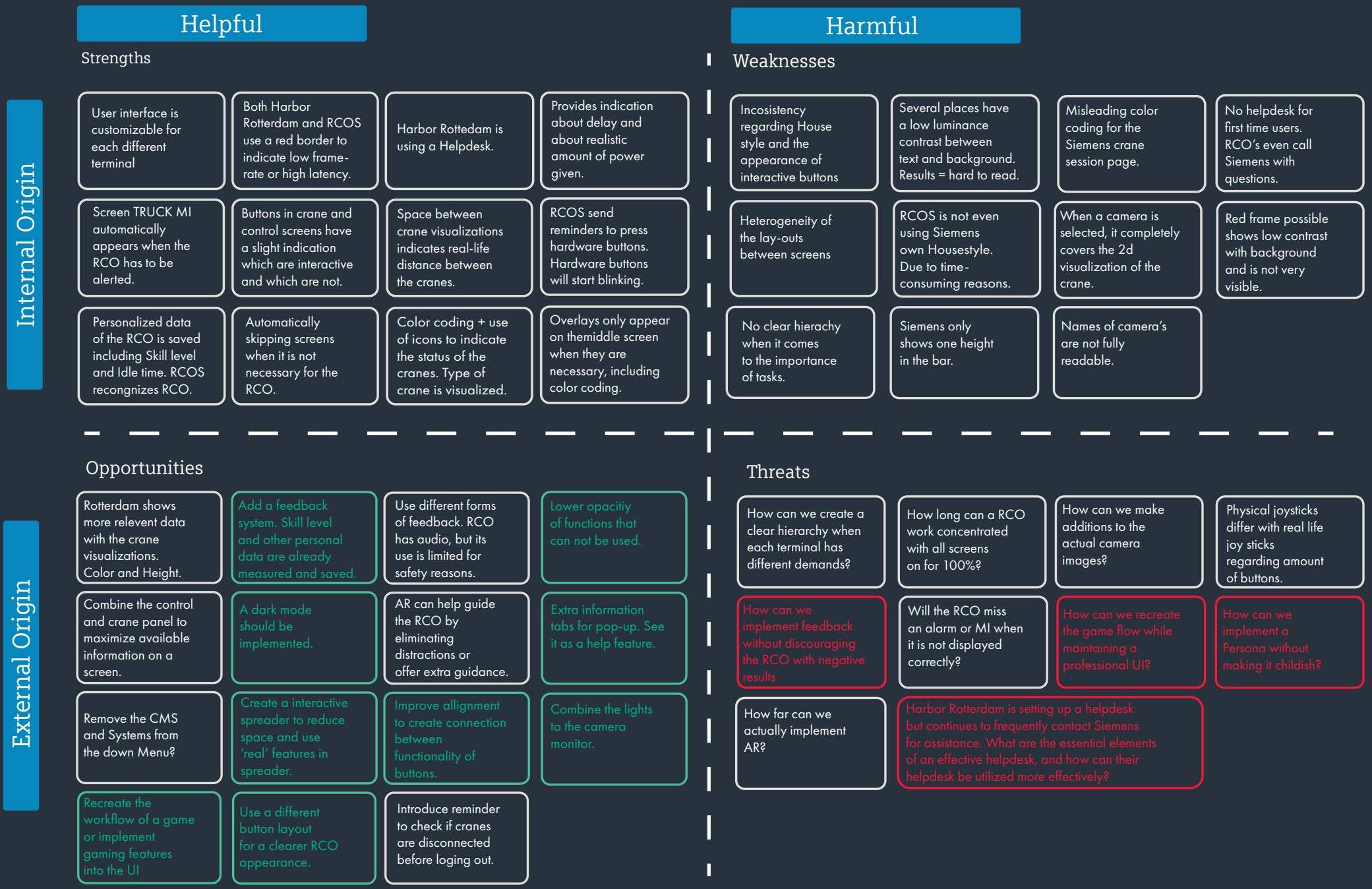
To enhance RCOS's user-friendliness, some Siemens UI guidelines will not be strictly followed. The housestyle's recommendation for using only flat designs limits design flexibility. To enhance 'out-of-the-box thinking,' guidelines for icons, shadows, and avatars/personas will be considered later. Some general guiderules for Siemens are:

- Flat-icon style
- Use of very simplistic icons
- The UI has a dark mode and light mode.
- Guidelines for the use of avatars, icons, animations, shadows etc.
- Primary colors used throughout UI:

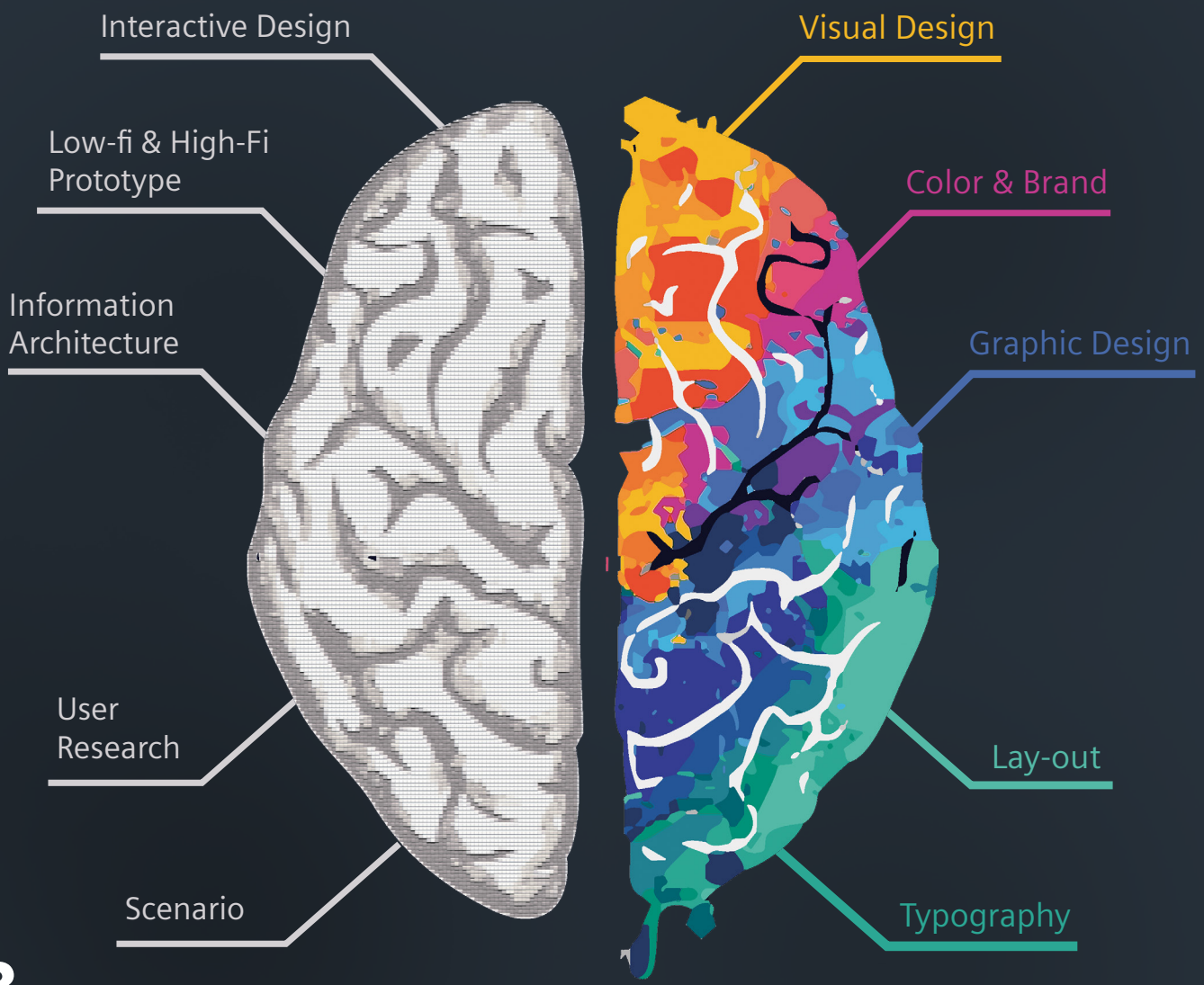
000028 00d7a0 009999 00e6bc

2.13 Opportunities and limitations current UI

A SWOT analysis was conducted to evaluate the strengths, weaknesses, opportunities, and threats of the previous UIs. This analysis helps identify key limitations and opportunities of the current UI features, see graph 2 on the next page. Opportunities with high potential are highlighted in green and will be explored further. These opportunities are derived from comparisons of various manuals, feedback from Harbor Rotterdam and Siemens, and relevant literature. The analysis also identifies significant threats, highlighted in red, that could hinder these opportunities with high potential. Testing solutions with the target group will be crucial for overcoming these obstacles and finding effective solutions.



Graph 2: SWOT Analysis



Chapter 03.

Theoretical Literature of UX & UI

This chapter presents the theoretical framework relevant for this project. The theory was researched through a literature review. The collected information and knowledge are used to support all parts of the project.

3.1 User Experience in UI

The challenge to design an interface that attracts the user's attention while simultaneously enhancing the user's experience (UX) is a challenge gaining more attention each day. UX is defined as the overall experience of a person using a product such as a website or computer application, especially in terms of how easy or pleasing it is to use.

UX is a human-computer interaction-related (HCI) concept that includes the user friendliness of an UI, which is one of the focus points regarding the improvements of the RCOS software (Sharma & Tiwari, 2021). According to Sharma and Tiwari (2021), usability stands central in user experience design, applying across all applications. Enhancing the usability correlates with improving the overall user experience. Longer and Nielsen (2006) further explain that usability serves as a measurement of how easily a product can be used. The usability of an UI can be measured by eight components:

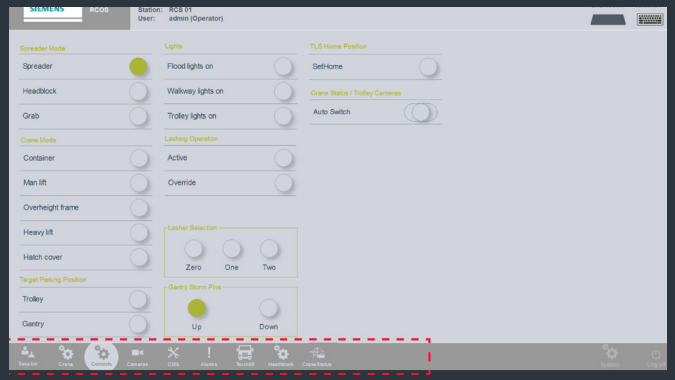
1. Effectiveness: If the performance of a task ends in success or failure:
2. Efficiency: The amount of effort that is needed to complete a task
3. Satisfaction: How pleasant the user experience is.
4. Guessability: How well a first-time user's experience is.
5. Learnability: How long it takes for a user to understand how to perform a task.
6. Experienced user performance: How well-experienced users achieve task success on a specific product.
7. System potential: The optimal level of performance of a task that is theoretically possible.
8. Re-usability: How easy it is for the user to achieve a particular task after a longer period of not using the product.

The only way to conclude if a user interface possesses a high usability is to conduct user tests and perceive the interaction between user and device (Nyman & Norén, 2021). According to Li and Malih (2012) user tests can also measure more abstract components in a UI such as cognition workload, learning curve, satisfaction, and emotional attachment. Nielsen and Landauer (1993) state that usually five participants for a user test are enough to discover the critical usability issues.

3.2 UI Design Principles

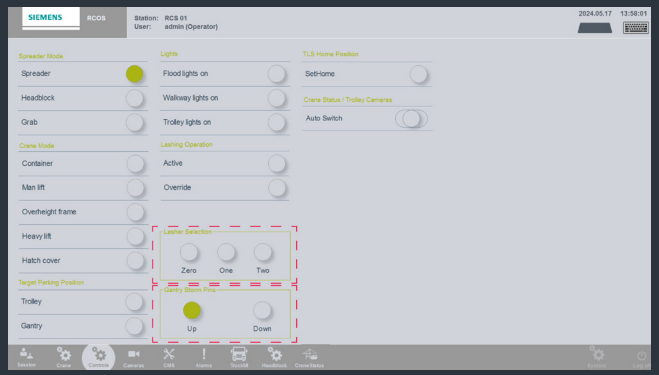
User interfaces have gone through a significant transformation since the 1970s, all due to the advances in Human-Computer interactions (HCI) and related technologies. Nowadays, we cannot imagine our life without technology and the daily interaction with computers or mobile screens (Uday Bhaskar et al., 2011). User interfaces apply for devices like computers, mobile devices to application programs and content usage (Sharma & Tiwari, 2021).

According to Uday Bhaskar et al. (2001) there are twenty design principles fundamental for a successful UI and for other implementations of interfaces, including Graphic User Interfaces (GUI) and Web ones. All these principles are crucial for a successful UI and can be found in Appendix I. For this project brief, we will first highlight the principles that are commonly used in the previous manuals on the next page.



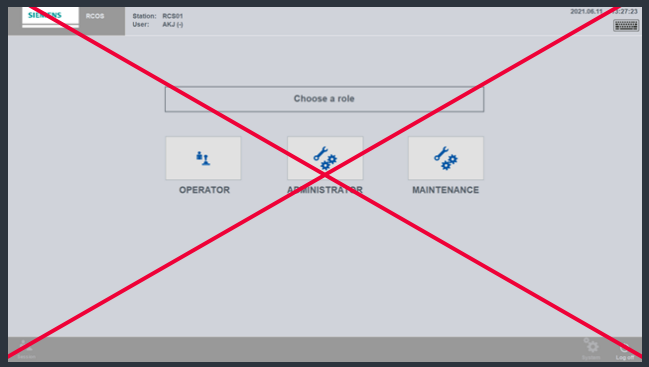
- *Efficiency*

The RCO can move around the UI with one tap on the menu bar located down in the screen.



- *Grouping using borders*

The functions in crane and control screens.

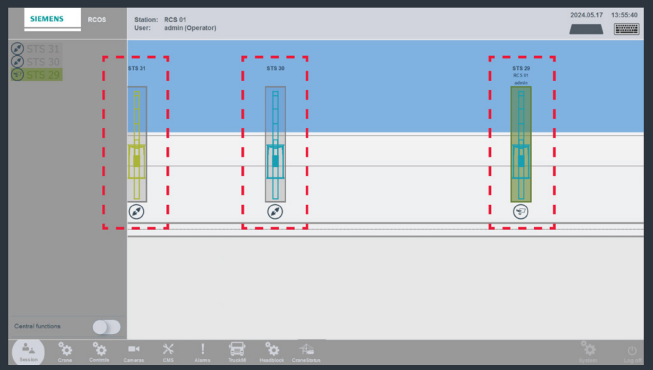


- *Simplicity*

RCOS offers simplicity by skipping unnecessary screens, such as the role selection page.

- *Directness*

The RCO can move around the UI with one tap on the menu bar located down in the screen.



- *Focus & Emphasis*

Highlighting the crane green if they are selected and gray if they are offline in the Crane selection screen.

Principles that did not occur frequently but are important for the user- friendliness of a UI should be considered in further iterations:

- Clarity
- Compatibity
- Comprehensibility
- Recovey
- Configurability
- Familiarity

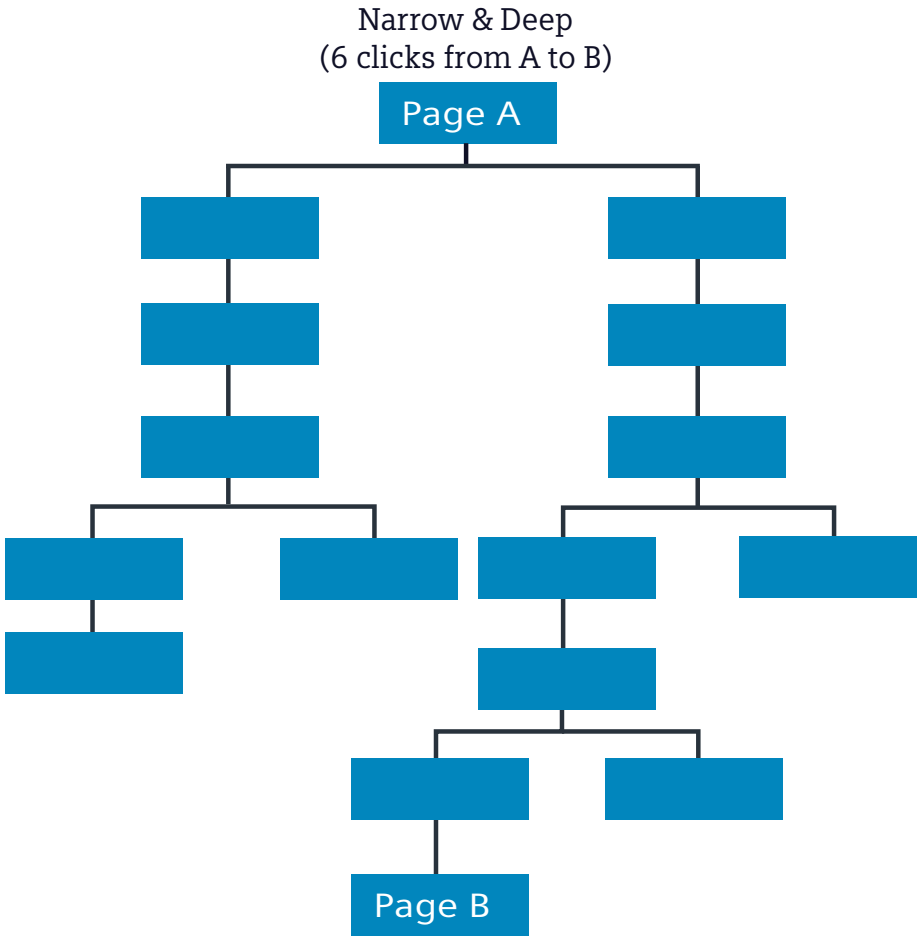
Still all UI principles are important, but these UI principles show most potential combined with the opportunities of the SWOT analysis.

3.3 Information Architecture

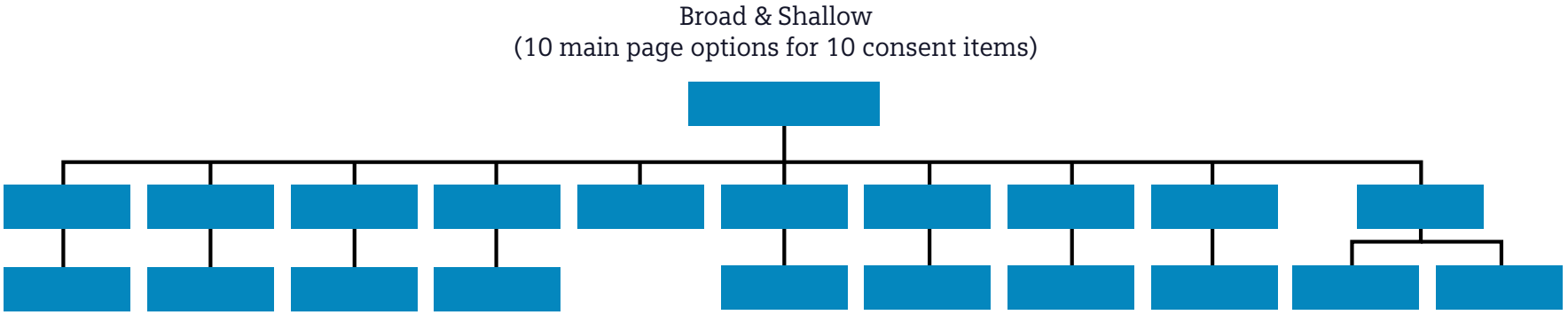
While many users perceive "the user interface as the application" since it is the part they see and interact with, it's crucial to understand that the usability of an application isn't solely determined by its interface design. The architecture of the application plays a significant role in shaping its usability. Information Architecture (IA) is defined as the combination of art and science of organizing information spaces to help the user meet their informational needs. The process of organizing requires structuring, classifying and labeling the contents of a website to enhance the user navigation and comprehension. (Perdomo et al., 2017)

Throughout history, information has been organized into hierarchies, a classic example being a family tree. How you display the information is crucial to achieve a hierarchy for information Achieving balance in the hierarchy lies between the depth and width. Depth refers to the number of levels in hierarchy, while width refers to the number of options available on each level. If it is excessively deep and narrow, users may find tapping through many levels to reach their goal.

Furthermore, if the hierarchy is too shallow and broad, each level contains little content, see image FIXME. Eventually resulting in an overwhelming number of options in the main menu.

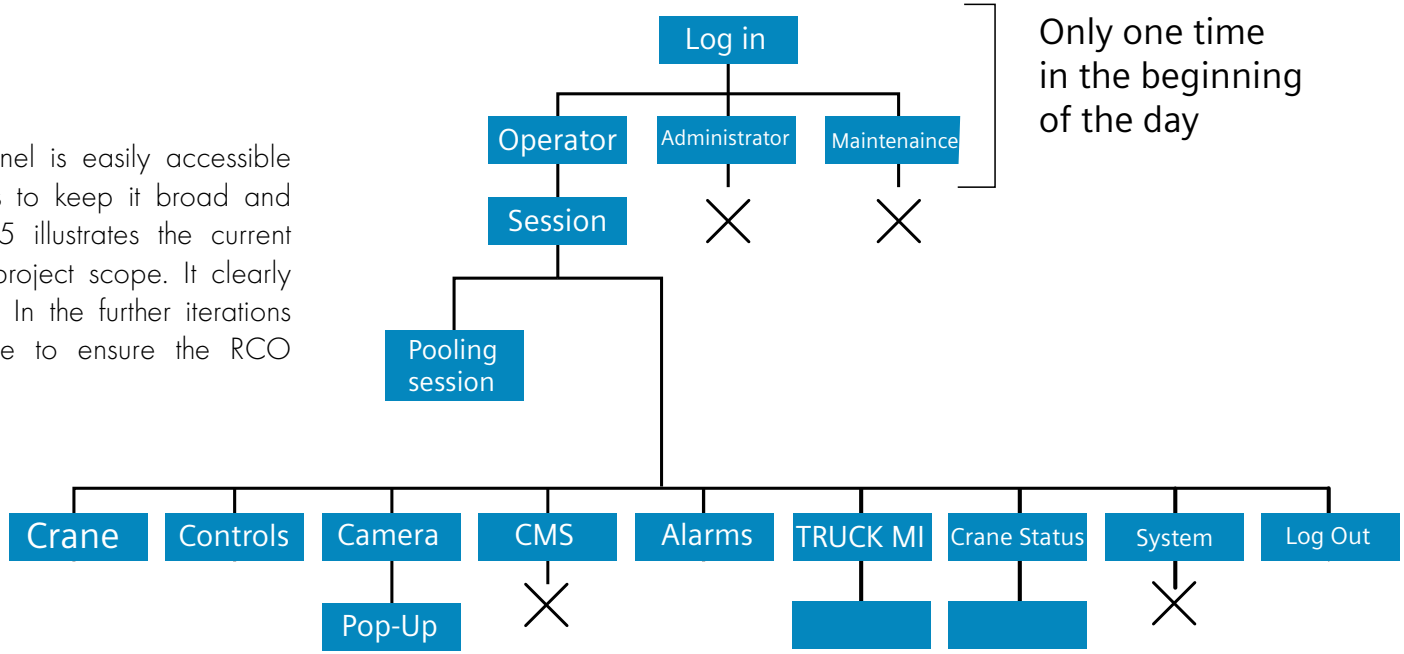


Graph 3: Narrow and deep informational architecture



Graph 4: Broad and shallow informational architecture

The RCOS UI is designed to ensure that every panel is easily accessible with minimal taps. To achieve this, the redesign has to keep it broad and shallow for fast rotations around screens. Graph 5 illustrates the current information architecture of RCOS, focusing on the project scope. It clearly demonstrates the current broad and shallow nature. In the further iterations we stay focused on a broad and shallow nature to ensure the RCO can move fast around the UI.



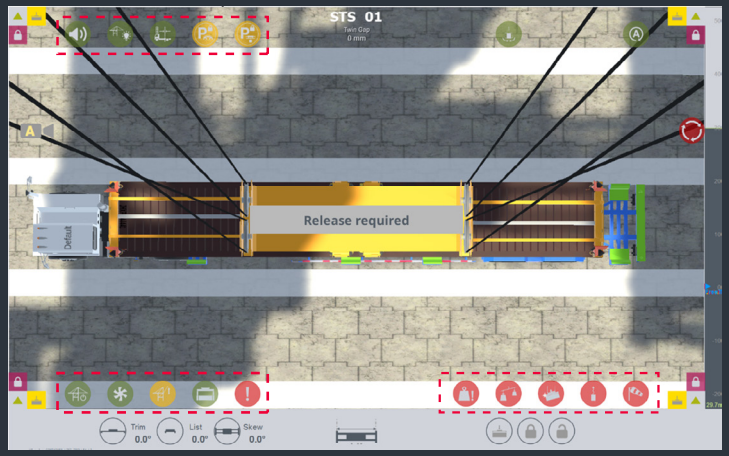
Graph 5: Broad and shallow informational architecture

3.4 Visual Design

The first impression a user forms is crucial in establishing trust and confidence. After the UI is started, the user should be able to productively use the application within the first 5 minutes. Interaction design establishes responses, gestures, defining behaviors, it is the visual design behind those things that breathes life into it. The key to a successful design for touch panels is a design that intuitively guides the user. Users should be able to distinguish where to touch or slide without explicit instruction. However, this presents a challenge as visual design must enhance aesthetic and branding without distracting from the content. Designing for touch panels involves crafting an adaptable design with distinct attributes such as, a language of shapes, colors, forms, and controls. These elements work harmoniously to visually guide users through tasks to meet their goal (AMX, 2012). A section of the design guides will be presented and explained.

3.4.1 Gestalt Principles

In today's psychology, the Gestalt principles are often viewed more as a descriptive framework rather than an explanatory or predictive theory. Current theories of visual perception rely heavily on the neurophysiology of eyes, optic nerve, and brain. Notably, the findings of neurophysiological researchers align with the observation of the Gestalt psychologist. Humans really are, along with other animals, inherently 'wired' to perceive our surroundings in terms of whole objects (AMX, 2012). In RCOS, 6 out of 7 Gestalt principles occur: Proximity, Similarity, Continuity, Closure, Symmetry, Figure/Ground. The last principles of Common Fate will be explained in Appendix I.



1. Proximity

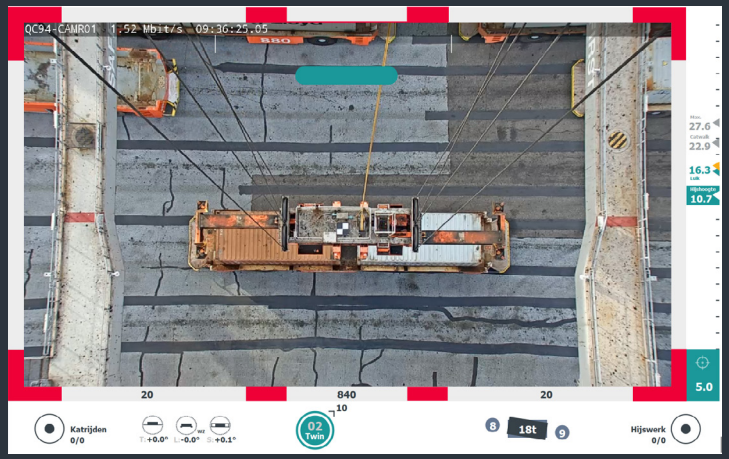
The principle of proximity states that objects close to each other are perceived as more related than those farther apart. This principle can override similarities in color and shape.

In Harbor Rotterdam's manuals, the middle monitor illustrates this well (see Figure FIXME). On the right side, red overlays are grouped and perceived as related by color. On the left side, differently colored overlays are seen as related due to their proximity.

The principle of similarity suggests that when objects share visual similarities, we tend to group them together. Additionally, we often assume that these similar objects serve the same function.

A good example of the similarity principle from the previous manuals are the crane visualizations. The visualizations are spread around the screen; however, we perceive it as a group since they share visual similarities.

2. Similarity



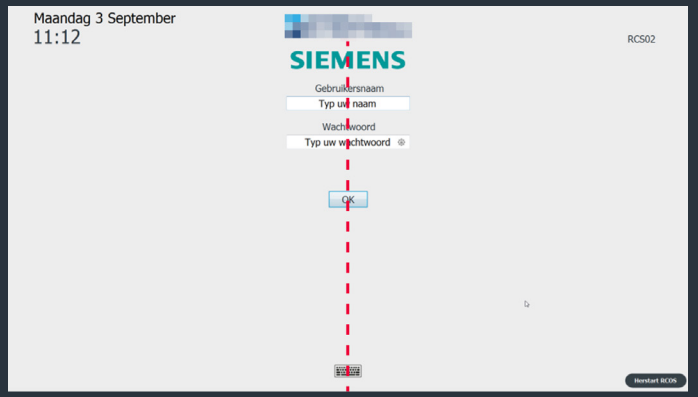
3. Closure

The Gestalt principle of Closure indicates that our visual system naturally seeks to complete open figures, perceiving them as whole objects rather than fragmented pieces. Our visual system is so strongly biased to perceive objects that it can even interpret an almost totally blank as an object.

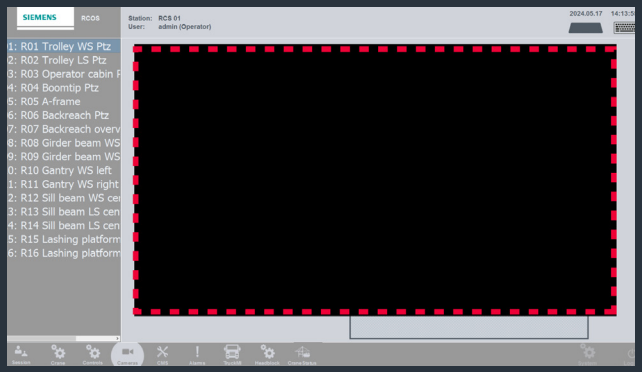
A good example of the closure is the latency alert on a camera ream for the Harbor Rotterdam UI. The red corners trick our biased mind to fill the gaps and see this as a whole red frame around the image.

The Gestalt principle of Symmetry suggests that we naturally process complex scenes in a manner that simplifies their complexity. Although the data in our visual field may offer multiple interpretations, our vision instinctively organizes and interprets this data to simplify it and introduce symmetry.

A good example is the comparison between the login screens for Harbor Rotterdam and Siemens. While Harbor Rotterdam implements symmetry, Siemens does not.



4. Symmetry



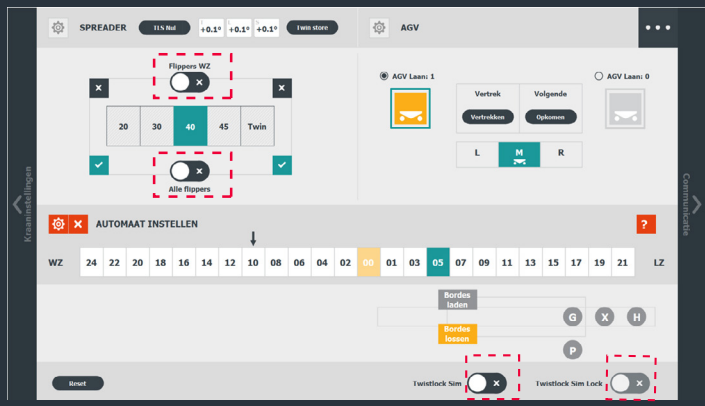
The Gestalt principle of Figure/Ground states that our mind instinctively separates the visual figure as either being in the foreground or the background. They either stand out prominently in the front (the figure) or recede into the back (the ground).

Harbor Rotterdam uses multiple tabs to display pop-ups and darken the background. In Appendix D, all pop-ups from the default screen are displayed. In contrast, the Siemens UI features a single pop-up, which appears when selecting a camera stream. This pop-up is more prominent, and the background does not darken. However, our mind still separates this visual as in the foreground.

5. Figure/Ground

The principle of Continuity suggests that we naturally perceive continuous forms over fragmented ones. This principle is often applied to UI sliders, which we see as a single range controlled by a handle, not as two separate ranges divided by the handle.

Continuity also applies to toggles in UI design. Our eyes are drawn to where the toggle button will move next, and we usually predict this correctly. In the default screen of Harbor Rotterdam, both toggles and tabs effectively utilize this principle.



6. Continuity

3.4.2 Color

Color is a crucial part of visual design. The user is able to distinguish elements in the interface that you want to draw the user's attention to. Color also possesses an associated quality where we frequently conclude a connection between items sharing the same color. Additionally, color carries emotional or psychological characteristics that influence our perception and feeling. This can differ for different cultures and the associations those cultures bring (Löffler, 2017). Luckily there is an overall association with several colors:

- Green indicates initiation, activity or serves as a common accent color.
- Red indicates a stop, an error or to signal an alert (AMX, 2012).
- Blue indicates calmness, coldness, or water (MSEd, 2024).

However, how a person can perceive a color can vary significantly. Human color perception is limited. According to Johnson (2010), the way individuals perceive colors has both strengths and limitations, many of which are relevant to designing a user interface.

- Our vision is optimized to detect contrasts, such as edges, rather than absolute brightness.
- The ability to distinguish colors depends on how they are presented.
- Some individuals are affected by color blindness.
- Color perception is influenced by the user's display and viewing conditions

These strengths and weaknesses can complicate the task of designing a UI. Fortunately, there are general guidelines that designers can follow when creating a user interface:

- Distinguish colors by saturation and brightness as well as hue.
- Use distinctive colors
- Avoid color pairs that cannot be distinguished by color-blind individuals.
- Use color redundantly with other cues.
- Separate strong opponent colors (AMX, 2012).

3.4.2.1 Color Blindness

Color blindness affects a substantial portion of the population. It doesn't mean an inability to see colors but rather that one or more of the color perception channels don't function normally, making it difficult to distinguish certain pairs of colors. Approximately 8% of men and slightly under 0.5% of women have difficulty discriminating against certain color pairs (J. Johnson, 2010). Protanopia and Deuteranopia are the two most common forms of inherited color blindness. The two forms are red-green color vision defects caused by the absence of red and green retinal photoreceptors. Photoreceptors are the cells in the retina that respond to light (Wong, 2023).

RCOS looks the following for people with protanopia:

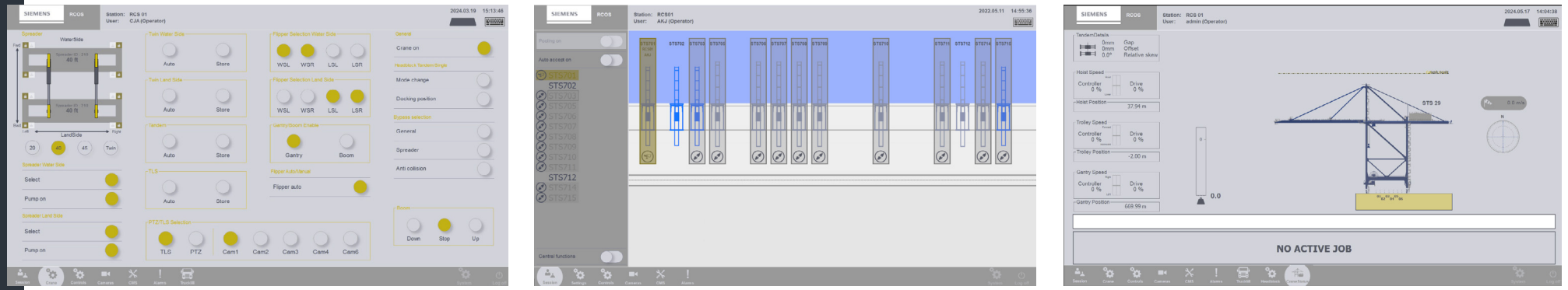


Image 22: A protanopia filter over the default screen, crane selection screen, and the crane status screen

RCOS looks the following for people with deuteranopia:

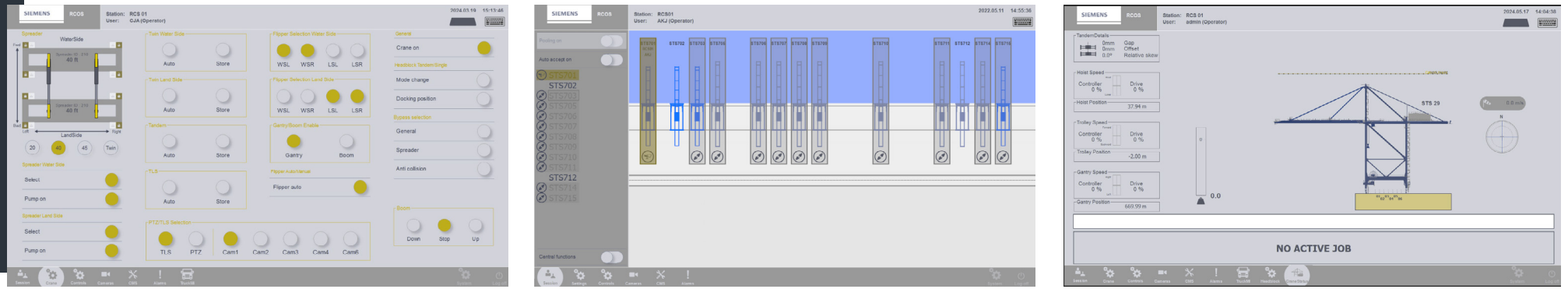


Image 23: A deuternopia filter over the default screen, crane selection screen, and the crane status screen

The color palette for protanopia and deuteranopia does not vary significantly in the RCOS UI. Consequently, the current UI would likely be as efficient for a person with 'regular' vision as for someone with either protanopia or deuteranopia. Similar problems would occur, like the titles of the functions still have low readability. For future iterations, we plan to implement the Siemens house style colors. To ensure the design is as user-friendly as possible, we should not rely on color alone. The design should provide multiple indications of a feature's status.

3.4.3 Lay out

Within a design, the layout consists of how the content and the UI components are aligned, spaced, sized and emphasized. Elements within a design should align with one another to create a sense of unity, cohesion, and enhance the overall aesthetic and perceived stability of the design. It is possible to guide a user through the UI with the help of the alignment (Lidwell et al., 2003). In a great and effective way, in addition to being appealing, it is easier for the user to scan the layout and have a better overview of it.

When it comes to Western cultures, it is most common to read left-to-right and top-to-bottom. However, when it comes to scanning a page, there are a few more lay out patterns possible: the Gutenberg diagram, the z-pattern lay-out, f-pattern lay-out and focal point strategy, see figure 24. It is important to note that the Gutenberg, Z-pattern, and F-pattern strategies apply mainly in contexts lacking hierarchy or visual cues, such as plain text layouts.

On the other hand, this project brief does not work with plane text but works with visual elements. According to the strategy of focal points, individuals tend to initially focus on the most prominent element, which holds the greatest visual weight on the page. The eye then follows paths from this dominant element to other focal points within the layout. The sequence of attention is influenced by the relative weight of these focal points and any visual cues that guide the user to the next area of focus (Eldesouky, 2023).

Given that all touch screens lack a form of clear hierarchy and display visual components, the assumption was made that the strategy of focal points would dictate how operators perceive the screen. To test this assumption, a study was conducted with first-time users. Participants were asked to scan the default screen for ten seconds and locate the 'Crane On' button. The participants had to acknowledge when the 'Crane On' button was found and afterwards the participants were interviewed in a qualitative format to gather further insights.

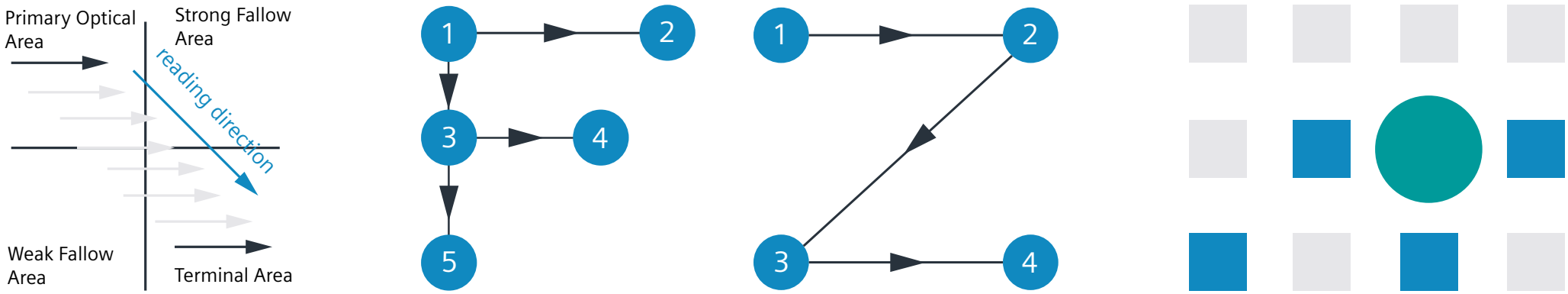


Image 24: The Gutenberg diagram, the f-pattern lay-out, z-pattern lay-out and focal point strategy

3.4.2.1 Eye tracking test RCOS

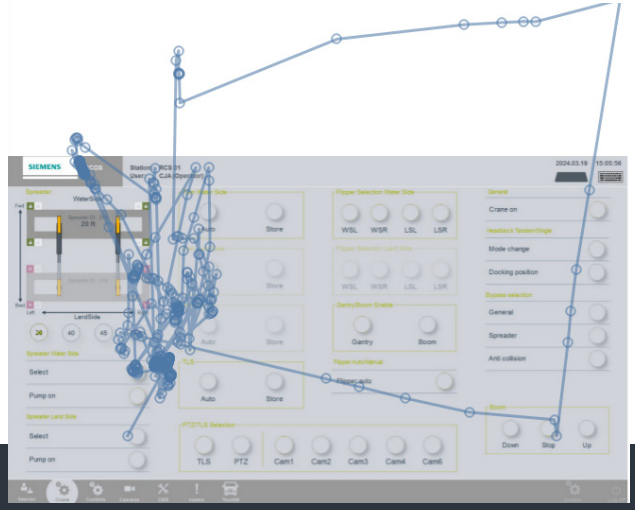
The test was conducted with six participants, and all detailed results can be found in Appendix K. The results are displayed in both eye tracking visualization and heatmaps. The goal of the eye tracking is to determine the precise movements of the eyes and determine at what precise time the participant finds the 'Crane ON' button. The heatmaps' purpose, see figure 25, is to find out where the majority of the participants' focus was during the 10 seconds. The following results came out the eye tracking tests:

Image 25: Heatmap old RCOS

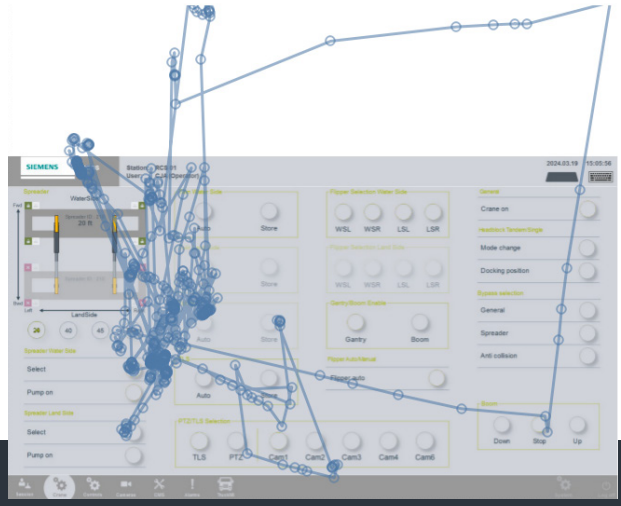
- 6/6 Of the participants found the 'Crane On' button within 10 seconds.
- 1 Participant used a pre-defined strategy of scanning the columns from top to bottom.
- 0 Participants found the 'Crane On' on first sight.
- 3/6 Participants noticed the visualization of the spreader first.
- The focus of 4 participants was mainly on the visualization of the spreaders.

In conclusion, most participants lacked a predefined strategy. However, after viewing the screen, they adopted a focal point strategy. Participants focused on the most prominent visual element, the spreader, and scanned around it. During the qualitive interview, participants reported confusion and uncertainty about where to begin due to the lack of alignment. In future iterations of the default layout, we will retest to see if the new arrangement and placement of the 'Crane On' button are logical and easily identifiable for first-time users. The complete set of results can be found in Appendix P.

First look of the participant



After 5 seconds



After 10 seconds

3.4.4 Identity

In terms of visual identity, it's important to consider both the user and the company. Users can have a persona within the software they feel connected to. A persona provides a fictional but detailed representation of the end user. Literature indicates that personas can enhance a better understanding of the target group among other advantages (Koreng & Krömker, 2021):

- Lead to more user-friendly design.
- Facilitate effective communication with the users.
- Lead to better design decisions.
- Increase focus of user needs.

Moreover, visual identity holds considerable importance in a company's recognition and communicating its core brand. This often aligns with the company's house style and influences how the company is presented by symbols, communication, and behavior. Using visual identification can help build employee identification with their company, making it a valuable organizational tool. Gregerson and Johanson (2018) state that a corporate visual identity can enhance employees' sense of connection to the company and enhance its reputation.

3.5 Flow

It is proposed that games, which are designed to generate positive affect, are the most effective when they enable a state of flow. Flow is a euphoric state of concentration and involvement, often claimed to be one of the most enjoyable and valuable experiences one can have. When the end-user is 'in the flow', they are happy, motivated and cognitively efficient. Moreover, an end-user in a flow state becomes totally absorbed in the activity and irrelevant thoughts and perception do not enter consciousness, which would enhance the concentration levels of the end-user.

It would be convenient for both the RCO and Siemens if it would be possible to create a flow when it comes to non-leisure software, such as RCOS. When describing flow, people tend to mention at least, and often all the following components (Johnson & Wiles, 2003):

- A task that can be completed,
- The ability to concentrate on the task
- A task with clear goals
- A task that provides immediate feedback
- Deep but effortless involvement
- A sense of control over one's actions
- Decreased concern for self during the task but a stronger sense of self after the task's completion
- An altered sense of time

Emphasizing these components more dominantly in future iterations could potentially create a flow in RCOS. However, consideration to the earlier identified threat should still be thought of: "How can we recreate the game flow, while keeping this a professional UI and not a game?"

RCOS is a serious system that handles heavy containers, which can cause significant damage and lead to high repair costs if not used correctly. Therefore, it is crucial to strike a balance between creating and engaging flow while preserving RCOS seriousness.

3.6 Nudging

As individuals increasingly make decisions on screens, such as those encountered on websites, mobile apps, games, and non-leisure software. When exposed to a vast amount of information, people tend to make deficient decisions. Digital nudging is an approach based on insights from behavioral economics that applies UI design elements to influence users' choices in the digital environment (Mirsch et al., 2017).

Users should not be restricted or held back, more assisted while respecting individual freedom of choice. According to Schneider and Graham (2017) nudges can be used in games to co-create flow and help the users throughout the game. There are some design guidelines on how to create a game flow in a software using nudges:

- Natural integration: Nudges should fit the game world, think of smoking and shaking in a gameplay when the character is tired.
- Comprehension: Nudges should be clear and conspicuous; two main components are relevant for this; clarity and conspicuity. An example of clarity would be a screen turning gray with excessive use. An example of conspicuity would be a nudge prominent enough that it could not be unnoticed.
- Multiple channels: Nudges should employ multiple feedback channels, feedback channels include visual, auditory, haptic or direct gameplay effects.
- Escalation: Nudges should escalate from low to high severity. To encourage players who ignore nudges, serious deviations should be met with harsher feedback.

The level for intervention differs from low to high, we conclude this to hugs (strong positive incentives) through nudges and shoves till eventually hugs (eliminating choices entirely). When deciding what level of intervention is desired, the next step is to decide in which way you are going to present the nudges. The perception of users is affected by selective factors of their attention. This means users are not always aware of every information or nudge presented to them (Jesse & Jannach, 2021). For this project brief, the following nudges show potential:

- Providing feedback: The audio set an RCO is wearing could introduce a new feedback system. However, safety hazards must be considered, ensuring that communication between the harbor and the RCO remains 100% clear to prevent dangerous misunderstandings.
- Order effects: Increase complexity of container relocation tasks when first order was successful, to minimize chance of boredom.
- Increase salience of incentives: Visible increase operator skill level
- Setting Default: People tend to stick with pre-set options, and carefully choosing these can guide individuals towards beneficial behaviors without restricting their freedom of choice.

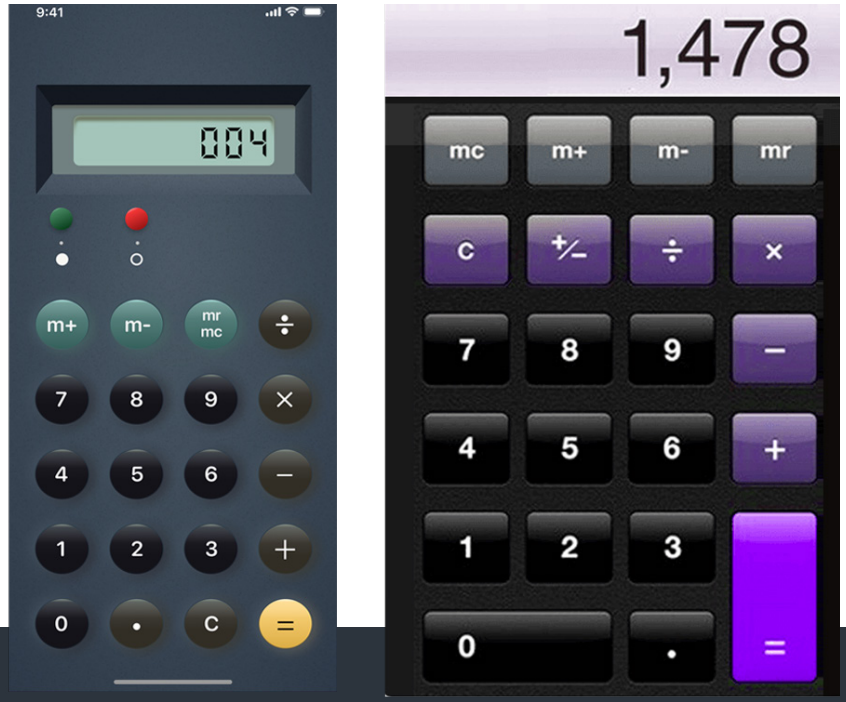
- **Framing:** Statements in the left Monitor or a feedback system are provided in a way that some options are presented in a positive and others are presented as a negative.
- **Spotlight effect:** Make the RCO believe they are getting more attention than they are.

3.7 Functionality of Icons

Over the last decade, the appearance of buttons and icons in digital interfaces has shifted significantly. The old approach, known as skeuomorphism, emphasized physicality and materiality by imitating real-life artifacts. This method was considered functional. Recently, however, the appearance of buttons shifted towards 'flat design', which focuses on aesthetic simplicity by avoiding faux materiality and three-dimensional effects like drop shadows, thereby reducing cognitive load. Despite this, flat design lacks the metaphors connecting icons to physical objects, resulting in fewer affordances and worse usability (Kolb & Oswald, 2014).

Burmistrov et al. (2015) found that flat interfaces require more time, impose a higher cognitive load, and are more error-prone compared to skeuomorphic interfaces. To blend the strengths of both skeuomorphism and flat design, skeuominimalism was created. This approach aims for simplicity without sacrificing usability. Urbano et al. (2020) investigated the performance and aesthetic perception of younger and older adults across the three design approaches. The study revealed that flat design often led to slower task completion and decreased accuracy, especially among older adults. Skeuominimalism did not demonstrate a clear performance advantage. Younger adults preferred skeuominimalism, while older adults preferred skeuomorphism.

A new trend, neumorphism, has emerged recently as a modern combination of skeuominimalism and flat design, focusing on shadows and highlights. Mejtoft et al. (2021) compared flat design with neumorphism in several cases during his tests. Their findings indicated that the oldest group showed a partial preference for flat design in one application but consistently favoured neumorphism prototypes in all other cases, though the difference was not significant. In conclusion, all styles except flat design show potential for improving UI user-friendliness. However, the three styles demonstrate inconsistency in delivering significant results, making it challenging to determine the best option. Further testing is needed to identify the most suitable design style for RCOS.



Skeuomorphims Skeuominimalism

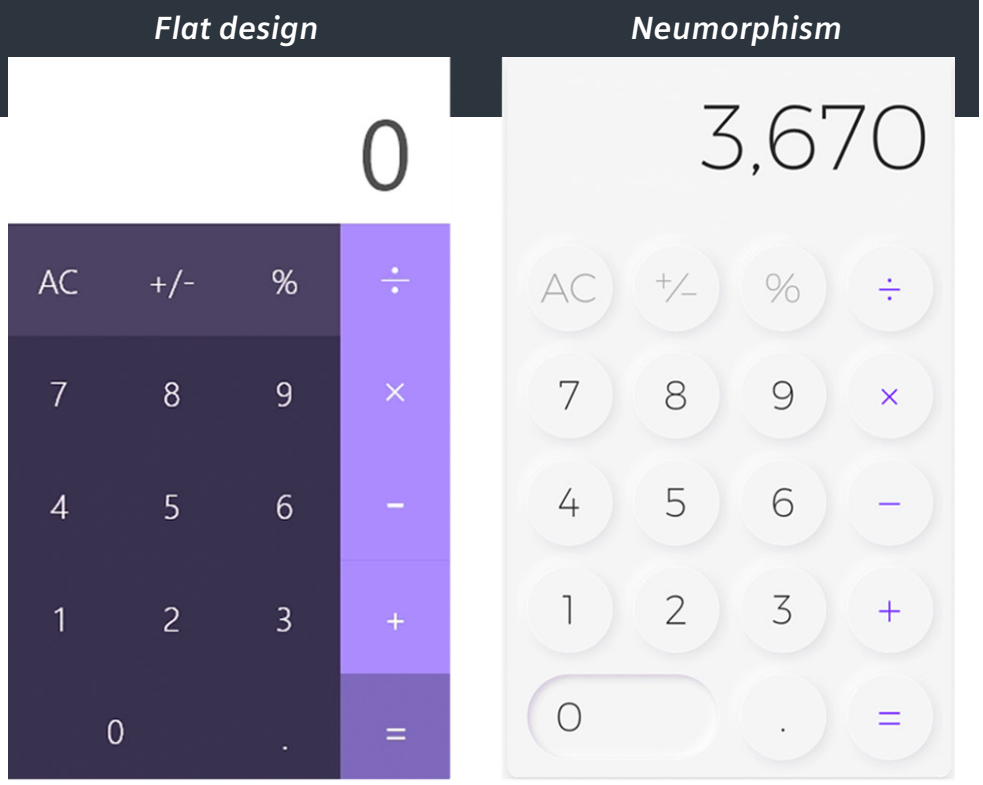


Image 26: Four UI styles

3.8 Dark Mode

As mentioned before, the RCO's have to work during the day and night and the system does not currently possess a dark mode which would cause less eye strain. The blue light from the hours from the screen during late hours affects the health of humans including eye strain and headaches. Furthermore, dark mode helped improve battery life in amole screen users (Shrestha et al., 2022). According to Eisfeld and Kristallovich (2020), Dark Mode significantly improves the user experience under certain circumstances, especially in dark environments.

Chapter 04.

List of Requirements and Wishes

This chapter presents the requirements and wishes stated by the stakeholders and collected from the literature. Requirements are non-negotiable elements that must be included the redesign, whereas wishes are features that stakeholders would like to see incorporated if possible.

4.1 List of requirements and wishes

Set up:

R. The Redesign of RCOS should work with the current set-up of three monitors and one touch screen.
W. The Redesign of RCOS should also function on additional monitors.
W. The Redesign of RCOS should not requere new movements of the joysticks.

UI:

R. The Redesign of RCOS should work with the current set-up of three monitors and one touch screen.
R. The UI should provide feedback about the latency of the current situation.
R. The UI should be able to work with multiple camera angles at the same time.
R. The UI should have a dark mode for usage during the night.
R. The UI should not solely rely on color to give indication about a features status.
R. There should be a clear distinction between interactive buttons and non-interactive buttons.
R. The UI should be able to be used by all nationalities, gender, and ages.
W. The UI should be able to use haptic feedback.
W. The UI should have a 'flow' when using it.
W. The UI should be in the new house style of Siemens.
W. The UI should contain a clear overview of which functionalities belong together.
W. The UI should use a layout that should make the RCO notice the relevant features first.
W. The UI should have a certain coherent look between all the monitors.

RCO:

R. The RCO should be an improvement compared to the current UI regarding user friendliness.
R. The RCO should be able to move fast around in the UI, with no more than 3 taps to move to a new screen.
R. The amount of cognitive information displayed to the RCO should be minimized regarding the relevance of the information.
R. The UI should guide the RCO effectively throughout the UI by using multiple nudges.
W. The RCO can work 1.5 hours straight without losing efficiency.
W. The RCO should always experience the feeling of being in control, while the UI functions as an assistant.

Safety & Privacy:

R. The redesign can be used without worrying about harm.
R. The redesign should not make the user feel uncomfortable.
R. The redesign should not invade someone's privacy.

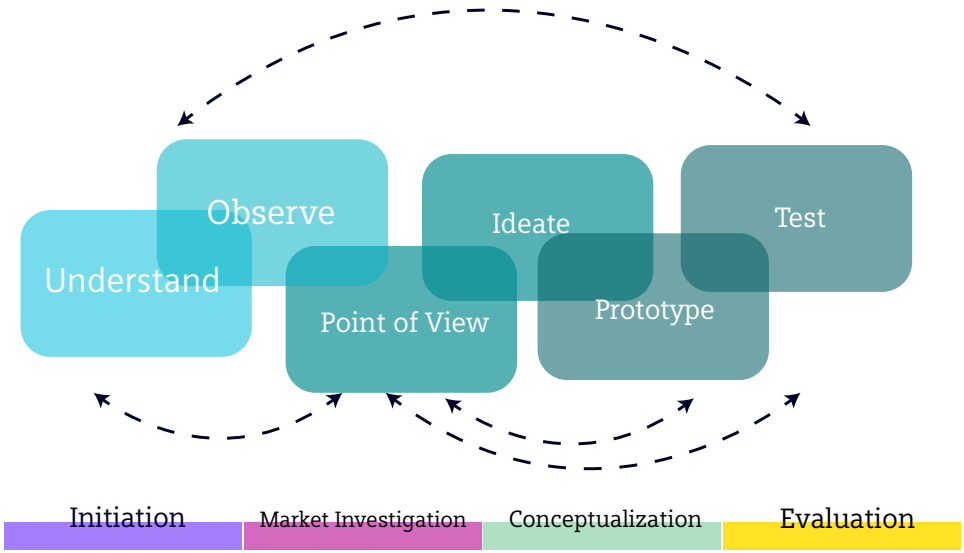
Chapter 05.

Method and Implementation

The following chapter contains a description of the project process, the methods supporting them, and the implementation. As we are designing for the experience and interaction between an individual and a user-interface, a design approach of human-centered design was chosen. For human-centered design we have to follow four main principles: be people-centered, find the right problem, think of everything as a system, and small and simple interventions (Vinney, 2023).

5.1 Design Process

In any human-centered design process, the primary focus should always be on the user, addressing their challenges and desires. According to Waidelich et al. (2018) the design thinking approach can differ in methods depending on how it is applied. As previously mentioned, the world of UI and UX was not initially familiar to me. Additionally, the RCOS system has a complex UX and UI with various iterations and interactions between elements that are not discussed in the manual. Building a solid understanding of the manuals, the interactions between elements, and recent iterations from Siemens was a lengthy process that required engaging with multiple stakeholders. For this reason, the two initial stages of the process were crucial. The understanding stage involved gaining better insights through literature research on UI and UX and reviewing the manuals. The observation stage focused on acquiring knowledge about the interactions and practical aspects of RCOS that cannot be learned from the manuals alone.



Graph 6: The design thinking approach by Meine et al. (2011)

The design thinking approach by Meine et al. (2011) appeared to be the most suitable for my process, as it emphasizes the necessary understanding and observational phases, as illustrated in graph FIXME. This design thinking process is a highly interactive and incremental process, driven by people with different backgrounds and experiences. The collection of information in the stages of Understand, Observe, and Point of view form a basis for envisioning and evaluating possible solutions in Ideate, Prototype and Test. The process is not linear but involves moving back and forth through the different stages.

5.2 Project Planning

To manage all phases of the chosen design thinking approach and maintain an overview throughout the project, a Gantt chart was created. The six phases of the design thinking process are organized into four sections in the Gantt chart: initiation, market investigation, conceptualization, and evaluation. Each section includes deadlines and milestones to ensure clear progress tracking and provide a clear overview, as shown in Appendix L.

5.3 Understanding

The initial phase of this project focused on establishing a framework for methods and literature relevant to UI and UX design projects. This phase encompasses most of Chapter 2: Context Analysis, Chapter 3: Theoretical Literature on UI & UX, and Chapter 4: List of Requirements and Wishes. These sections cover an exploration of all iterations of the RCOS UI, an analysis of their advantages and disadvantages, user interviews, and literature research.

5.4 Observe

To gain insights about the entire project and its UI, it was essential to interact and observe various stakeholders to create a complete scenario. Given my initial lack of knowledge about the UI of RCOS, a roadmap was set up to fit my learning curve. The steps in the roadmap were as follows:

Step 1: Observe RCOS engineers using the system to understand its general operation.

Fortunately, at Siemens, close collaboration with engineers was possible, which allowed for detailed observations of their interactions with the RCOS' UI. Multiple sessions were recorded in video and/or audio formats to capture the flow and task hierarchy. The information was processed in Miro and is detailed in Appendix K. Key takeaways from this step include:

- The 'Crane On' button is the most crucial on the screen as it initiates the entire process.
- Overlays on the middle screen disappear when no longer relevant, while information in the lower bar remains fixed.
- The camera needs to be more zoomed out to provide the RCO with a broader perspective, reducing safety hazards such as unnoticed pedestrians.
- The camera automatically switches views based on the crane's movements.
- Different types of cranes may require different UI designs.

Step 2: Observe first-time users interacting with RCO to identify possible confusing elements, see image 26.

The first-time users were Siemens interns who had not previously interacted with RCOS. Afterwards , they were interviewed to summarize the main take aways. Key takeaways from this step include:

- The jargon for a first-time user is unclear.
- There are no icons to help you guide through the process.
- The joysticks works in an unexpected way. (Outside the project scope)
- The camera automatically switches views based on the crane's movements.
- The 2D visualization accurately shows the locations of the hoists, allowing the RCO to estimate the amount of power needed to reach a specific location.

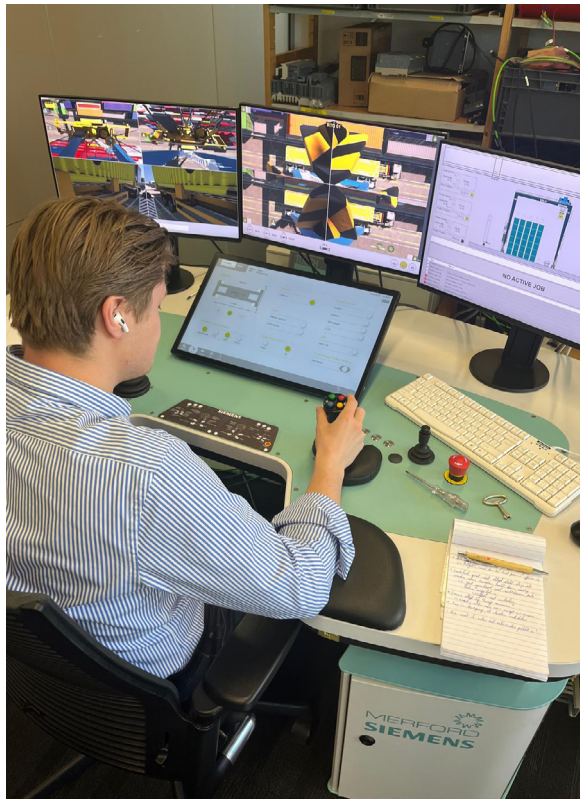


Image 27: Observations of a first time user

Step 3: Observe Harbor Rotterdam employees using RCOS to understand real-life usage by the target group.

The RCO's at Harbor Rotterdam provide invaluable insights as they interact with the UI ay and night. Harbor Rotterdam is Siemens' only client using a distinct UI, occasionally complicating to understand their actions. Unfortunately, it was not allowed to take pictures this time on site. Both managers and RCO were interviewed and/or observed. All raw notes about the visit can be found in Appendix M. The main takeaways from this step were:

- All RCO's used the icons correctly, the functionality behind the icons was remembered quickly. However, the size of the icons was in some cases too small. The flippers located at the side of the spreader visualization were often mistapped.
- The RCO's had a positive experience with the interactive visualization of the spreader.
- The RCO's are experiencing extreme eye fatigue during night hours. The RCO room uses ambient lighting, but the transition to the cafeteria lighting is intense for the RCO's.
- When it rains, the wet containers reflect the crane lights heavily. This reflection can be so bright that the RCOs disable the crane lights, resulting in decreased safety.
- The alarm alerts should be displayed more prominently. When an RCO is focused on the middle screen while moving a container, an alert or alarm could be overlooked.

Step 4: Interact with RCOs myself as a first-time user to develop a personal feel for the system and identify any aspects that stand out or cause issues. The main takeaways from this experience were:

- The landed overlay and twist lock overlay are crucial for each container relocation. They are positioned in the corners of the middle monitor.
- The left monitor is not used as frequently as the middle and right monitors.
- The trolley speed is the element that changes most frequently.
- Due to the system's delay, the power versus drive feature is crucial for getting a proper feel for the system.

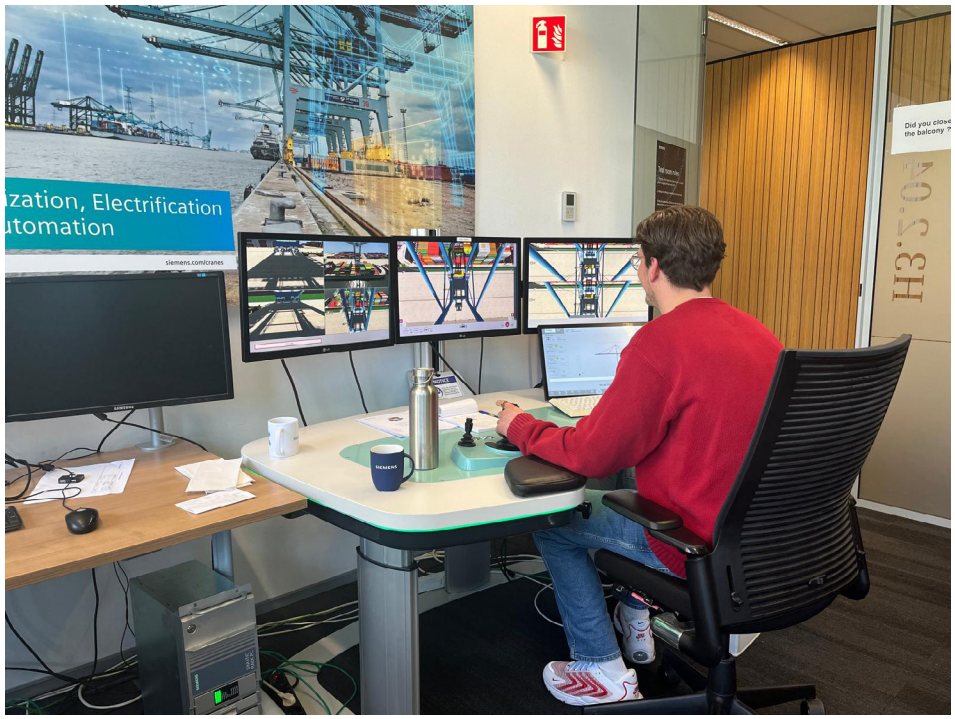


Image 28: Conducting step 3

5.4 Point of View

The goal of the Point of view stage is to define the problem areas and user's needs. For a multi-user software system, such as RCOS, this implies frequently validating insights and assumptions with stakeholders. Fortunately, it's possible to present design and prototypes for validation to multiple stakeholders inside Siemens, in the form of presentation in front of an audience or a quick one to one meeting. After each test or observation, the main takeaways are discussed with the engineers of the Crane department to receive feedback and iterate the observations. In that way, we can make sure the iterations are going in the right direction and remain aligned with Siemens' desires.

Image 29: Point of view meeting with entire crane department

Chapter 06.
Ideation

This section covers the exploration and ideation phase within the design thinking process. It outlines various methods for generating ideas and explains how these methods were applied to the project.

6.1 Generate Buttons

A good starting point for the ideation phase is establishing the overall style of the UI. Since widgets largely determine the UI's style, we experimented with widgets, specifically the button, in four different styles. The most crucial quality of a button is providing the user with a clear indication of its state, whether disabled or enabled. A common way to indicate this is through color. However, a well-designed button should communicate more than just through color. Additional methods for communicating often include using toggles or text.

The style of neumorphism introduces a new way to indicate a button's state without the sole use colors, using shadows and highlights to give the impression of being pressed, mimicking a real button.

At this stage, we focused mainly on the visual presentation and the functionality of the ON/OFF feature of a button. We created interactive buttons in Adobe XD and presented them to Siemens stakeholders for feedback. The main takeaways from these low-fi prototyping were:

- It feels logical to see the button move to the right side when enabled.
- Flat design is aesthetically pleasing but not functional.
- ON/OFF text is preferred in a toggle rather than the name of the function.
- An extra light above or next to the button can provide a quick indication of its state.
- Skeuomorphic buttons were seen as outdated and overstimulating by most participants.

After more literature research, feedback from both Siemens, and the coaches, the decision was made to proceed the ideation phase without the flat design. However, a new style, a variation of neumorphism will be introduced in the further ideation process, which will be called neu-minimalism.

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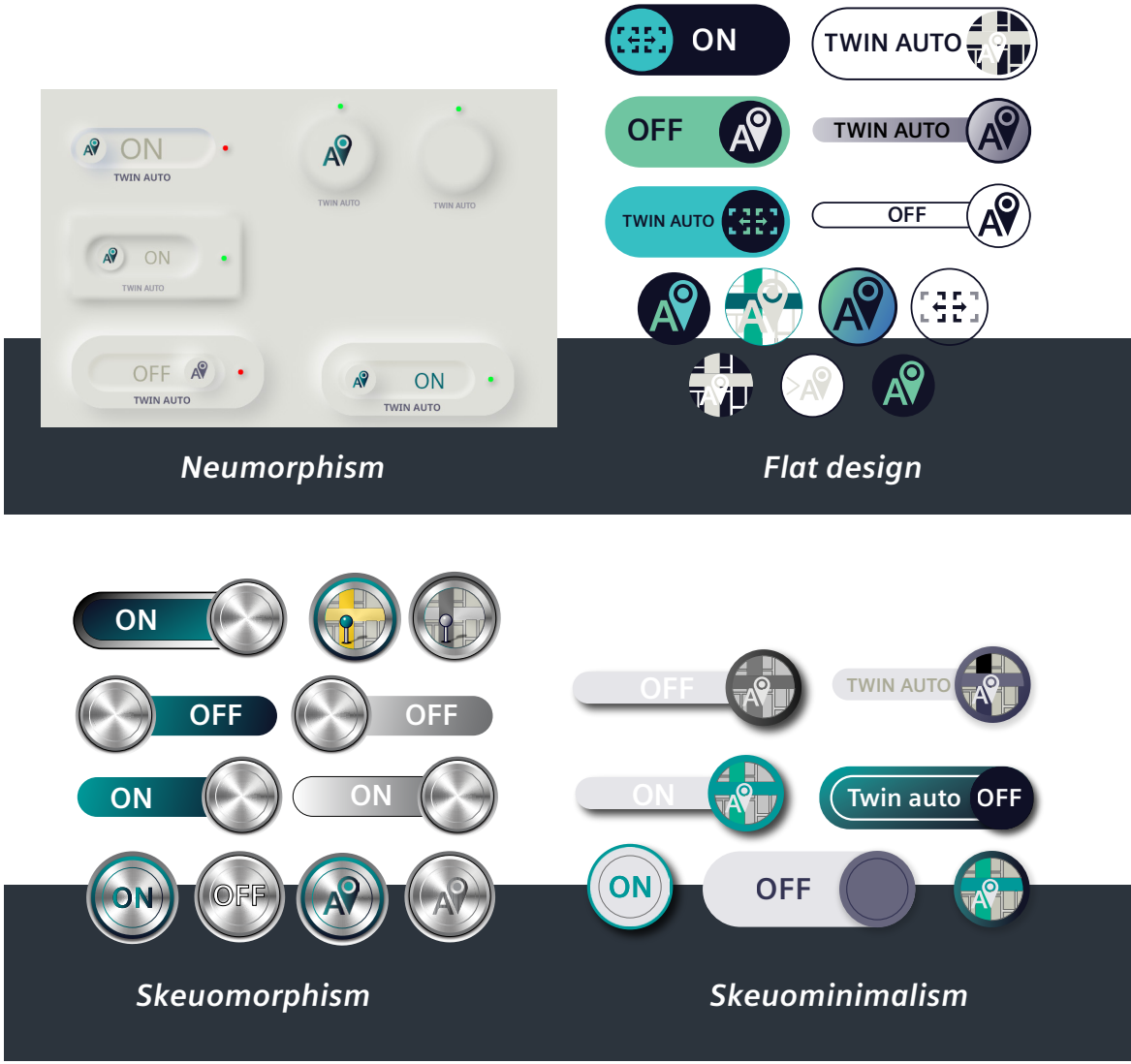


Image 30: Buttons created in four UI styles

6.2 Generate Icons

Icons are pictorial representations of objects, with their level of detail varying based on the UI style. When an action is taken on an icon, it reflects this change by updating its state. It was unnecessary to create icons for the skeuomorphism style, as this style uses uniform buttons that do not convey additional information through icons. For the three remaining redesigns, we adhered to the following guidelines from AMX (2012):

- Use an icon to represent an object.
- Use an icon to reinforce important information.
- Use an icon to provide a visual anchor, helping users quickly navigate through a task.

The goal of incorporating icons in the RCOS redesign was to enhance usability while adhering the design principles of predictability, familiarity, and clarity. During the redesign, it became clear that first-time users are often unfamiliar with crane industry jargon, such as terms like spreader, gantry, boom, and PTZ. Therefore, the redesign needed to strike a balance between being informative without being overstimulating, while also maintaining aesthetic appeal. The main takeaways from the low-fi prototyping were as follows:

Skeuomorphism:

No icon

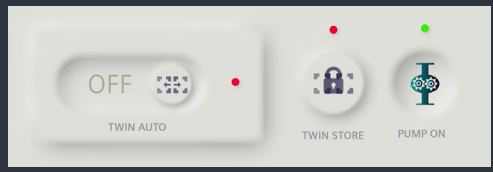
Skeuominimalism:

Most detailed representation of an object or metaphor

Main takeaways:
- Gradient is too intense.
- Overall appearance is unattractive.
- Icons inside the buttons are too small to read clearly.
- The icon's representation is not always clear.

Neumorphism:

Simplistic representation of an object or metaphor



Main takeaways:
+ Participants found these icons most helpful.
- Green and purple were hard to distinguish.
+ Clear indication of overall status due to the pushed-in effect.
+ The buttons are less overstimulating because the pictograms within the icons are less dominant.
+/- Gradients look good individually but can appear crowded when used together.

Neu-minimalism

Simple icons with universal meanings or no icon

Main takeaways:

+ Participants found this consistent and aesthetically pleasing.
- A lack of information provided by the icons could be problematic for first time users.
+ Particpants found this the best overall look.

6.3 Generating Layout

The initial redesigns of the layout were based on one of the original RCOS layout. Since the layout can be customized for each client, creating a single fixed layout is not feasible. The goal is to optimize the arrangement of buttons and visual elements to allow for easy modifications in future iterations. AI was used to help create various layout options and provide inspiration, see Appendix R. However, the resulting screens were insufficient and did not significantly contribute to the redesign process.

6.3.1. Optimize space and combining functions

The current layout features a non-interactive spreader that occupies a big portion of the screen. To better mimic the real-life situation situation and save space, flipper buttons were implemented at the actual location of the spreader. The selection button was placed on the corresponding spreader to provide a clearer navigation of the operator, see image 31.

It became clear that the alignment in the current RCOS causes confusion and fails to clearly connect related elements. The redesign focuses on creating a clear alignment of functions for the waterside and landside spreader. The UI evolved from having 2 elements, twin autos and spreaders, to having 5 elements in the same area, see images 32 and 33.

By making the spreader visualization larger and interactive, it gained more weight in the visual hierarchy. Employing a focal point strategy, which guides the user's eye from the spreader to other critical elements. Thus, the most important button must be positioned near the spreader. For that reason, the Crane on button is placed next to the waterside spreader, see image 34. Furthermore, user testing showed that the Flipper auto has a natural correlation with the flippers on the spreaders and flipper auto feels natural next to the spreaders.

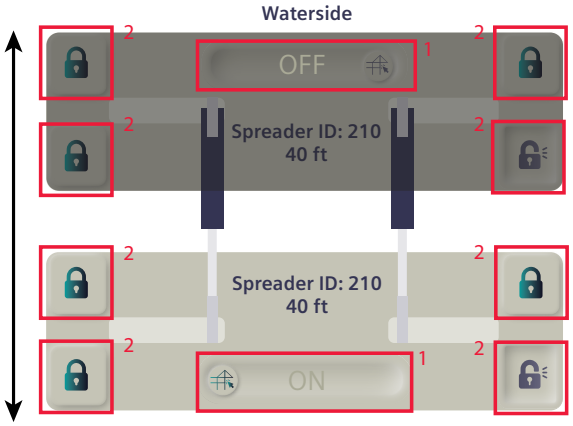


Image 31: Spreader optimization

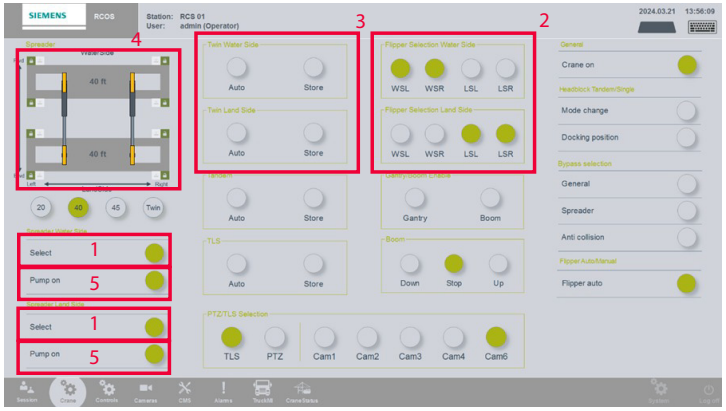


Image 32: Recognizing areas of improvement

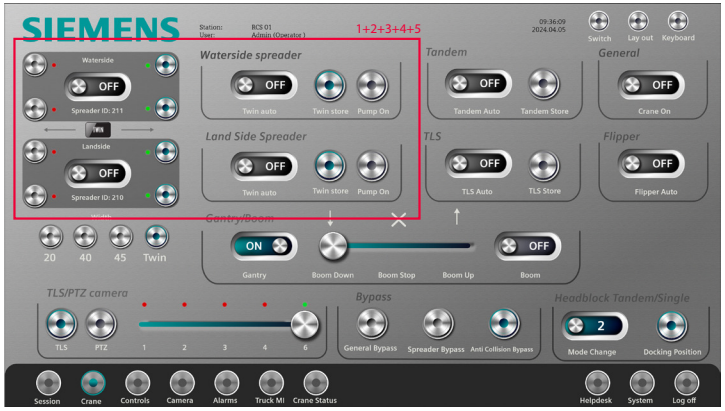


Image 33: Result of combining the elements

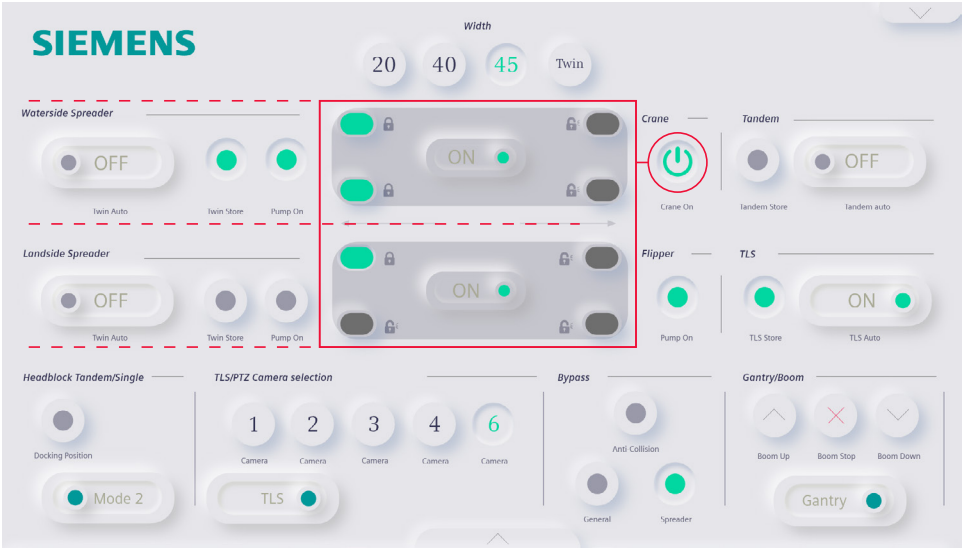
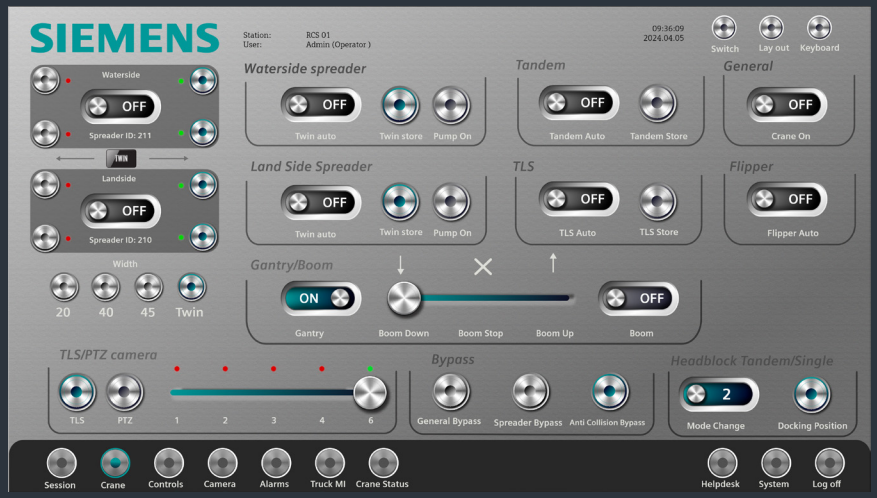


Image 34: Implementation of focal point strategy in layout

6.4 Generating Redesign Default Screen

The default screen, being the most important screen which the RCO interacts most frequently with, served as a great starting screen for the redesigns of RCOS. The screen was developed through brainstorming sessions with Industrial Design students and separate sessions with Siemens engineers. The initial three redesigns shared similarities in alignment, grouping, and proximity. For the final redesign, we implemented a focal point strategy to enhance task hierarchy and the alignment of functionality related buttons. Once each style's final redesign was completed, it was made interactive in Adobe XD. Each redesign got its own compatibility between elements to evaluate UX. The user interfaces were tested for user-friendliness, the ability to maintain high concentration, aesthetics, and a sense of control. The test plan for this high-fi test can be found in Appendix N. The main takeaways from the high-fi test are as followed:



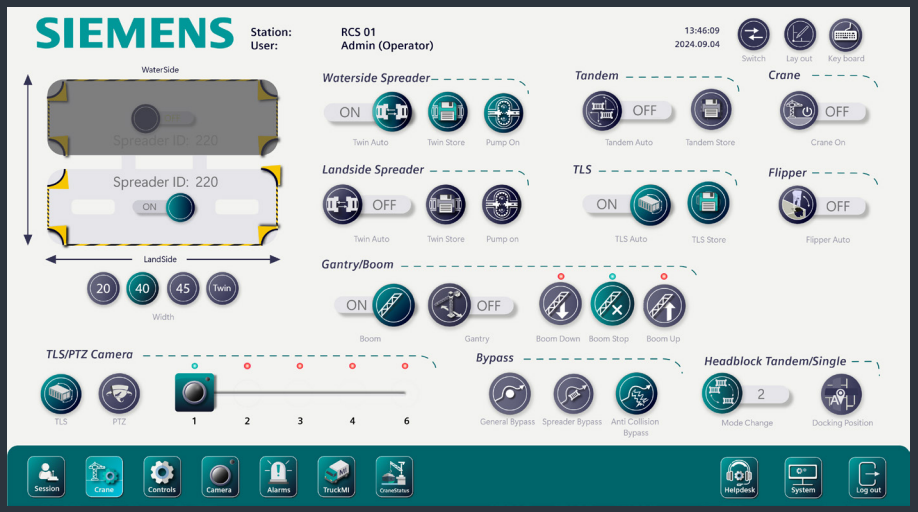
Main takeaways from the skeumorphism screen:

+ Participants recognized it quickly.
- It looks outdated and can be overstimulating due to the intense buttons.
+ The skeuomorphism screen ranked highest for providing a sense of control.
- Flippers are unclear, feels unnatural.
- Icons lacked clear functionality, leading participants to press buttons at random.
- Scored lowest in both high concentration and aesthetics rankings.

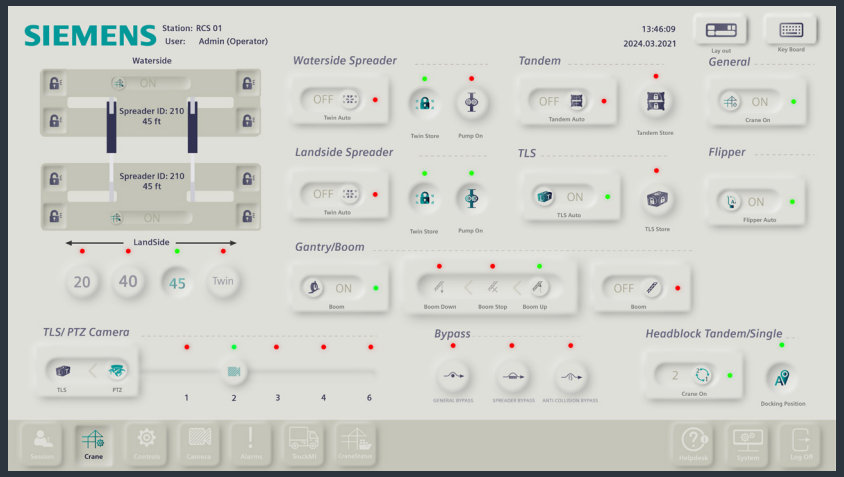
Goal:
To resemble an old DJ board, it aimed to provide RCO's with familiarity, providing a sense of control based on their previous

Main takeaways from the skeuominimalism screen:

+/- The information provided was appreciated. However, some icons were not interpreted as intended.
- Scored low for feeling in control and high concentration
Participants found the color use of white and green behind a white background ugly.
+ Mimicking the flippers was preferred by the participants.
- Titles were hard to read due to the low luminance contrast with the background (Kelly & Gregory, 2017).



Goal:
Provide participants with comprehensive information through icons, allowing them to predict each icon's functionality.



Main takeaways from the neumorphism screen:

+ Participants ranked this style first for user-friendly, with clear indications of when a button was disabled or enabled.
+/- Icons were clear, though some were too small.
+ This style ranked second in high concentration, aesthetics, and feeling in control.
+/- Half the participants liked the light, while the other half found it unnecessary.

Goal:
Experiment with the Figure/Ground Gestalt principle to see if icons can effectively convey a sense of foreground and background.

Main takeaways from the neu-minimalism screen:

+ Preference to this lay out, due to its calmness.
- Might be hard with in the beginning to understand
+ Ranked first in aesthetics and maintaining a high concentration.
+ Participants highly favored the comprehensibility of the Gantry/Boom function in this form.

Goal:
Explore a new layout with different interaction between elements, maintaining a soft UI while minimizing the displayed information.

Based on the high-fi test results, the optimal direction combines elements of neumorphism and neu-minimalism from the soft UI. The layout from the neu-minimalism was highly favoured and the use of simplistic icons of neumorphism. Moreover, there were several main takeaways that applied to all styles:

- Dark mode is preferred by everyone
- Participants unanimously desire the ability to hide the menu bar.
- Replace Waterside spreader title above twins' settings.
- The floppy disk icon effectively conveyed the "store" functionality.
- Users preferred icon removal over resizing.

6.5 Iterating Layout + additional features

Following the first high-fi test and the selection of the preferred design style, the next steps involved iterative testing and refinement of the layout, along with the addition of new features.

A total of three different lay outs were tested with Siemens engineers to determine the most convenient lay out and how effectively the user experience differed across interactions with various elements. The high-fi test started with an open discussion, where previous redesigns were reviewed to pinpoint any notable aspects, both positive and negative. Engineers expressed a preference for the icons, though no other significant takeaways were noted. To ensure nothing was missed, all observations were recorded in video and/or audio formats, the test plan can be Appendix O.

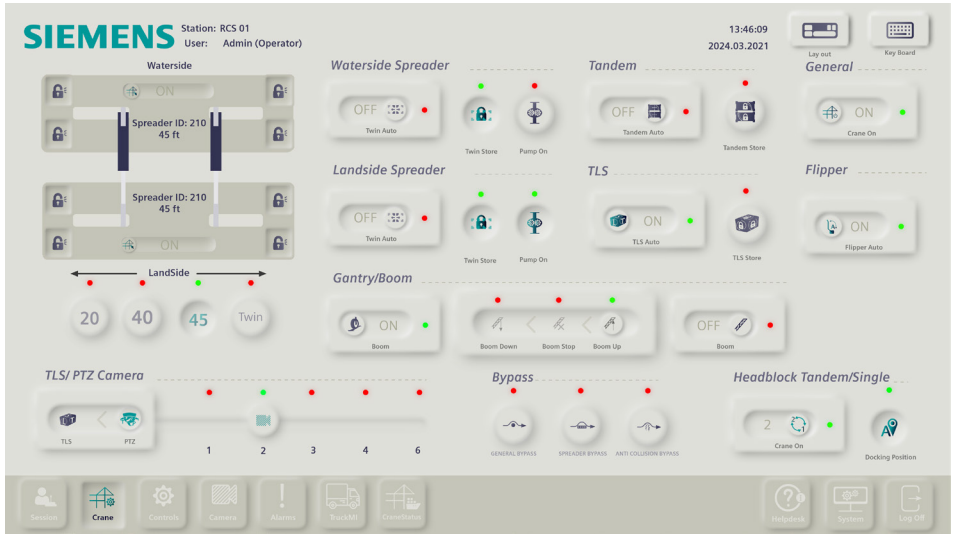


Image 34: Lay out 1: Neumorphism light modus

The first test used the old neumorphism layout, selected for its similarity to the original design by Siemens engineers. This was tested again to discuss why the engineers might prefer a layout similar to their original. The main takeaways from their feedback are:

- The lights are used incorrectly. Red does not indicate disabled status; it signifies an error. Using red in this context will make the RCO think all the functions are malfunctioning.
- The Layout button is misused. It is intended to provide extra information about the hardware joystick.
- Do not use gradients in your icons, as it makes it difficult to distinguish between purple and green.
- Do not use locks to indicate the flippers. In previous designs, locks have been used to represent twist locks. Additionally, there is no clear "landed" icon, which is crucial for relocating the containers.

The second redesign introduced a new layout in dark mode. The UI redesign mimics the flippers in the neumorphism style. The aim of this layout was to experiment with different interactions of elements. The main takeaways from their feedback were:

- Sliders are not favored by the engineers, as the system prefers working with HIGH and LOW alerts from the buttons.
- Everyone preferred the dark mode, with a clear indication for the right corner to switch between light and dark modes.
- The flippers are not accurately mimicked; an additional function should indicate their position (up or down) and whether they are selected or not.
- The icons for Tandem and TLS are not clear enough for the user.

Image 34: Lay out 2: Neumorphism dark mode

Image 35: Lay out 3: Neu-minimalism light mode

During the third test, the neu-minimalism screen was explored, introducing Siemens engineers to new forms of configurability. Icons could be resized, menu bars were movable off-screen, arrows indicated the spreader's width, and the dark mode button was positioned next to the Siemens logo. The main takeaways from this test were:

- Adjusting the size of icons is not favored by the RCO during operational use of the RCOS but could be valuable for their training program.
- The preferred menu option is the push menu, with the ability to pin it for the RCO's personal preference.
- While the arrows provide useful feedback, engineers suggested they could be more effective if they changed width based on the speed of real spreaders, providing RCOs with real-life feedback.
- The moon icon next to the Siemens logo was not favored.

The final test involved the dark mode version of the previous layout. In this version, we added a help desk and used the floppy disk icon for all 'store' features. The help desk aims to enhance the currently missing recovery aspect of the UI. The main takeaways from this final test were:

- The crane button should have extra functionality, similar to the arrows. It should only turn green when feedback is received from the system. The crane-on button should flash until the crane signals that it is on.
- The help desk function is favored by everyone and should be applied to all features.
- When the crane is on, the waterside settings should automatically be turned on as well.

The conclusion of this test with the Siemens engineers was to proceed with the neu-minimalism layout from the third and fourth redesigns. A limitation so far is that testing has only been conducted with Siemens engineers and first-time users. The next steps are implementing the previously mentioned main takeaways in the RCOS UI and they will be further discussed in the next chapters.

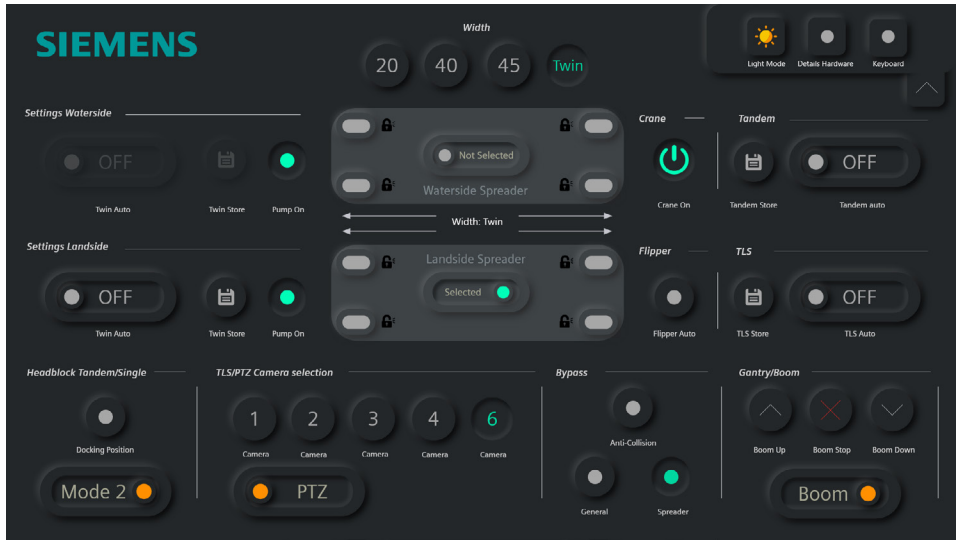


Image 36: Lay out 3: Neu-minimalism dark Mode

6.5.1 Eye tracking final layout

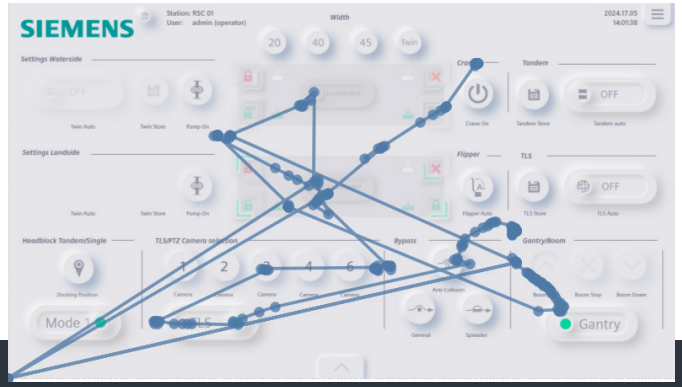
To ensure the focal point strategy worked as intended in the new layout, we conducted another eye tracking test with 6 first time users for the redesign of the UI. The users were once again asked to search for the 'Crane on' button within 10 seconds. Afterwards, there was a follow up with questions and a discussion about their reasoning for focusing on certain elements. The main takeaways drawn from this final lay out are:

Image 37: Heatmap redesign RCOS

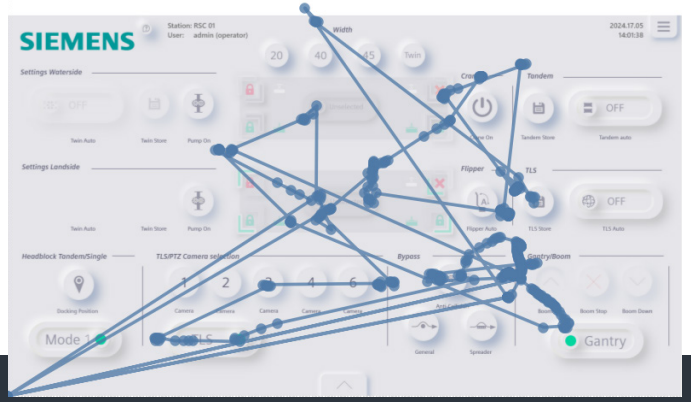
- 6/6 of the participants found the 'Crane on' button within 10 seconds
- 4/6 of the participants saw the 'Crane on' button on first sight.
- Multiple participants stated that the green buttons lower located caused of distraction.
- 5/6 of the heatmaps show the majority of the focus was on the middle part of the screen.
- 6/6 noticed the visualization of the spreader first.

In conclusion, the results of the eye tracking test were promising. All participants first focused on the visualization of the spreader, supporting the focal point strategy, and the majority of the participants even found the 'Crane On' button at first sight. From these results, we conclude that the 'Crane On' button is correctly positioned. However, it is notable that multiple participants diverted their attention from the 'Crane On' button to the lower part of the screen. When asked afterwards, they all stated that this distraction was caused by the bright green light located on the lower part of the screen. A further iteration would be to make the color the same as the other icons. The complete set of results can be found in Appendix Q.

First look of the participant



After 5 seconds



After 10 seconds

6.6 Generating additional features

One of the objectives of this project was to develop additional features to better guide users through the UI and provide additional help, thereby reducing cognitive burden. During the test at Siemens and the faculty of Industrial Design, various features were evaluated to assess their desirability and their potential to improve efficiency and effectiveness of the RCOS. Reflecting on the SWOT analysis and the identified opportunities, the following additional features were found to have the most significant impact for RCOS.

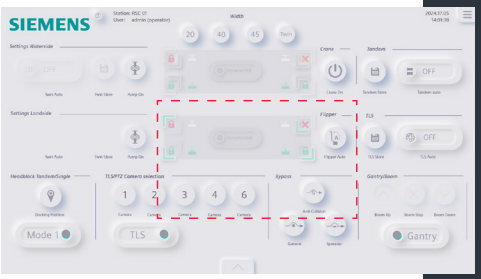
6.6.1 Optimizing compatibility by visibility

The RCOS UI will display only the necessary information on the screen as needed. When a feature is unavailable, its visibility will decrease or it will completely disappear. Additionally, features linked to each other will automatically activate or deactivate accordingly. This approach clarifies which functions are available and which are not. This addition to the UI aims to enhance the principles of Focus and Emphasis, as well as Compatibility. The following optimizations in the default screen are implemented:

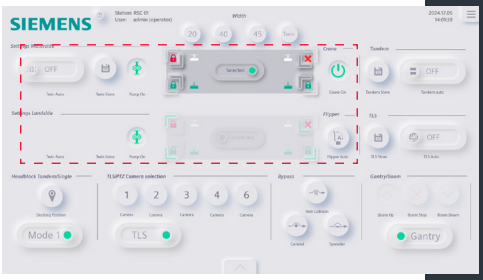
The lower and hamburger menus can both be pushed off the screen. Both menus can also be pinned, allowing operators to keep them visible for quicker navigation if desired.

Image 38: All features regarding optimizing compatibility by visibility

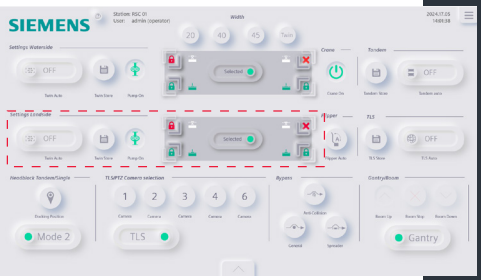
When the crane is disabled, both the Waterside and Landside spreaders have decreased visibility. When the crane is enabled, only the Waterside spreader becomes fully visible.



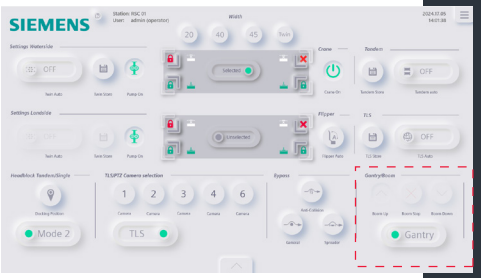
When the crane is in Mode 1, there is no second spreader connected to the real-life crane. Consequently, all functionalities of the land side spreader, except for the "Pump on" feature, completely disappear.



When the UI is set to mode 2, the operator can select the Landside spreader. When the landside spreader is selected, it will automatically show the corresponding functionalities.



One of the following movements can be selected: Boom or Gantry. Boom movements are controlled via the Boom section, while Gantry movements are controlled by joysticks. If Gantry is selected, the Boom buttons' visibility decreases.



6.6.2 Dark Mode

By testing the dark mode with a filter of protanopia and deuteranopia, we can get an indication of how it would be perceived with the conditions. Most colors will be perceived in either a yellow or blue hue. It is important to make the comparison between ON/OFF states to see if the difference is significant enough. Employees at Harbor Rotterdam reported having significant eye fatigue during night shifts using the UI. Although they use the night light feature at their desk stations, it is not sufficient. Both first-time users and Siemens Engineers, during testing, preferred having a Dark mode option. Some participants even suggested that they would use the Dark mode during the day. When designing a dark Mode, the UI must remain accessible to users with colorblindness. Fortunately, individuals with colorblindness can still determine the button's state by observing whether it appears "pushed in" or not. This remains one of the strengths of this redesign, both for people with and without color blindness.

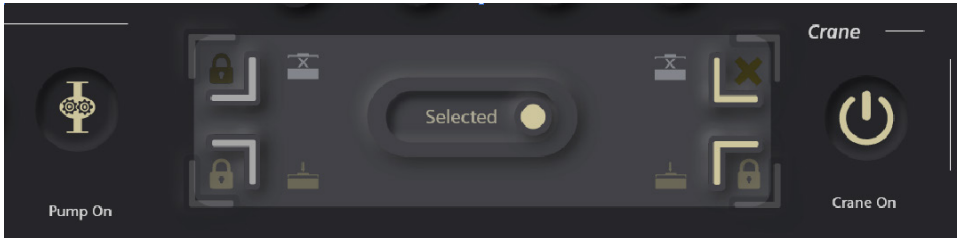


Image 40: Dark mode with a protanopia filter

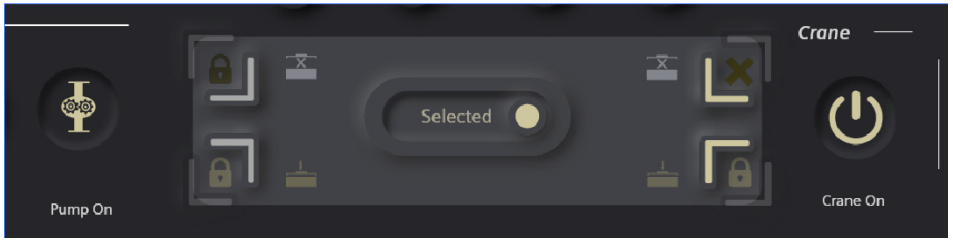


Image 41: Dark mode with a deuteranopia filter

6.6.3 Help Desk

The help desk feature emerged as one of the most favoured additional tools among Siemens engineers. Its primary objective is to enhance the UI principles of configurability, simplicity, and recovery. A RCO must undergo training and study a manual to learn about covering jargon, functionalities, icons, and color coding. However, RCO's still contacts Siemens frequently for functionality-related questions. Harbor Rotterdam does possess a helpdesk, apparently not working effectively enough. The current Help desk feature needs to be effective enough to prevent the same situation.

The help desk is accessible above the Siemens logo, which is consistently displayed on every screen. By tapping the question mark, users will enter the help desk interface, see image 42. To obtain more information about a feature, users can tap the title, which will display additional explanations. Users can exit this information by tapping anywhere on the screen, with a highlight at the top indicating how to exit the help desk, see image 43.

Image 42: Step 1 of the help desk feature

Image 43: Step 2 of the help desk feature

Image 44: Remove and add button in the hamburger menu

6.6.4 Add or Remove Icons

During the tests, participants were evenly split in their preferences for simplistic icons versus no icons. Both first-time users and Siemens engineers believed that beginner RCO's would prefer icons to help guide them more effectively through the process. However, as RCO's will gain more experience, they will become familiar with the placement and functionality of each button, making the icons unnecessary over time.

At that point, the RCO's can choose to remove the icons and work with only the "Crane On" button visible. If they find that using icons is still more effective, they can easily add the icons back to the UI with a simple tap in the hamburger menu.

6.7 Persona

During the literature research, multiple options for improving the current RCOS were explored. The following options showed the most potential when integrated into a persona feature:

- Identity
- A task with clear goals
- Nudging: A task with immediate feedback in the form of framing
- Nudging: Order effect
- Nudging: Increase salience of incentives by increasing the green circle
- UI Principle: Forgiveness
- UI Principle: Recovery

The persona can be fully personalized to resemble the RCO and display the operator's skill level. Since skill level and idle time are already measured, tasks can be tailored to provide clear goals based on the RCO's proficiency. This could be combined with an 'order effect' nudge, increasing the difficulty of tasks when the operator is doing well. Feedback during this entire operation can be provided by the persona in the form of framing to nudge to operator even more. This approach can enhance the UI principles of recovery and forgiveness, and ideally, create a sense of flow. The most logical placement of the persona feature would be on the Crane status screen, which has sufficient space to incorporate the persona and can be displayed in one of two screens.

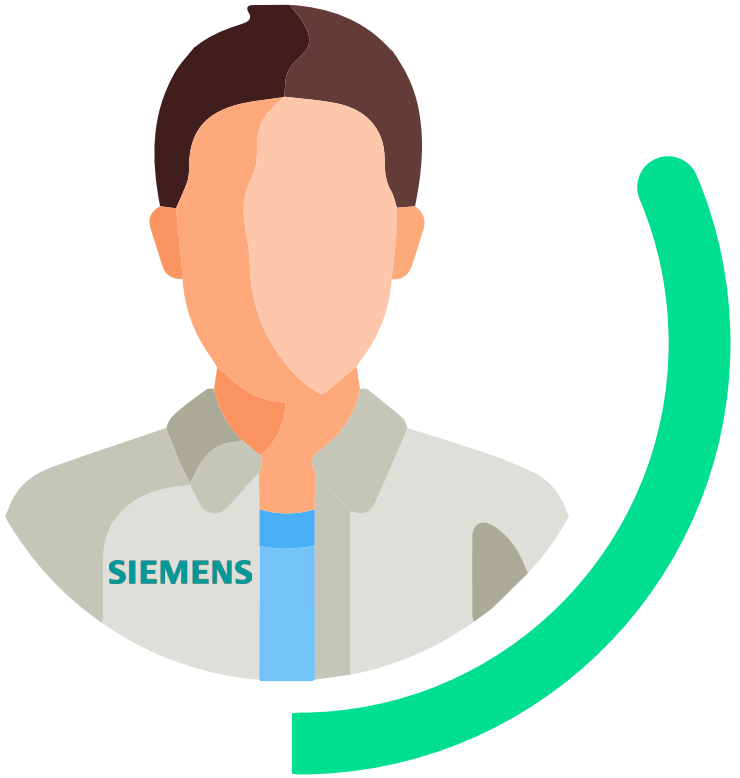


Image 43: Persona feature

6.8 Generating redesign screens

The majority of this project focused on the default screen. In this chapter, the other screens within the project scope will be discussed. The predefined opportunities from the SWOT analysis and gathered research will be implemented as additional features for these remaining screens. To gather feedback on these redesigns, a final user test was conducted with the engineers of the Crane department.

6.8.1. Redesign Login

The first screen the RCO encounters is the Login screen. The goal of this redesign is to ensure consistency in both information display and visual design. The previous design used multiple styles for displaying icons on a single screen, such as flat designs and various hues.

In contrast, the new design features consistent interactive buttons in a uniform form. The menu bar includes a keyboard feature and OK button to confirm the RCO's login. The new feature introduced is the 'forgot password' element, where the operator could recover the password if they completely forgot it. To enter text, the RCO taps the text area, which contains embedded instructions. The following take aways were drawn from the final user test:

- Add a language selection button in the hamburger menu to prepare for international use.
- All participants appreciated the updated appearance, describing it as modern and welcoming.
- Include the RCOS name in the title.
- Add a "Change Password" button in addition to the "Forgot Password" button.
- Display the current date, name, and copyright icon.

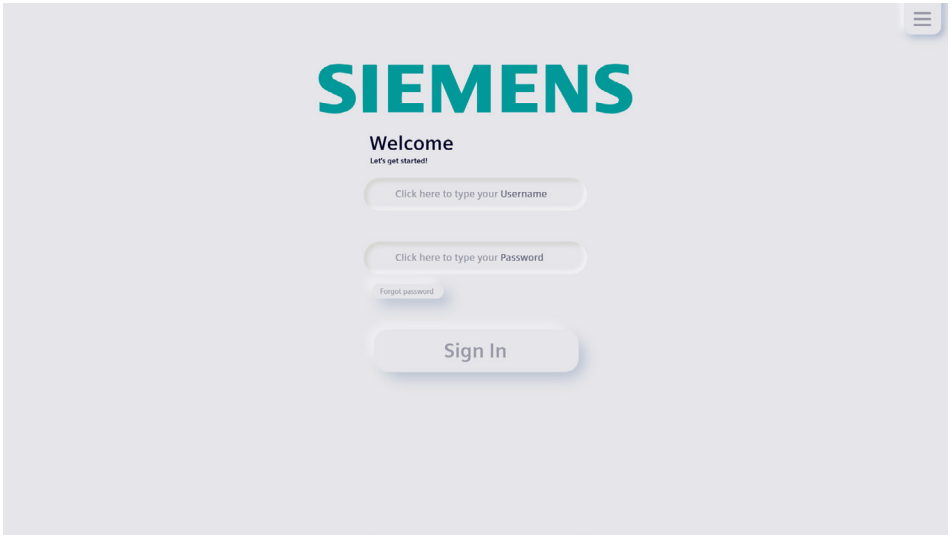


Image 43: Redesign loginscreen

6.8.2. Redesign Role selection

The role selection process keeps the same functionalities as the old RCOS. If the RCO has only the option to choose an operator, the system will automatically skip the role selection screen. Once assigned the operator role, the next screen will let the operator choose a crane. This crane selection screen mirrors the layout and functionality of the role selection screen.

After successful authentication, the RCO cannot return to the role selection screen without logging out. The following key takeaways were identified from the final user test.

- Icons are clearer compared to the previous RCOS.
- Add an administrator button.
- Do not assign a gender to the supervisor.

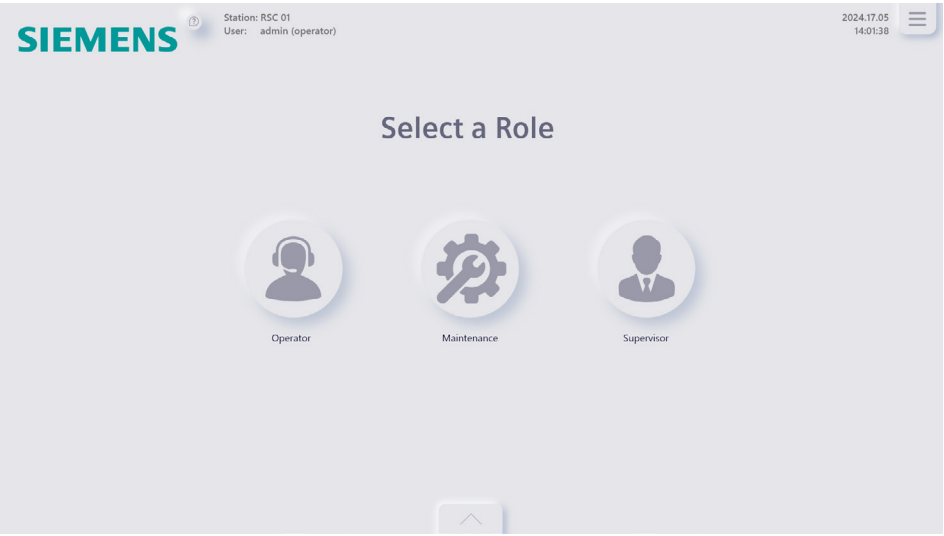


Image 43: Redesign select role screen

6.8.3. Redesign Crane selection screen

The redesigned crane selection screen now incorporates features similar to those used in the Harbor Rotterdam UI. The entire crane visualization uses color coding to represent crane status: red indicates unconnectable, green shows connected, and gray denotes availability for an RCO to connect with the crane. The icons described in Chapter 2 are employed. A crane can be selected by pushing on the button placed under the visualization. In the previous UI, the manual intervention was displayed by blinking between blue and green, but these colors can be difficult to distinguish quickly. In the redesign, cranes now blink between gray and green to indicate a manual intervention required. Additionally, inspired by the Harbor Rotterdam UI, we have included extra information on the crane visualization. The layout of the screen is customized based on the type of crane. Two distinct layouts have been developed: one for STS cranes and another for RMG cranes. The STS layout, used for cranes located at sea, includes a scale to indicate distance indication between cranes. In contrast, the RMG layout features a numerical system representing the 'field' location of each crane. The following key takeaways were identified from the final user test:

- The operator should be able to navigate through the map by swiping left or right, allowing for easier access to cranes located off-screen.
- The operator should be able to zoom in and out by pinching.
- Participants were divided, half of them correctly interpreted the red color as indicating an unconnected crane, the other half perceived it as an error.
- The names or icons of the cranes should be interactive in the name overview, here the operator can tap the name without searching for the crane visualization.
- The name overview should be turned into a pushable menu as well to allow for a larger map view.
- The central function button can be removed as it no longer serves a purpose in the UI.
- The visual distinction between STS cranes and RMG cranes needs to be enhanced as they appear too similar now.
- Participants unanimously appreciated the text within the crane visualization
- The blue color representing the sea should be implemented in the STS layout.
- The blinking of the button until the system responds for selecting a crane is well-received, but the blinking animation should be more distinct and less similar of a loading indicator.

6.8.4. Redesign Default screen

Image 44: Redesign select STS crane screen

Image 45: Redesign select RMG crane screen

The Crane screen received the most attention during the redesign process. Additional features and layout choices were previously discussed. This chapter provides a summary of the implemented test results. Multiple overlays display spreader and container status: a cross icon for errors, red locks for unsecured, green locks for secured, white for not landed, and green for landed. When all overlays are green, the container can be separated from the spreader.

Image 46: Redesign select default/crane screen

The eye tracker test revealed that participants were distracted by the green colors at the bottom of the screen when the crane is off, leading to confusion. Thus, the default colors are now gray. Once the crane is turned on, the green color will automatically appear. The 'Crane on button' provides live feedback by blinking and turning completely green when the system confirms the feedback. The same applies for the arrows indicating the spreaders width. When the arrows are completely reformed, the width of the spreader changes in real life. The feature aims to enhance the directness and control of the UI.

The following main takeaways were drawn from the final user test:

- Gantry/Boom controls should have an off option, to prevent accidental joystick movements in gantry mode from causing significant damage.
- Add a text frame to display the boom angle.
- Lower the proximity of the camera buttons in TLS mode.
- The visualization and functionality of the flippers are complete and a valuable addition to the UI.
- The hardware details button is now clear.
- The feature allowing users to add and remove icons should be tested with harbor personnel to assess its usefulness, as participant opinions were divided.
- Both the green and red locks in the spreader display a secured lock. Green should be open and red should be secured.

6.8.5. Redesign control screen

The control screen is designed for less frequently used crane buttons, with icons providing additional information about each button's functionality.

A previously discussed issue involved missed information when the RCO switches to the control screen. To address this, two options have been developed. One option maintains the current information architecture and screen layout, while the other option incorporates all control buttons into pushable menus located on both sides of the screen, see Figure 48. Since these control buttons are used less frequently than the crane buttons, the menu bars will remain hidden most of the time. Additionally, light controls have been moved from this screen to the camera screen visualization. The goal of these changes is to enhance efficiency and streamline the information architecture.

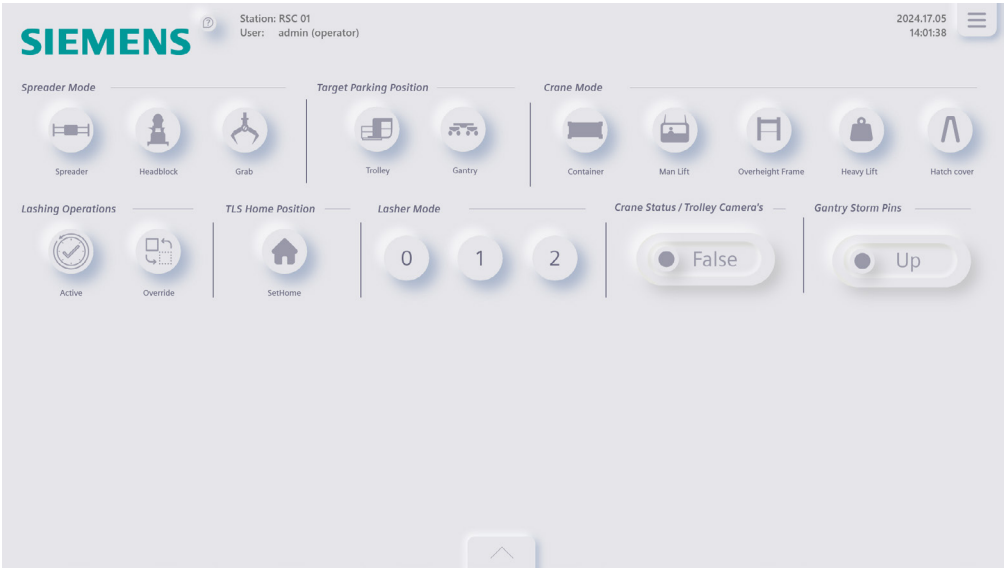


Image 47: Redesign control screen

Image 48: Control panels implemented in the default screen

The following main takeaways were drawn from the final user test:

- Engineers appreciated the new feature that integrates control screen buttons into pushable menus on the default screen. However, it should be customizable. Users can enable pushable control menu bars via the hamburger menu for quick operation.
- The existing control screen should remain as an overview screen.
- The existing control screen should have the same layout as the pushable buttons to enhance familiarity.

6.8.6. Redesign Camera

The camera screen is used when an RCO needs additional dimensional information from a specific angle. The old RCOS had several weaknesses that we addressed in the redesign, see image 49.

The Harbor Rotterdam UI showcased two strengths that have been incorporated into the redesign. First, the camera stream can be significantly smaller while still providing sufficient data to the RCO, an assumption confirmed through observations at Harbor Rotterdam. If desired, the operator can maximize the camera stream. Second, we integrated the light controls into the camera screen. The visualization now displays the lights' locations on the crane, enhancing the comprehensibility and directness of the UI. Even many Siemens operators were unaware of the lights' positions on the crane. The camera stream is displayed next to the visualization and uses the closure principle to indicate low frame rate or high latency, similar to the camera streams from Harbor Rotterdam. Both the camera name and number can be pressed to select the corresponding camera, and the same functionality applies to the lights.

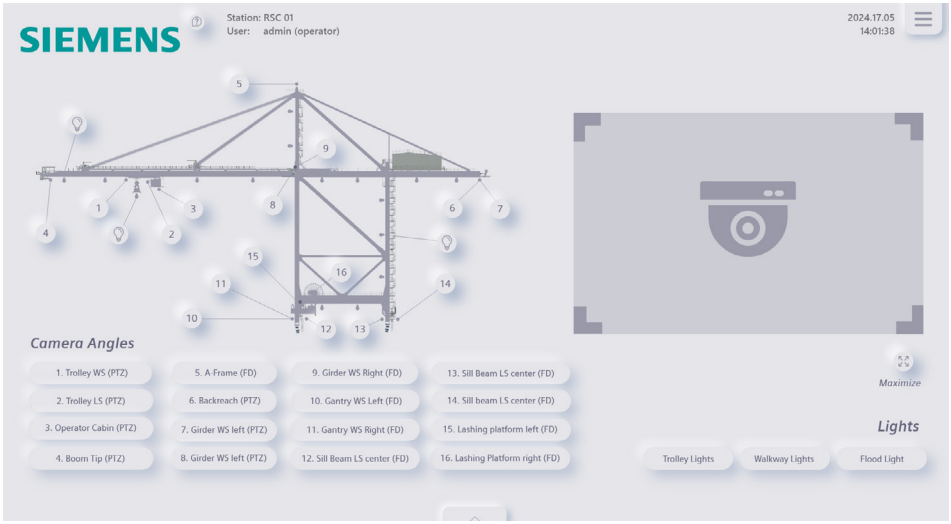


Image 49: Redesign Camera screen

The following main takeaways were drawn from the final user test:

- The red corners used in the test to indicate high latency already signify twistlocks. Engineers agreed that a different shape should be implemented for high latency.
- The high latency indication should blink.
- The indication of interactive buttons is very clear on this screen.
- Display the latency parameter above the camera stream to show the operator the exact delay.
- For the administrator role (outside scope), implement a pushable menu to alter the settings of a camera stream.
- Lights are a valuable asset on this screen.
- Change the name from "Camera angles" to "Camera."

6.8.7. Redesign Alarms

The old alarm screen displayed at least the seven most active messages using a color code that can possibly lead to confusion. Green was used for informational messages, but throughout the entire RCOS UI, green indicated an enabled state of 'go'. To address this, blue is now used for informational messages, as it conveys calmness, and this color seems appropriate for non-urgent information (MSEd, 2024).

While the blinking functionality remains the same, the old RCOS did not clearly indicate where to tap once an alert had been addressed. RCO feedback from Harbor Rotterdam indicated that some icons and rows were too small, increasing the risk of mistapping. In the redesign, once an alert has been addressed, a button appears in the status column. The RCO can tap this button to remove the alarm, and additional space between rows has been provided to prevent mistapping.

A scroll option was implemented for operators to scroll through the alarms and if a urgent alarm would occur, the arrow in the scroll option would turn red to indicate to the operator he has to scroll up or down.

The following main takeaways were drawn from the final user test:

- Siemens no longer allows the operator to acknowledge alarms by tapping the row. Instead, the system features a hardware button that enables the acknowledgment of multiple alarms simultaneously, saving time for the operator.
- The icon should have a E (error), W (warning), or I (information message) embedded in the icon, to enhance clarity
- Urgency should be represented by a number that specifies the type of alarm.
- Add filter for type of alarm and urgency.
- The red arrow indicating the alarm is not prominent enough; the entire button should be highlighted in red.

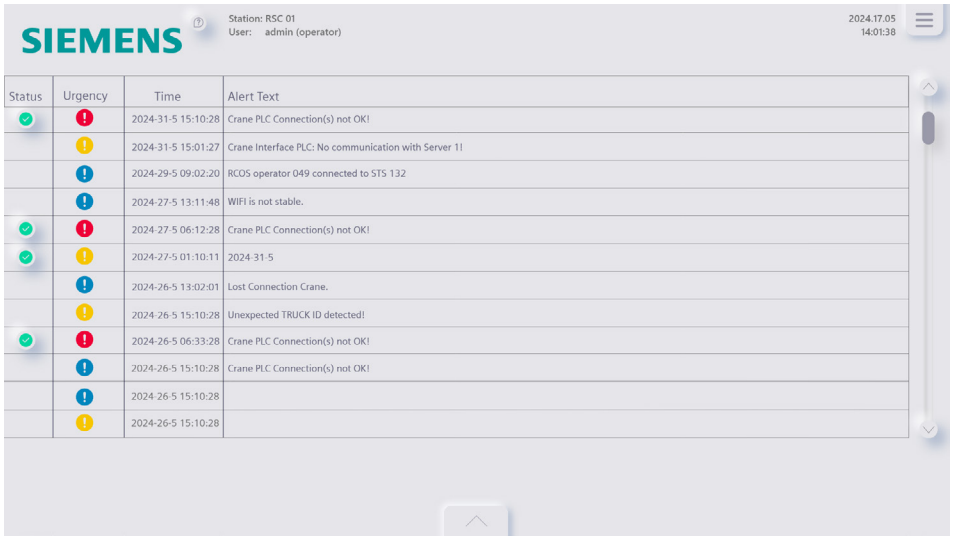


Image 50: Redesign Camera screen

6.8.8. Redesign Truck MI

The primary purpose of this screen is to clearly display information about the truck ID. If there is a mismatch between IDs, this screen will automatically appear. The goal of the redesign is to improve the clarity of the information presented.

To enhance readability, the contrast between the ID text and the background has been increased. Additionally, the visual representation of the truck has been aligned with the text below to create unified appearance. There were no noteworthy takeaways from testing this screen.

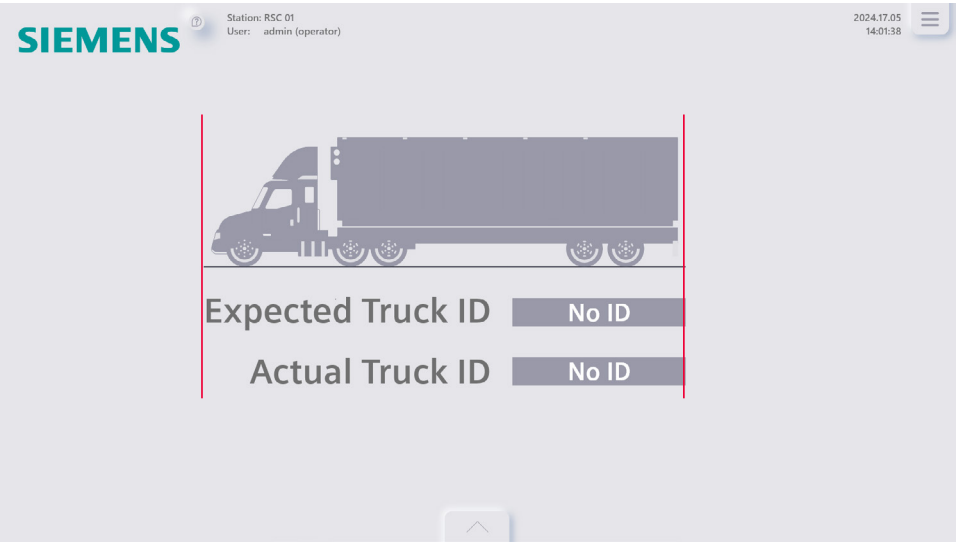


Image 51: Redesign Truck MI screen

6.8.9. Redesign Crane status screen

The crane status screen is likely the most frequently accessed touch screen by an RCO when not using the default view. Although the camera stream can be accessed, there is limited scope for redesigning that screen. Consequently, the primary focus has been on enhancing the clarity of the crane status screen itself.

Engineers at Siemens consider all information on the crane status screen equally important. However, observation step 4 revealed that trolley speed data is the most frequently interacted with. Thus, this data has been positioned next to the most significant visual elements.

Engineers at Siemens consider all information on the crane status screen equally important. However, observation step 4 revealed that trolley speed data is the most frequently interacted with. Thus, this data has been positioned next to the most significant visual elements.

The following main takeaways were drawn from the final user test:

- The new layout is clear.
- The persona looks good, but engineers are curious how RCO's will interpret it. However, the persona draws a bit too much attention; the primary focus should remain on the information.
- All engineers prefer the 2D visualization. The 3D visualization would only be beneficial if operators could control and navigate within it..
- The wind compass should include a color indicator for dangerously strong winds.
- Wind speed should be displayed in m/s, and position should be shown in meters.

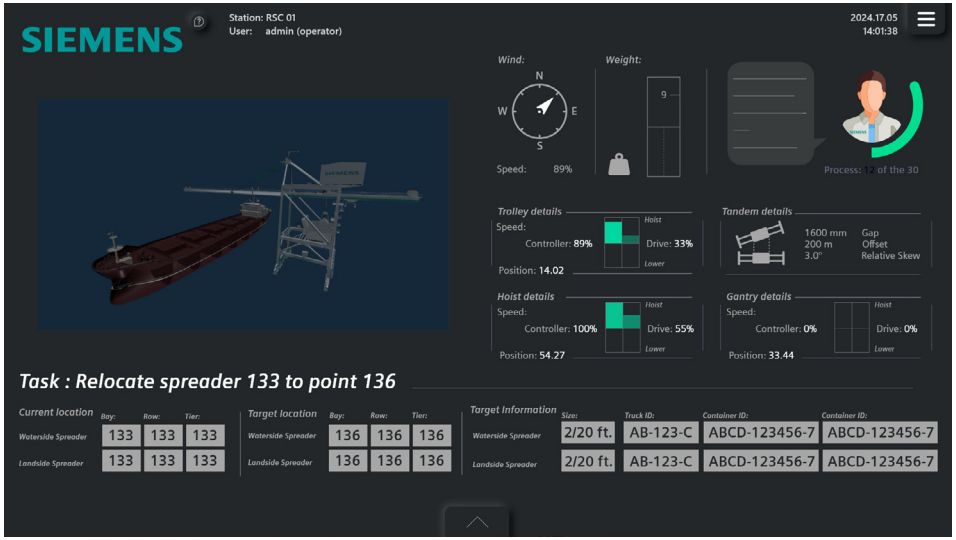


Image 52: Redesign crane status screen with 3D visualization

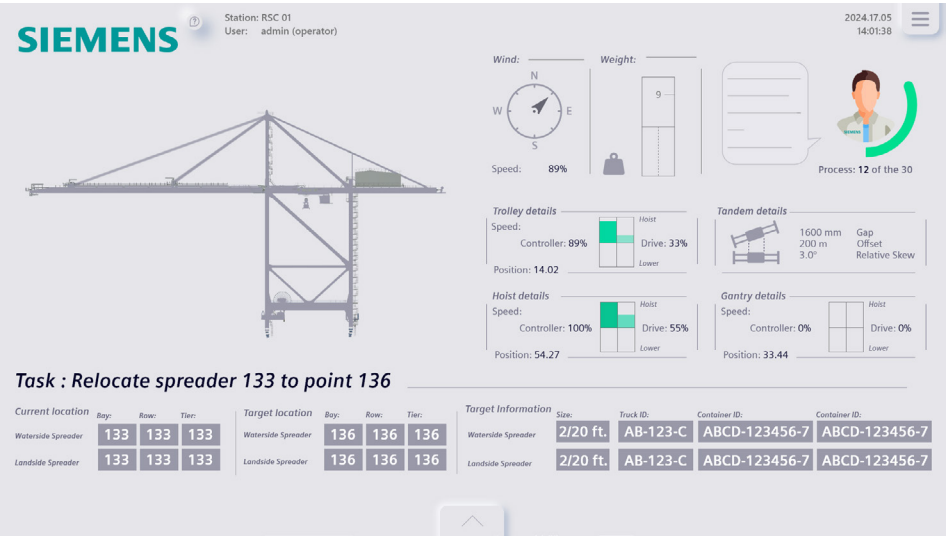


Image 53: Redesign crane status screen with 2D visualization

6.8.10. Redesign Left monitor

The left monitor had limited room for a redesign. It has been updated to align with the corresponding house style. No significant issues or feedback were noted for this screen during the user test.

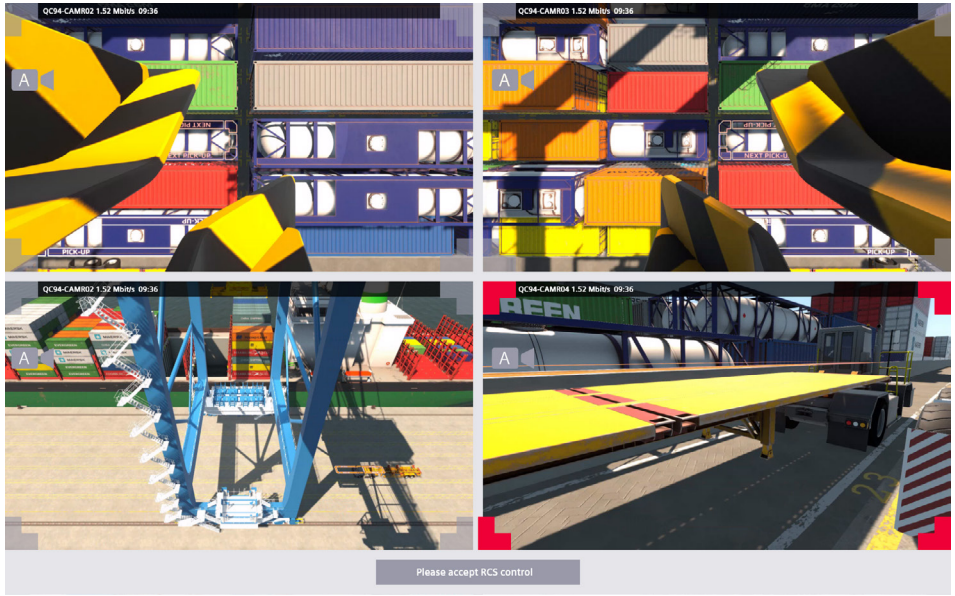


Image 54: Redesign left monitor

6.8.11. Redesign Middle monitor

The middle monitor is designed to provide a clear overview of the camera stream and overlays that display information about crane and spreader changes. In the current RCOS, icons may be overlooked if their color is too similar to the background or if a wet container reflects excessive light in the camera stream. Since this screen has no interactive elements aside from the camera stream, we could not test interactions with it. Therefore, two design options were created, and at the end of the user test, participants were asked for their preferences and reasons, as shown in figures 55 and 56.

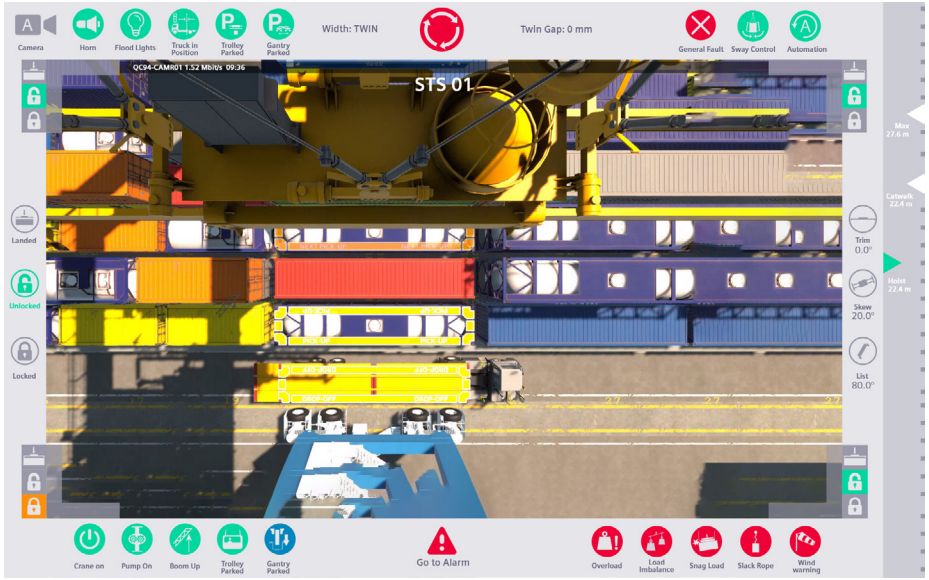


Image 55: Redesign left monitor option A

Image 56: Redesign left monitor option B

The following main takeawasy were drawn from the final user test:

- Option A was preferred by the majority of participants, although the decision was close. The consistent background and the placement of names under icons were seen as positive additions.
- Engineers are concerned that reducing the camera stream size might increase latency, as maintaining resolution on a smaller screen could be problematic.
- The camera icon should be positioned the same as on the left monitor to ensure consistency.
- Icons should be kept simple to avoid placing an excessive load on the system.
- The engineer specializing in load management believes that resizing the camera will not impact latency or frame rate, which was a key consideration for engineers who preferred Option B.

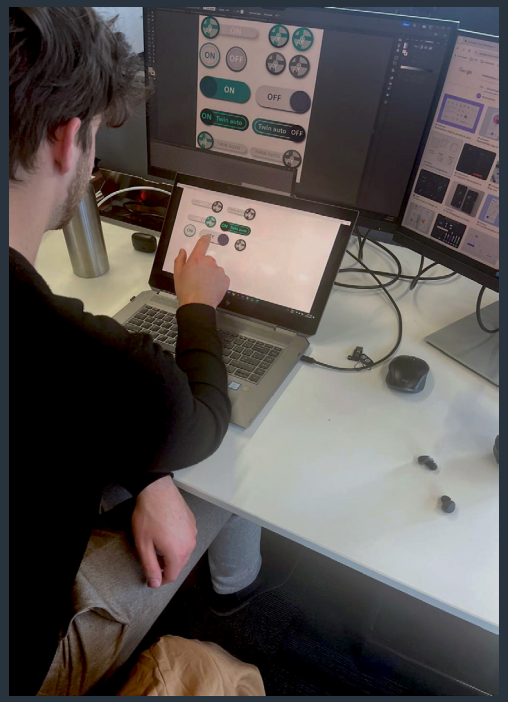
All main takeaways gathered from this final user test are going to implemented in the final redesign and will be further discussed in the conclusion.

Chapter 07.
Prototyping and Testing

In the previous chapters, we covered the main takeaways from both low-fidelity and high-fidelity prototyping. In the next chapter, we will present an overview of the various prototyping methods and testing methodologies used throughout the design process. Due to the complex nature of the RCOS UI and data presentation, it is crucial to test a wide vary of methods and tools. All tests were recorded and later on processed and processed in Miro.

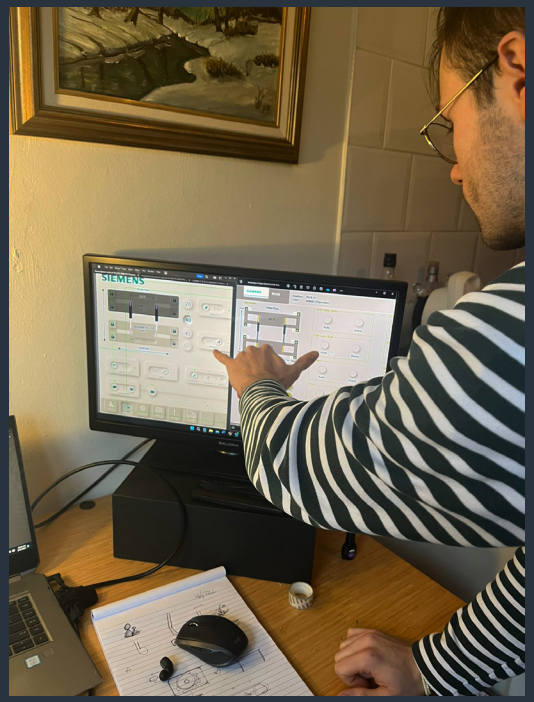
Low-fi prototyping and testing featuring SIemens Engineers.

Throughout the entire project, the test room could be visited to conduct quick tests with engineers and hold brainstorming sessions. Going back and forth with each other, concepts were iterated and refined. These concepts were then made interactive in Adobe XD. The touch screen of my laptop could be used as a tool to quickly test the concepts and see how the elements would interact and their potential on a larger scale.



Low-fi prototyping and testing featuring Industrial Design students

To gather external opinions, fellow Industrial Design students were consulted. As first-time users unfamiliar with the jargon, they provided valuable insights into what appeared illogical or overly complicated. The focus of our tests and brainstorming sessions was primarily on the appearance of elements and how to improve them.



First High-fi testing featuring First time users

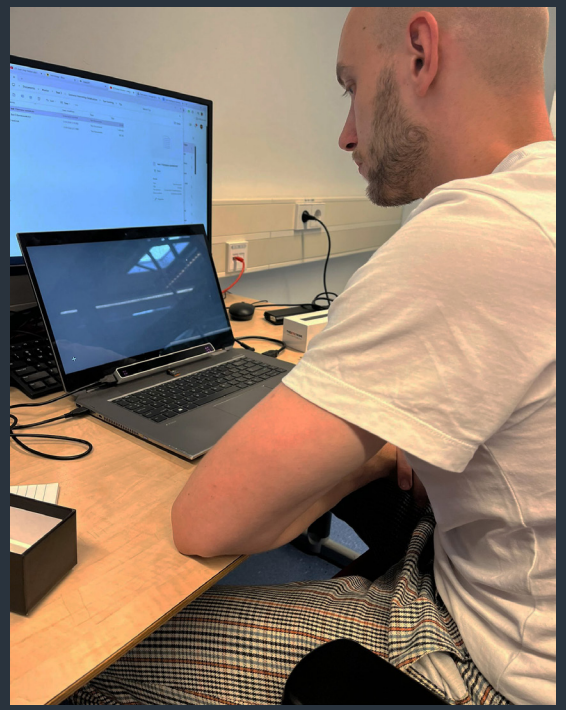
This was the first high-fi test conducted. It began with a small explanation about the scenario, followed by the test and concluded with a quantitative survey. The default screens were tested in 4 styles: skeuomorphism, skeuominimalism, neumorphism, and neu-minimalism. Participants were asked to think out loud during the test. To replicate the real scenario as closely as possible, the actual Elo screen from the real desk station was used.

Second High-fi testing featuring SIemens Engineers.

The second high-fidelity test focused on evaluating different layouts, new features, and the configurability of the redesigns with Siemens engineers. The setup mirrored that of the first high-fidelity test, using the same Elo screen. The test began with interviews about the previous 4 designs and general feedback on them. Participants then engaged in task assessments while thinking out loud.

Third High-fi testing featuring First time users

The third high fi test was the eye tracking test, where participants had to locate the 'Crane on' button on both the current RCOS and the Redesign. The tool used here was an Eye tribe device, providing raw data with the average X and Y coordinates every 30 milliseconds. This data was sorted in Excel and processed using Tableau Public software. In this software it was possible to create eye tracking maps and heatmaps.



Fourth and final high-fi testing featuring Siemens Engineers

The setup of the fourth and final high-fidelity test was similar to the second high-fidelity test. However, in this iteration, we displayed the old RCOS UI alongside the new one, allowing participants to make direct A/B comparisons. The objective of this test was to gather feedback on the redesigned screens. Throughout the test, participants were asked to perform various tasks and share their opinions, focusing particularly on the new features.

Chapter 08.
Validation

In any research project, validation is crucial to ensure the credibility and reliability of the findings. Since the intended UI is designed for global, around-the-clock use, it must be accessible to people of all genders and nationalities. Therefore, the tests should closely simulate the potential real-world scenarios in which RCOS might be used. In this chapter, we will validate the results of the UI/UX tests and reflect on potential improvements.

Nielsen and Landauer (1993) suggested that five participants are typically sufficient to uncover critical usability issues in user tests. Fortunately, all our high-fidelity tests involved more than five participants. In the following section, we will discuss the strengths and weaknesses of the high-fidelity testing. Low-fidelity testing was excluded from this validation as it was conducted more casually and without a fixed test plan.

8.1 High-fi test 1

The test was conducted with nine first-time users, who were instructed to think out loud as they participated. The group included both male and female participants, all of whom were of Dutch origin and under the age of 25. The setup used part of the original desk station, with only the touch screen included. The following strengths (+) and weaknesses (-) can be drawn from this test:

+ Included both male and female participants.
+ Setup resembled the original desk station.
+ Used first-time users to analyze first impressions without prior knowledge.
+ Gathered both quantitative and qualitative results.
- No participants were older than 25 years old.
- Participants did not have diverse cultural backgrounds.
- Test was conducted only during daytime.

8.2 High-fi test 2

The test was conducted with eight Siemens engineers who were instructed to think out loud. Although all participants were male, the group included a range of ages and nationalities. Despite the smaller group size, the test duration was significantly longer. The following strengths (+) and weaknesses (-) can be drawn from this test:

+ Significant age differences in the group.
+ Setup resembled the original desk station.
+ Engineers provided in-depth feedback on all features and the underlying functionality, contributing to the longer test time.
+ Gathered both quantitative and qualitative results.
+ Participants had diverse cultural backgrounds.
- No females participated in this test.
- Test was conducted only during daytime.

8.3 High-fi test 3

The eye tracker tests were conducted two times with six first-time users. A notable problem arose when participants wore glasses, as the eye tracker had difficulty measuring eye movements accurately. Additionally, if a participant blinked, the eye tracker would reset the eye's position to coordinates (0,0). The participants included both males and females, but there was no cultural diversity in the group. The following strengths (+) and weaknesses (-) can be drawn from this test:

+ Included both male and female participants.
+ No participants wore glasses.
+ Able to filter out some of the clear ‘blinking’ resets.
- Participants did not have diverse cultural backgrounds.
- Almost all participants blinked during the test.
- No participants were older than 30 years old.

8.4 High-fi test 4

The final user test was initially planned to be conducted at Harbor Rotterdam with the actual target group. This test would have been crucial, as the actual users of the UI could provide valuable insights on the additional features. Unfortunately, in the final weeks, they declined to test the redesign. As a result, we conducted the final user test with 10 Siemens employees, including 8 engineers. To gather first-time user insights on the redesign of the remaining screens, the test also included two employees from another department. The following strengths (+) and weaknesses (-) can be drawn from this test:

+ Included participants from different departments.
+ Significant age differences within the group.
+ Setup resembled the original desk station.
+ Participants had diverse cultural backgrounds.
+ A/B comparison between all the screens.
+ Engineers provided in-depth feedback on all features and the underlying functionality, contributing to the longer test time.
- Actual target group could not be used for the user test.
- Test was conducted only during daytime.
- Actual camera streams could not be used for the monitors.

8.5 Improvements

In conclusion, multiple strengths and weaknesses emerged from all the tests. However, there are some consistent weaknesses that should be addressed in the future. The most significant issue is that the UI has not been tested with the actual target group, which means some of the problems identified in the SWOT analysis remain unresolved. Future improvements should include testing the UI during nighttime, as the UI is used around the clock. Another key improvement is increasing the number of participants. Although Nielsen and Landauer stated that five participants are typically enough to uncover critical usability issues, testing with a larger group would create more significant results.

Chapter 09.

Conclusion

This chapter showcases the final redesign of RCOS in its entirety.

To begin this conclusion, we will discuss points that are consistently applied throughout the UI, starting with the house style of this UI:

- **Style of the UI:** Neu-minimalism
- **Coherent Use of Visible Interactive Buttons:** Ensuring clarity and accessibility
- **Multiple Indications of Button States:** Providing feedback through different states
- **Use of Simplistic Icons:** Employing single-color icons for simplicity
- **Dark Mode and Light Mode:** Offering visual flexibility for different environments
- **Typography:** Siemens Sans
- **Consistent Use of Color Codes:** Red indicates errors, yellow means warnings, and green signifies enabled states
- **Framework Used for Alignment and Task Hierarchy:** Maintaining a • structured layout
- **Primary Colors Used for Light Mode:**

e5e5e9	00da70	ef0137	9999a9	66667e

- **Primary Colors Used for Dark Mode**:

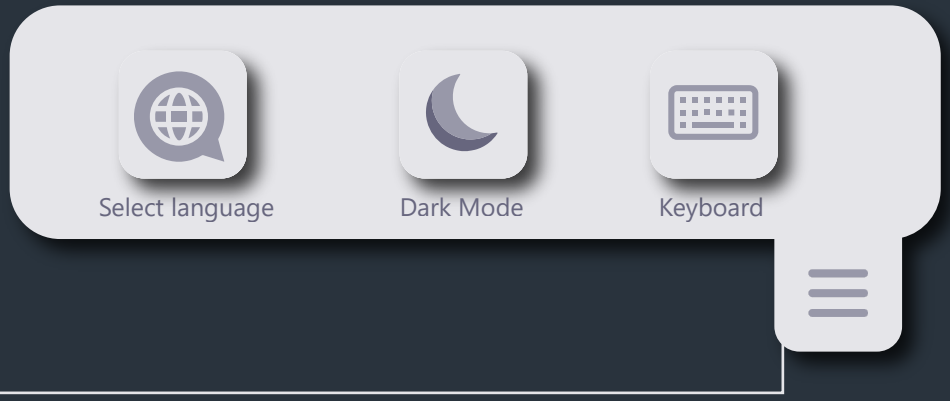
233729	00da70	ef0137	9999a9	FFFFFF

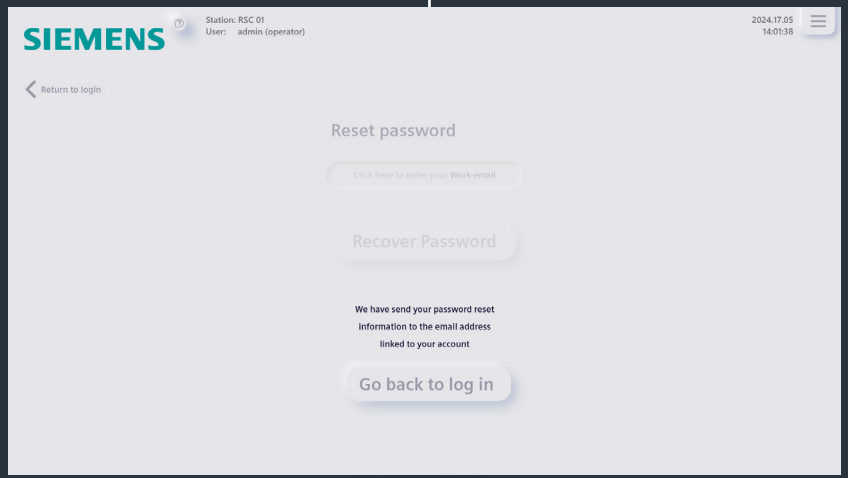
In the previous chapters, the additional features have already been discussed. For that reason, the topics of the redesigns will mainly pinpoint the recent improvements and notable strengths of these screens. The visualization will display the original RCOS next to the redesign for a clear comparison between the two. The screen with animated elements features a hyperlink guiding to the animation of the redesign. Here the interaction between the elements can be further perceived.

The Login Screen

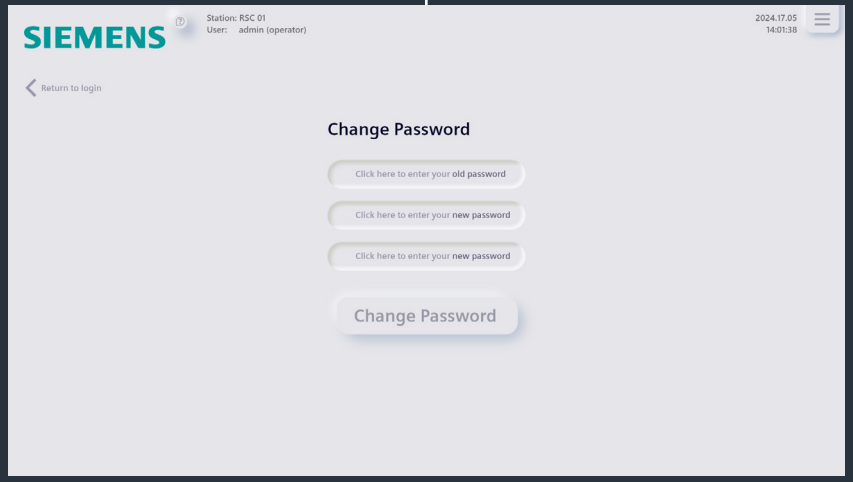
Animation of Log in screen

The final redesign of the login screen includes two recovery options: "Change Password" and "Recover Password." After selecting one of these options, the user is directed to a new window for further action. Additionally, the operator can choose their preferred language from the hamburger menu or switch to dark mode. The redesigned screen now also displays the date, time, user name, and copyright logo to make the login screen complete.





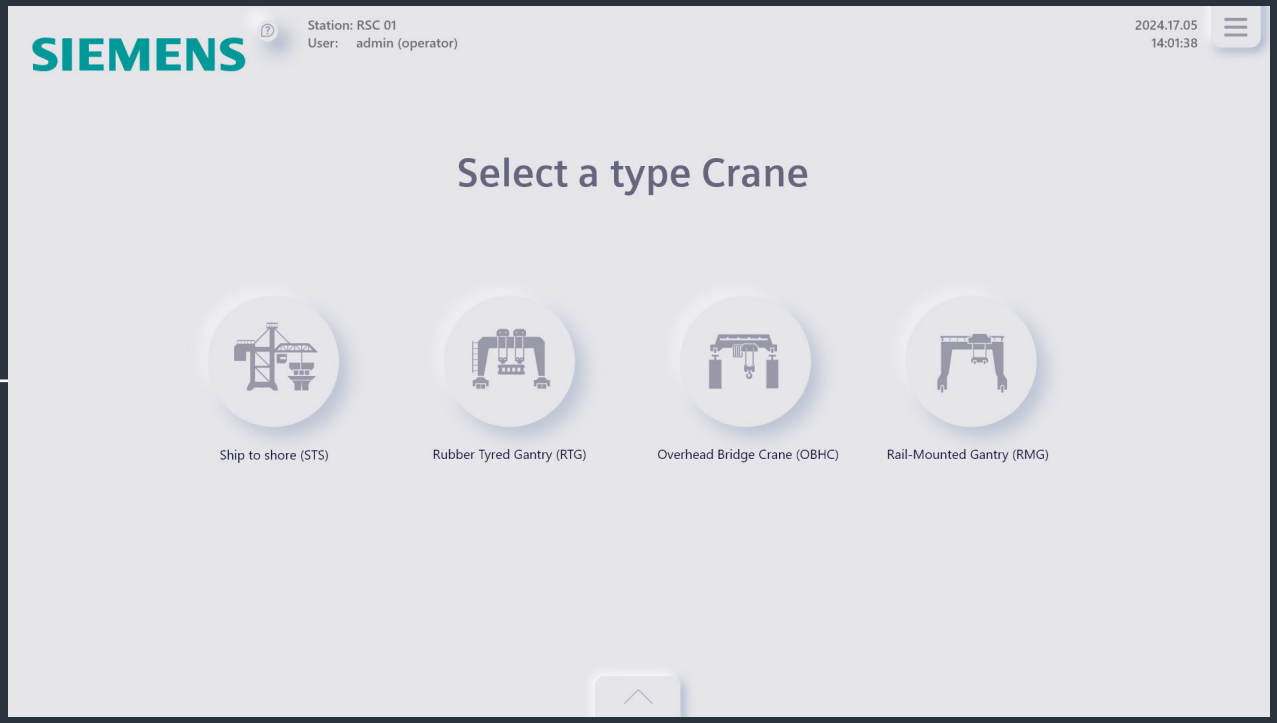
The "Recover Password" feature allows the RCO to completely reset their password by simply entering their work email. The administrator will receive an alert indicating that the employee needs to reset their password and will send a new password to their work email. After this process, the operator will be guided back to the login screen.



The operator should always be able to change their password. If the password they receive from the administrator is too difficult or they prefer to use a personal password, they can easily change it by entering their old password and selecting a new one.

The Select a role screen

[Animation of select a role screen]



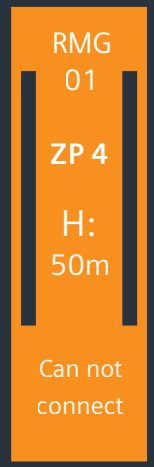
This is a relatively simple screen with straightforward functionality. An RCO can choose the roles they have access to. If they only have the operator role, the screen will automatically skip this step. An important takeaway from the final user test is to ensure the use of gender-neutral icons.

The next screen allows the operator to choose the type of crane. The same functionality applies here as with the role selection: the operator can choose from the cranes they have access to, based on their skill level.

The Select a crane screen

[Animation for select a crane screen]

In the final redesign, we implemented a new color-coding system to prevent confusion: orange indicates "cannot be connected," green means "already connected," and gray signifies "ready to be connected." The names in the menu bar are now interactive, allowing operators to easily access the crane visualization without searching, even when working with a large number of cranes. Additionally, the crane visualizations for RTG, OHBC, and RMG have been updated to more closely resemble the real crane top view of those cranes and differentiating them more clearly from the STS cranes.



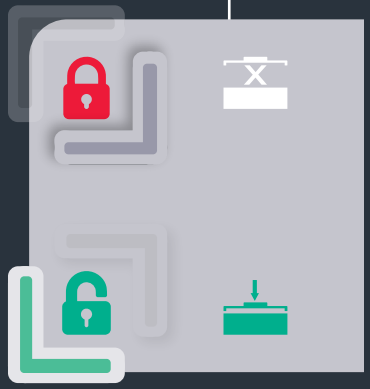
The name overview can now be pushed off the screen to create a larger crane map, enhancing the screen's directness. The cranes are positioned in fields that indicate their real-life locations. The indication for manual intervention remains the same, with the crane blinking between gray and green.

In the STS crane interface, the sea is now indicated with a light blue color. The distances between cranes are clearly marked, and an overall length indication on the crane provides the operator with a clearer map. Lastly, the central function button has been eliminated, as its functionality is no longer used in RCOS.

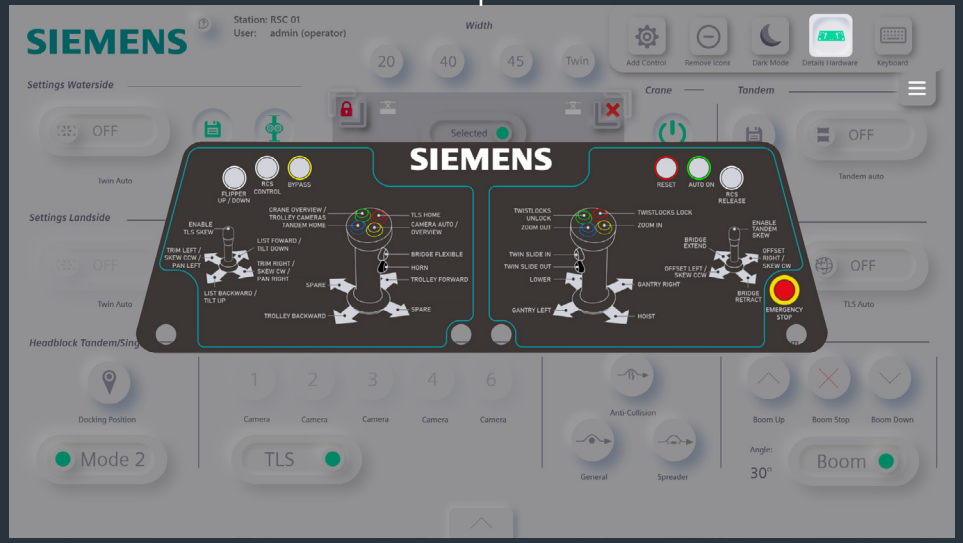
The Default screen/Crane screen

[Animation for the default screen]

As the default screen was the focus throughout this project, we will highlight the new improvements since the last user test. The layout and spacing of the overall screen have been optimized by incorporating the flippers inside the spreaders, mimicking their real-life use. This is also the only place in the entire UI where red has a different meaning: the red cross still indicates an error, but the red lock signifies that it is secured. Red is universally used to indicate a secured lock, even online.



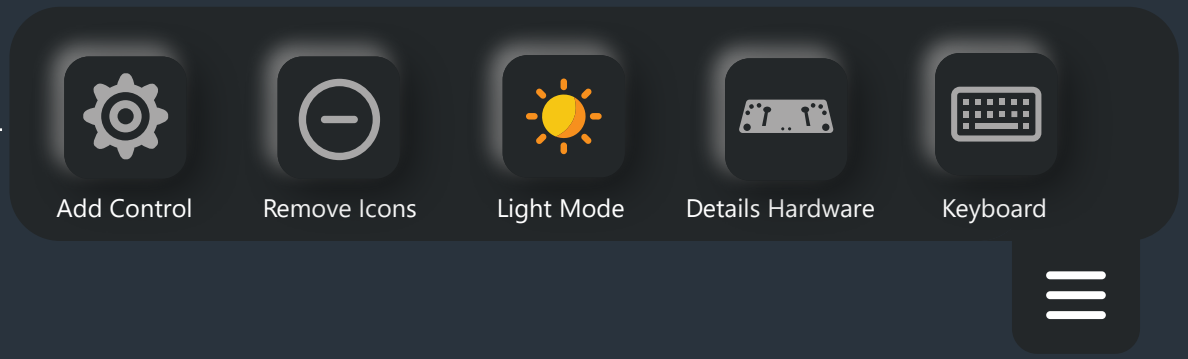
Following the last user test, the camera buttons in TLS mode are now incorporated in the optimization of compatibility by visibility feature. In addition, the boom angle is now displayed as test, when returning to Gantry mode, the text will disappear.



Lastly, when a system is updating and the sheet on the desk station has not yet been changed, the operator can use the hardware details feature for updated information.

The Control Screen

[Animation for the control screen]



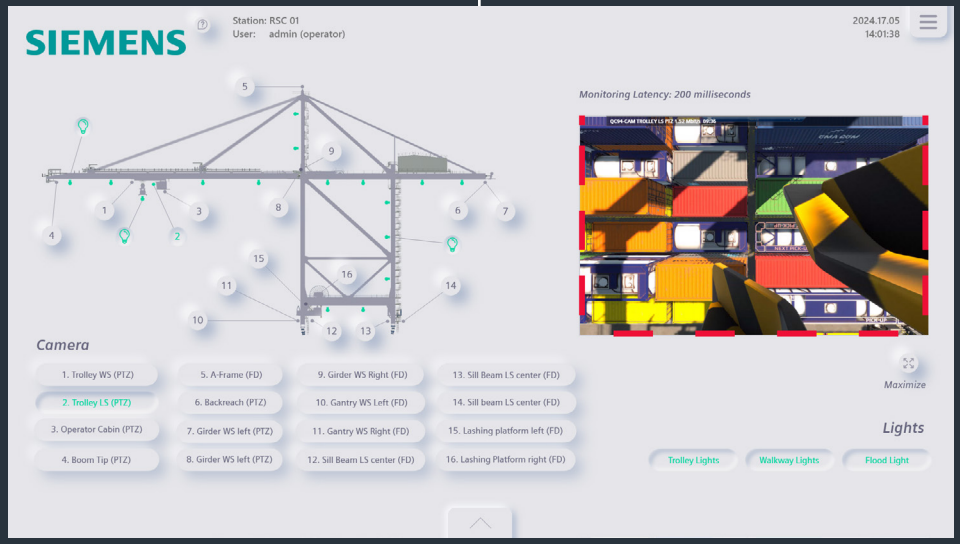
The operator can access the control elements in two ways. First, they can navigate to the control screen and enable the buttons there. Alternatively, they can enable the control panel options in the hamburger menu, which displays six panels on the default screen for quick access to the control buttons. For a clear view of all enabled buttons, the operator can always navigate to the control screen via the lower menu bar. The system will remember the operator's preference for this feature and, after it has been enabled several times, will set it as the default mode.

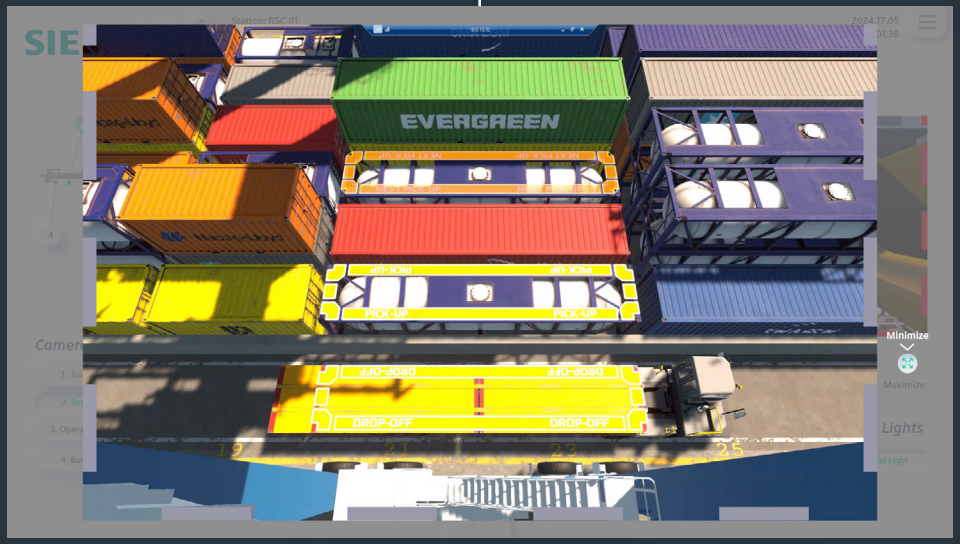
The Camera selection screen

[Animation for the camera selection screen]

The redesign of the camera screen features two ways of selecting a camera. Both the name and number can be used to enable the camera. The camera stream incorporates a new high latency/low frame rate indicator, which differs from the recording screen and the twistlocks currently used in RCOS. The high latency indication will also blink to ensure to catch the RCO's attention. An addition to the screen is the time of the latency. With that information the RCO can have a better understanding of the actual situation. The operator has to control the light in this screen from now on, as it provides a visual representation of the light's location on the crane.

The redesign uses a smaller camera stream. However, if the RCO desires, the camera stream can be maximized. When in the maximize mode, the operator can simply return by pressing the same button.



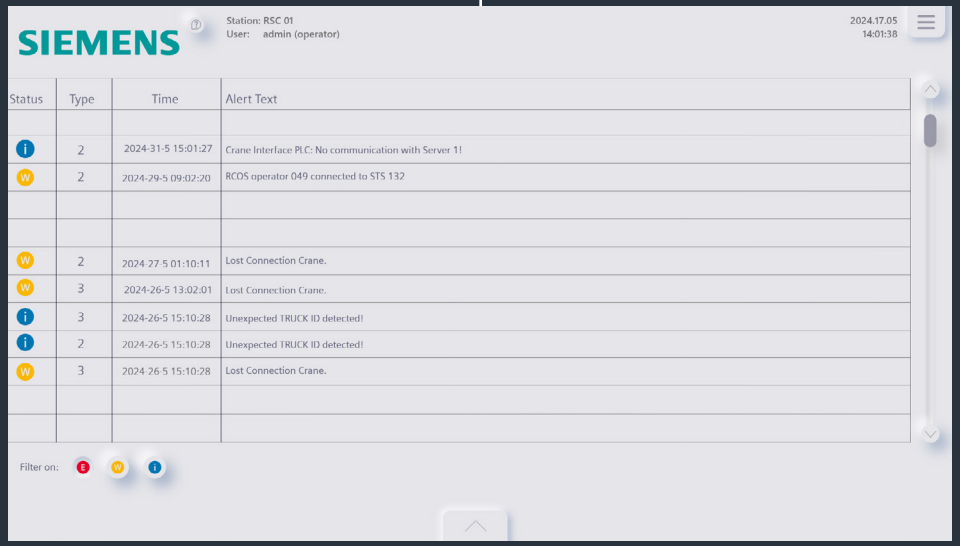


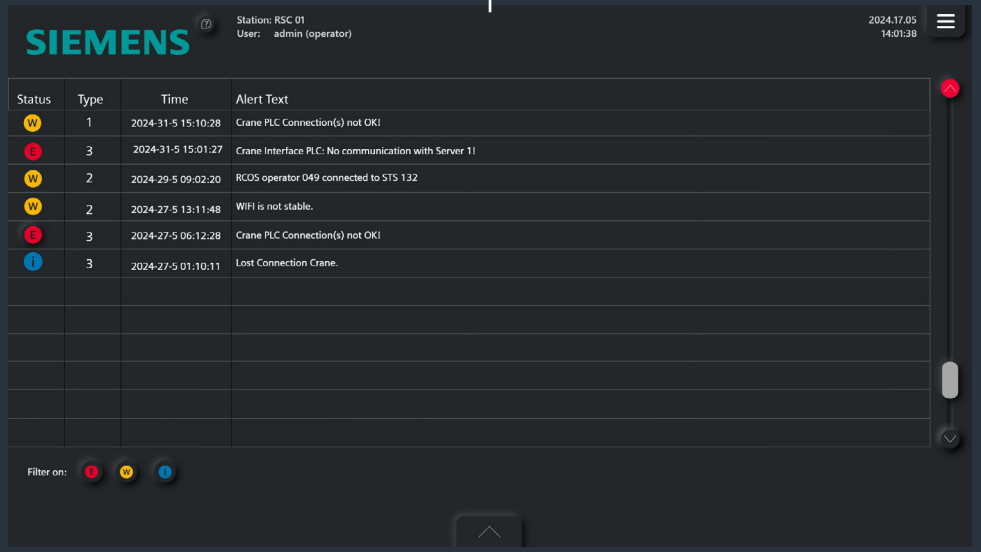
The Alarm screen

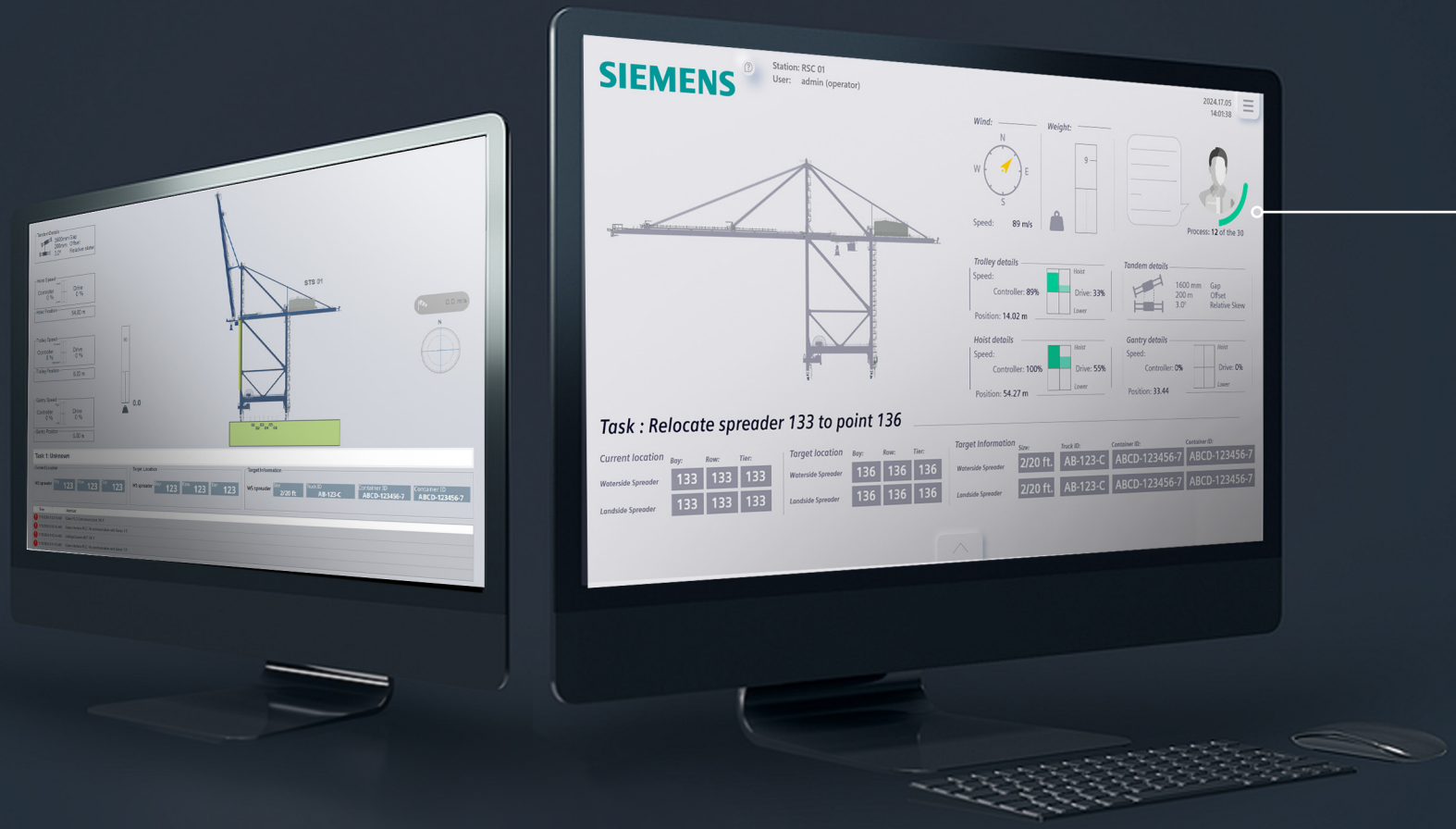
[Animation for the alarm screen]

After the last user test, it became clear that acknowledging individual alarms has been eliminated. RCOS now uses a hardware button to dismiss a significantly larger number of alarms simultaneously, saving the operator time. In the redesign, we removed the fixed alarm icon and instead display the first letter of the type of alarm. Blue alarms show an “I” for informational messages, yellow alarms show a “W” for warnings, and red alarms show an “E” for errors.

In the redesign, it is now possible to filter alarms based on their urgency. Additional information under “type” provides a numerical value corresponding to the kind of error, allowing the operator to find further details as needed. Additionally, the toggle bar now has a more prominent appearance, requiring the operator to scroll up to access it.

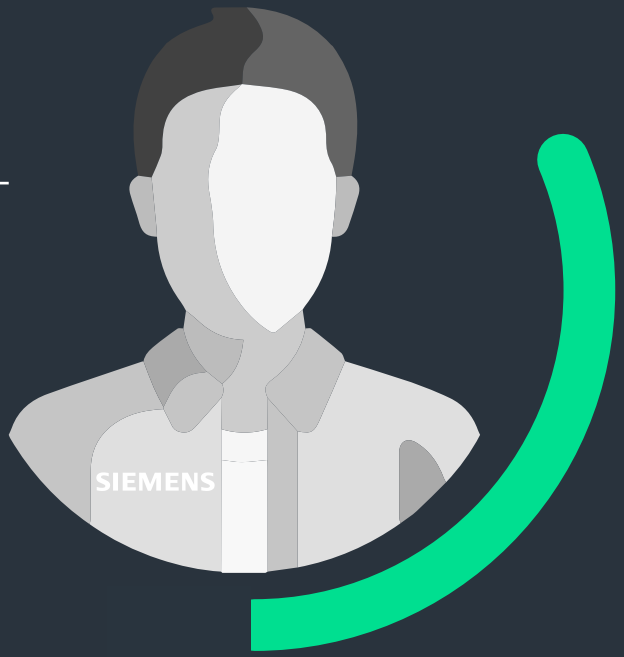






The Crane status screen

From this point, the screens do not have any interactive elements anymore cannot display animations



The main takeaways from the user test have been implemented in the redesign. One notable takeaway is that a 2D visualization would be more beneficial at this time since we cannot control the 3D visualization. If this feature becomes available in the future, we will need to reconsider its implementation.

Another key takeaway is that while the Persona feature could potentially enhance user flow by providing feedback and visibly increasing the operator's skill, it is currently too prominent in the UI, drawing attention away from the priority data. To address this, the Persona now uses a less dominant color palette that better fits the housestyle.

The Truck MI screen

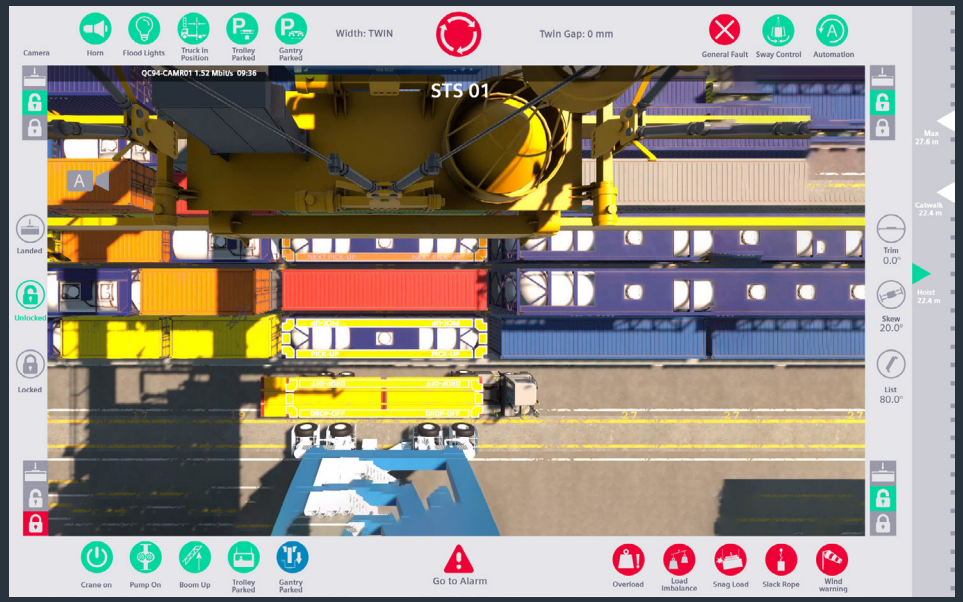
Nothing changed after the last user test. The only change to this screen in total were the colors and aligning the visual with the text.

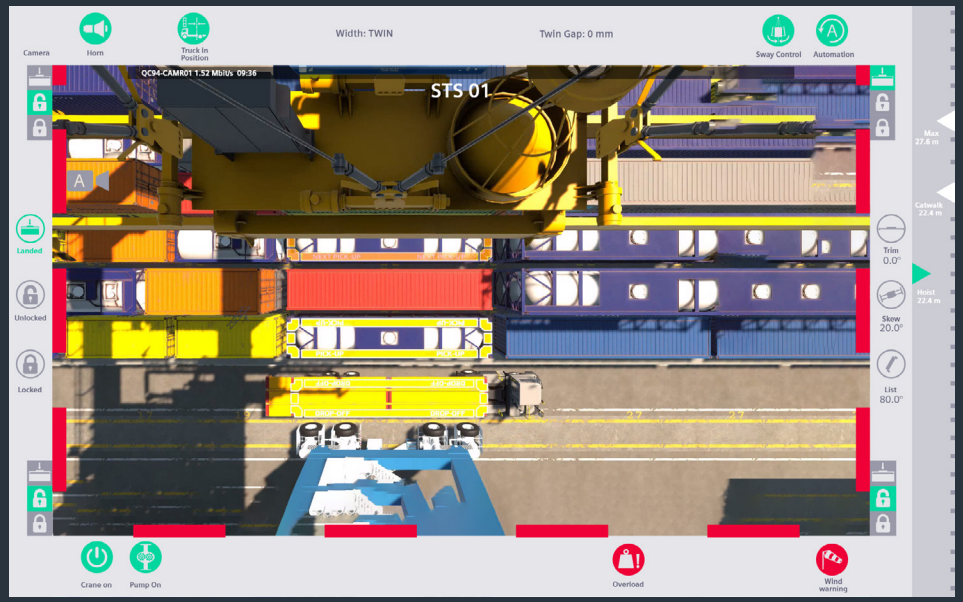
The Left monitor

Nothing changed after the last user test except for the high latency indication. In the picture, high latency is shown in gray and red. When the stream is functioning normally, there will be no frame around the stream. The gray is here used as example.

The Middle Monitor

The middle monitor now displays the names of the overlays to provide operators with a clearer understanding of their functionality. Each overlay has a fixed background to ensure it stands out and isn't overlooked. An added feature is the alarm icon, which was requested by the RCO's at Harbor Rotterdam to prevent alarms from being missed. The icon will be blinking as well if the alarm is of high urgency. Additionally, the camera now has a fixed position, matching the camera streams on the left monitor to enhance consistency throughout the UI.



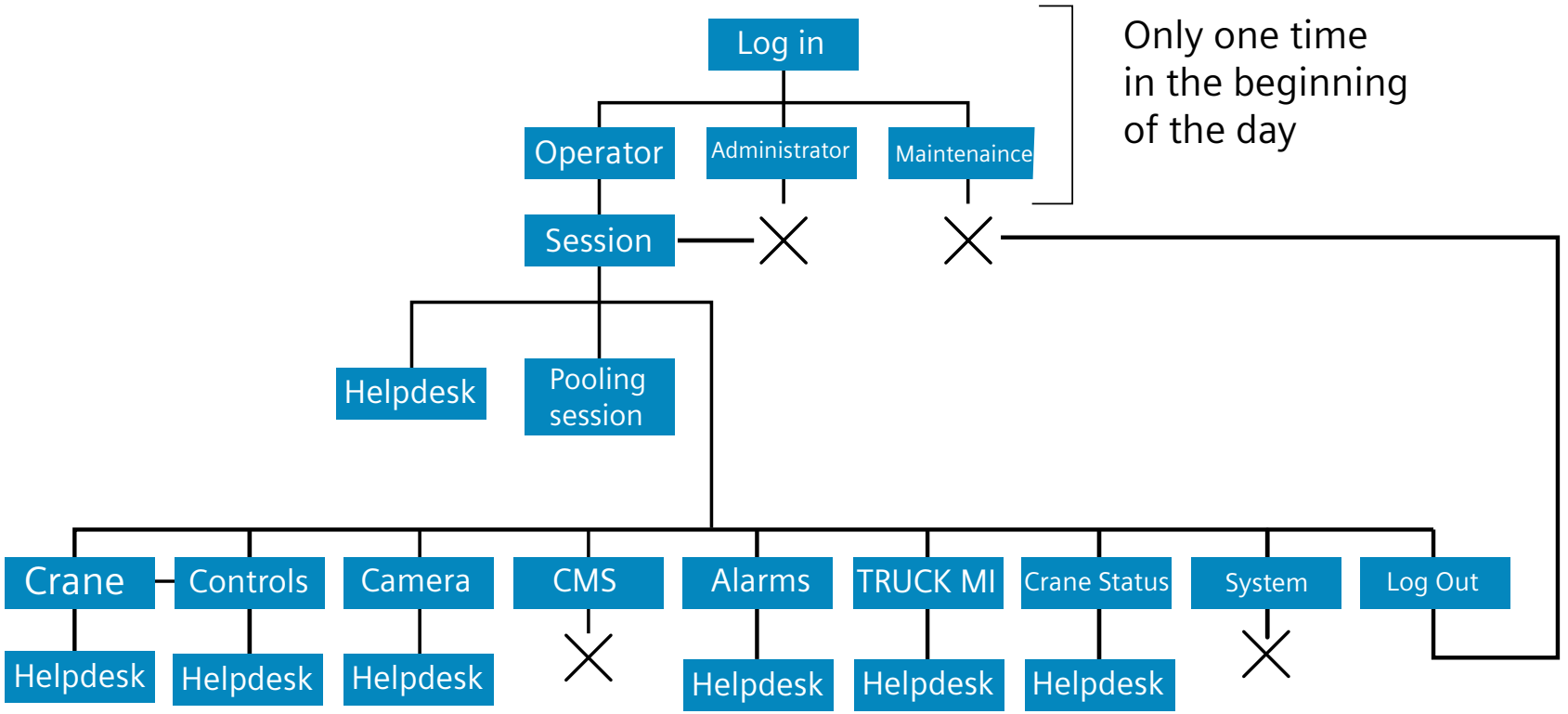


The Logout Screen

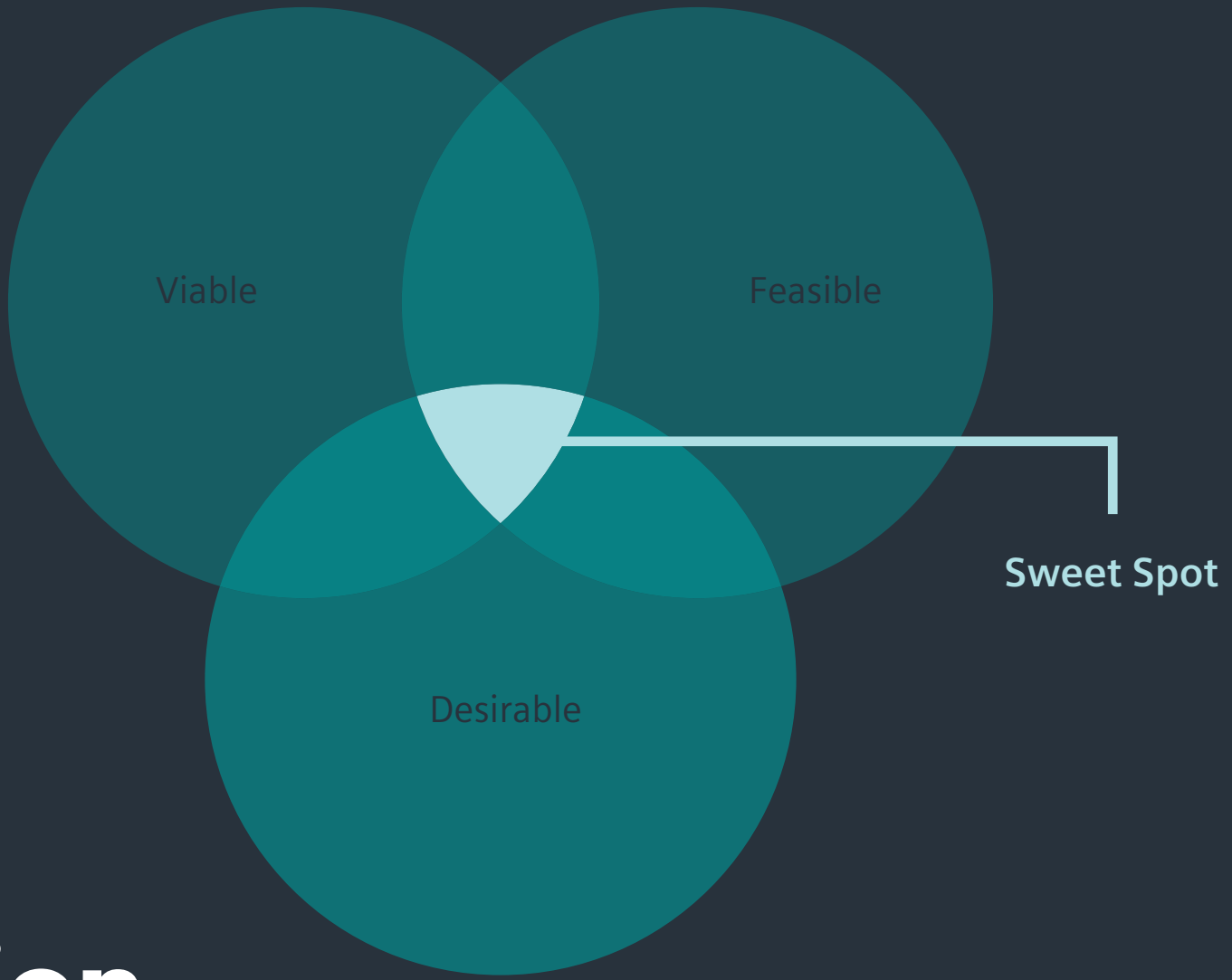
In the original RCOS UI, there was no dedicated logout screen; operators had to disconnect from the crane before logging out. Siemens did not provide instructions for logging out if an RCO forgot to disconnect, resulting in an unresponsive logout button. To address this issue, if an RCO fails to disconnect from their crane, they will now receive a reminder and be directed to a screen where they can complete the disconnection process. After disconnecting, they can proceed with logging out.

It is important to note that this is still a proposal for Siemens and not a fully functional user interface yet. Further improvements are necessary and will be discussed in the recommendations. The defined information architecture of the UI is broad and shallow, allowing the RCO to navigate quickly and easily access controls. The goal is to maintain this architecture to ensure efficient operations. The current information architecture of the redesign is as follows:

The new information architecture is similar to the previous one, with only a few differences. A new helpdesk layer has been added, along with an option for the RCO to return from logout to session if they forgot to disconnect the crane. Additionally, there is now a connection between the control and crane screens when an RCO enables the control panels.



Graph 7: Current informational architecture redesign RCOS



Chapter 10.
Evaluation

In any research project, validation is crucial to ensure the credibility and reliability of the findings. Since the intended UI is designed for global, around-the-clock use, it must be accessible to people of all genders and nationalities. Therefore, the tests should closely simulate the potential real-world scenarios in which RCOS might be used. In this chapter, we will validate the results of the UI/UX tests and reflect on potential improvements.

10.1 Objectives & Aims

In the beginning of this project, specific objectives and aims were established to guide the development of a viable proposal for a UI. Some objectives focused mainly on building a foundational understanding of UI/UX design, an unfamiliar field to me. The total set goals and objectives pioritised high usability in the UI.

According to Nyman & Norén (2021) the only way to determine the usability of the UI is through user tests that observe the interaction between users and the device. Unfortunately, we were only able to conduct tests with first-time users and Siemens employees, not the actual target group. Consequently, the research questions derived from the objectives and aims cannot be fully answered.

However, it can stated that the redesign incorporates findings from relevant literature addressing the research questions. The redesign focused on creating a flow by nudging and enhancing the following design principles of UI that were not prominently present:

- **Clarity:** Clear indication of the state of buttons beyond the sole use of color.
- **Compatibility:** Optimizing compatibility through visibility.
- **Comprehensibility:** Clear task hierarchy and alignment.
- **Recovery:** Inclusion of help desk, password recovery, and logout reminders.
- **Configurability:** Pushable menu bars, ability to remove and add icons, control panels in crane screen, dark mode, and persona options.
- **Familiarity:** Addition of icons that mimic real-life functionality or items.

10.2 Desirability

The core values of Siemens are responsibility, excellence, sustainability, and innovation. RCOS was created to enhance safety and efficiency for both the RCO's and their client by, allowing them to work from a desk station rather than inside the crane. However, initially Siemens did not consider the user-friendliness of RCOS or the interaction between the user and system. If the system is not user-friendly or easily understood, it can lead to mistakes and may lead to an unsafe working environment. Additionally, the RCOS UI did not align with Siemens' housestyle, which was addressed in the redesign.

The redesign includes multiple features to support clear usage and to guide operators through safe system use, preventing mistakes that could lead to material damage or safety hazards. The new features aim to enhance the core values of Siemens, promote increase safety and incorporate responsibility and sustainability by introducing the UI. The appearance has also been refined to align with Siemen's housestyle. However, some elements of the house style, such as flat design, conflicted with the system's user-friendliness. Therefore, innovative ways were sought to implement Siemens' simple icons and colors while displaying them differently. This approach has been presented to Siemens on several ocassions to ensure the style matches their expectations.

As a result, Siemens has accepted the proposal and plans to implement the UI redesign. Currently, engineers are evaluating how to integrate the proposal, although the scale of implementation is yet to be determined.

10.2 Feasibility

Since Siemens plans to implement the redesign, we have already brainstormed how to convert the Adobe XD layout into their system. This enables us to present a clear plan to support the transition from the redesign to the RCOS stage.

First, a plugin, QT Bridge, needs to be downloaded to convert the layout and images used in Adobe XD to a QT style sheet. The code of the QT style sheet will be in C++.

It is important to note that this conversion might result in visualizations that differ from the original Adobe XD design. This issue should be manually addressed by the coder. To minimize the chance of discrepancies, it is advised to use simple icons without gradients or unnecessary effects. This potential problem has already been discussed with the engineers specialized in load management, and they have confirmed that the icons currently used should not become an issue. Furthermore, another important risk we have taken into account is the possible change of the buttons going from a enabled to a disabled state. A possible solution will be presented in the discussion chapter.

The style sheet is a textual specification that can be applied to the entire application or specific widgets. This style sheet will be integrated into Siemens' open architecture, where it will function as a configurable table within the code.

Another concern raised by Siemens engineers was the resizing of the camera stream on the middle monitor. However, after consulting the load engineer, it was determined that this minor resizing adjustment would not cause any issues with high latency or low frame rate.

10.3 Viability

For this project, a digital proposal was created, eliminating the need for physical prototypes and the associated complexities. However, it must considered how this UI will adapt in the future when customized for different harbors globally.

Customization was a recognized challenge during the redesign of the layout, as creating a fixed layout was not feasible.

For that reason, one of the most complex and crowded layouts, a twin mode spreader, was used as a reference. If the UI needs to be customized for something other than a twin mode, the layout can be simplified instead of complexified. Elements can be removed, providing more space in the UI to experiment with the placement of elements. Image 57 illustrates how the UI might look when used for single spreader cranes.

Additional client-specific customization can be found in the type crane, including STS, RTG, RMG, or OHBC, and their corresponding crane selection screen. STS cranes will be visualized next to the sea and RTG, RMG, and OHBC will be visualized on land in a 'field'. Both screens are designed, so they can both be implemented in both cases. If the map is larger than the screen used, the RCO can either zoom out, use the name overview, and/or scroll through the map. These features ensure that the amount of cranes required for customizations will not become an impeding problem in the long-term.

Lastly, the redesign will be implemented globally, taking into account the challenges of different cultural design preferences. Therefore, the UI has been designed to be as neutral as possible, e.g. avoiding gender-specific icons. Other ethical, social, and environmental standards outside Siemens' were not in the project scope.

Image 57: Potential layout of single spreader UI

Chapter 11.
Discussion

This following chapter reflects on what could have been done differently to improve the results related to the desirability, viability, and feasibility of the project. This analysis will help identify areas for improvement and provide further insights for future integrations.

Desirablitiy

The acceptance of the UI proposal by Siemens reflected a positive step forward for the proposed solutions. However, we can explore further enhancements that could provide additional value to the UI for Siemens. A promising technology that could transform how Siemens uses the UI is the implementation of Augmented Reality (AR).

Harbor Rotterdam has already indicated that AR would be a valuable addition for enhancing safety in the field and assisting the RCO at their desk station. AR technology is already capable of recognizing a person's face (Golnari et al., 2020). By implementing AR in the camera stream, we could potentially alert the RCO when a person is in an unsafe area while operating the containers. Additionally, AR could guide the operator to relocate containers more efficiently.

An important consideration is that the AR implementation should not place an additional load on the system, as this could affect the latency or frame rate of the camera stream.

Viability

Evaluating the viability, we primarily focused on practical standards for customizing the UI for future harbors, pivoting to a more complex design as a reference point in the redesign

The ethical, social, and environmental values of Siemens were considered by frequently informing Siemens on the status of the project and the design phases, promoting transparency. However, we did not take into account the ethical, social, and environmental values of their foreign clients.

Siemens aims to remain neutral in their designs to avoid conflict, but a more fitting approach would have been to contact their stakeholders in foreign countries. Establishing online contact could have effectively set up a framework regarding their values and contributed to the design of the UI, making it more attractive and sustainable for long-term use.

Feasibility

One way to improve the feasibility of this UI is to create a trial QT style sheet. As previously mentioned, the icons, camera size, and typography are not expected to cause any issues. However, a potential challenge could arise from the transition between an enabled button and a disabled button. There are two possible solutions taken into accoun. First, we could implement the plan previously defined in the feasibility section to observe how the transition looks.

Secondly, the other solution is to export several layers of the transition as SVG files. In this approach, the disabled state would contain all the layers of the transition, and the enabled state would progressively eliminate an SVG layer each time until it reaches the disabled state. See figure 58. This would reduce the load of the system.

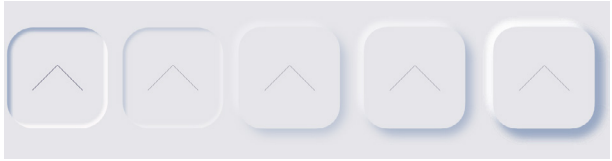


Image 58: Creating the transition by eliminating a SVG layer

Chapter 12.
Limitations

In this chapter, the limitations of the project scope are examined to provide an evaluation of the constraints and challenges encountered throughout the process.This chapter will discuss three topics that may have impacted the project: stakeholders, tools, and testing difficulties.

Stakeholders

One of the major limitations encountered during this project was the unexpected withdrawal of Harbor Rotterdam from the final user test. Initially, they appeared enthusiastic and willing to offer support and insight on how to improve the User interface. As highlighted in the discussion, relying solely on this target group was deficient. Consequently, the final user test had to be quickly reframed, which caused a loss of time and shortcomings in the results. Certain research questions and threats defined in the beginning of this project will remain unanswered.

Tools

Throughout this project, various tools were used, each with its own limitations. One significant limitation arose from Adobe XD, which lacked the ability to implement certain features such as blinking or setting time limits on a page. As a result, some interactive elements could not be fully tested and were instead designed to simulate these features. For example, blinking effects were emulated using a large mask behind the icon, which created a loading effect rather than actual blinking.

Another limitation was the absence of real camera streams on the middle and left monitors. Participants were only able to view static images representing how the monitors might appear. If participants had been able to interact with live camera streams, the monitors would have responded dynamically, potentially leading to more accurate results and a better sense of realism for the users.

Testing difficulties

When conducting a study, having a sufficient sample size is essential for drawing valid conclusions. During the high-fidelity tests, several difficulties were encountered. One major challenge was the time required to conducht a high-fi test with colleagues at Siemens, as they were often busy. Colleagues frequently needed to reschedule or lacked time for extensive tests, making it very time-consuming to obtain a sufficient sample size and process the data.

Another problem was measuring user concentration levels in a way that accurately reflects real conditions. User tests typically last about 45 minutes to an hour, but this does not represent the concentration levels of an operator working an 8-hour shift, 5 days a week. To address this, literature-grounded methods to optimize users' concentration should be implemented. However, to be fully certain, an operator should use the UI for several days.

Chapter 13.

Reccomendations

The recommendations can be partly drawn from the discussion and limitations sections, outlining what could be done to prevent similar issues in the future. Additionally, there are several parts of the UI that still need attention, and further additions could improve the overall user experience. The following bulletpoints present a summary of future recommendations:

- Explore the future implementation of AR.
- Investigate the needs and values of foreign clients, creating a framework for each client based on their unique national values and needs (Moran et al., 2010).
- Develop a trial QT sheet to test the transition between disabled and enabled states within the Siemens system.
- Test the proposal with the actual target group during both day and night sessions to address research questions.
- Find a precise way to measure users' concentration levels to determine if the redesign improves focus.
- Transition from Adobe XD to FIGMA. Adobe has a better interaction between programs, such as Photoshop and Illustrator. However, FIGMA has the possibility to test more features inside the UI, such as blinking.
- Test the new layout for the control screen, ensuring it matches the layout of the pushable control panels, enhancing the consistency and familiarity in the UI. This idea emerged from the last test, but conclusions can't be drawn until it's tested.
- The feature to change size is not of value when the RCO is actually operating the desk station. However, it could be of value when a RCO is still in training.
- Experiment with different nudging techniques to determine which are most effective

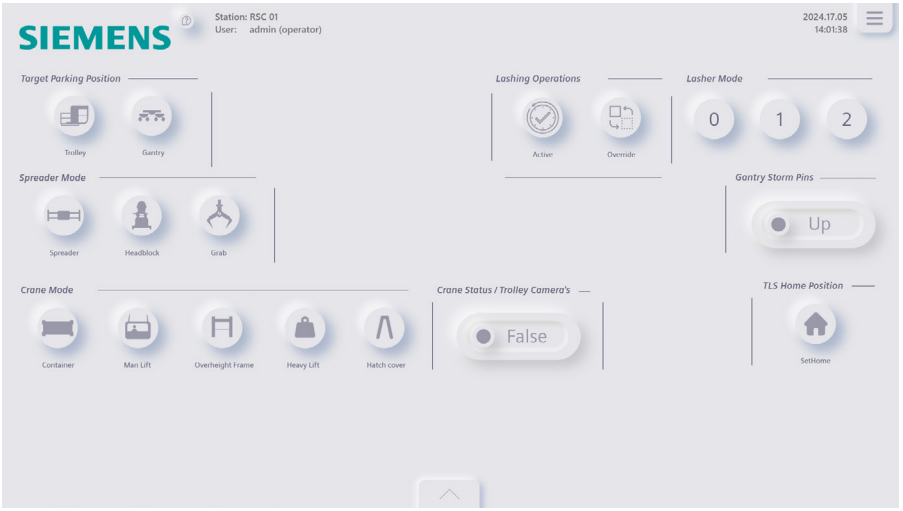


Image 58: Possible layout matching the control panels

Chapter 14 .
Reflection dive

In this chapter, we will delve deeper into the overall reflection of this design project. We will discuss the predefined goals, how I would approach the project if I were to do it again, and highlight the key learning points I will consider for in the future.

At the beginning of this project, I set two main goals: to learn about UI & UX as part of my final project during my Industrial Desing career and to work in a large multinational company. I did my best to achieve both goals, but my learning journey is far from over. Since I was the only designer in the Siemens crane department, it was hard to brainstorm with someone on visual communications. However, this pushed me to explore new ways of discovering visual communication through literature research.

I am grateful to Siemens for offering me the opportunity to work in a large company, where I experienced a new way of low-fi testing. I aimed to have direct on-site interaction with engineers to quickly integrate ideas, rather than the limited client interaction I encountered during my previous projects. I realized that I can still improve my skills regarding high-fi testing, and improve my approach to managing the schedules of stakeholders in the corporate setting better in the future. If I were to start this project again with the knowledge I have today, I would adopt a different design thinking approach. The design thinking model by Shapira et al. (2017) would have been a good fit. This approach includes the stages of discovery, interpretation, ideation, experimentation, and evolution. Given my current knowledge of UI and UX literature, the discovery phase would be a fitting first step. In this phase, challenges are immediately identified, and research is conducted through interviews and field visits, leading to a better understanding of the RCOS system and the stakeholders from the beginning. This would have been beneficial, especially considering the absence of Harbor Rotterdam in the last phase. In the interpretation phase, we would transform the gathered information into meaningful insights, identifying the key aspects of the problem. From this point, the design thinking approach of Meinel et al. would be similar.

By reflecting further on the project, I can identify several other areas where there is still room for improvement. Firstly, estimating the workload more accurately would be a great start. I have a habit of underestimating the time and effort needed to complete a task effectively. This became clear during the last user test, where I needed more time than I had initially estimated. Secondly, improving my written communication skills is crucial. I have always been aware that writing grammatically logical narratives is not my strong suit. This became particularly clear when I read back papers, that I thought were logical,only to discover that the written words did not match the story in my head.

Thirdly, enhancing my communication with stakeholders outside of Siemens. Harbor Rotterdam was initially open to being a pilot test client, and during the field research, they appeared enthusiastic to assist. However, their refusal to participate in the user test disrupted a significant part of the planned testing. This might have been prevented if I had a more stable communication and larger network of stakeholders outside Siemens. Lastly, regularly reading manuals would have helped me to prepare for certain unexpected events. This is another area I need to focus on to prevent future surprises. My next step would be to work in a smaller design agency to have more on-site interaction with fellow designers, where I can hopefully learn a lot from their experiences and insights.

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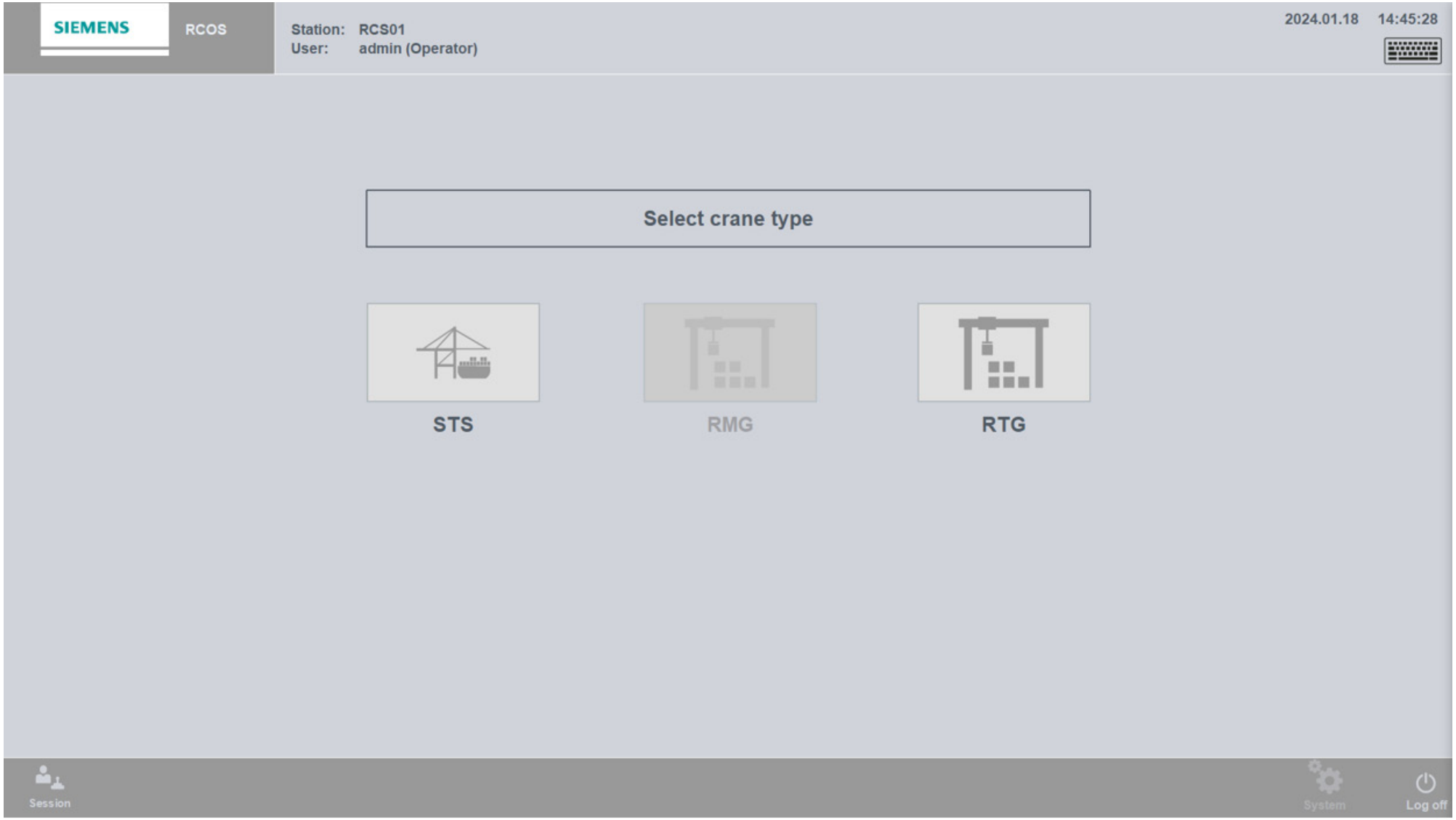
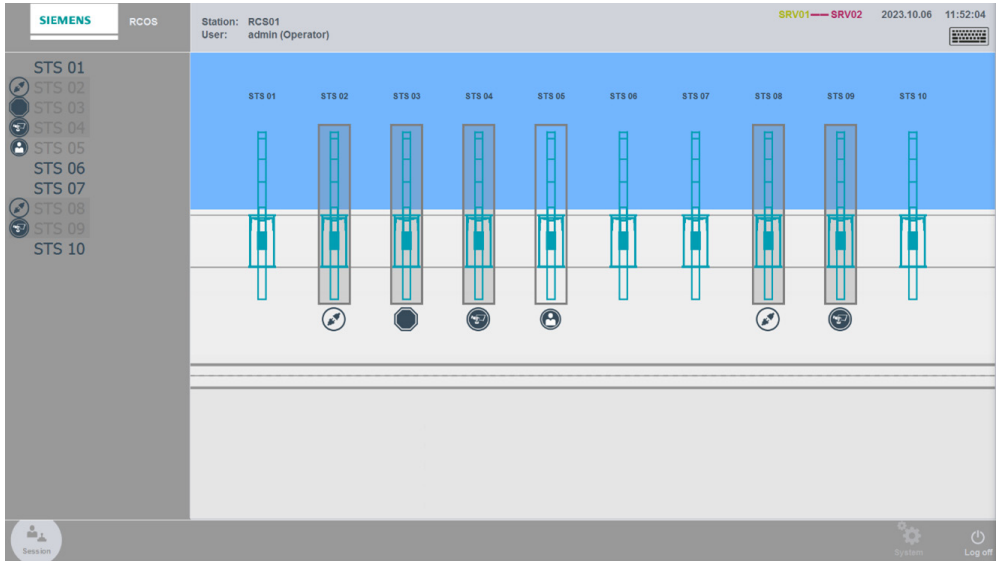
Appendix A.
Selection Crane type screen



Appendix B.
Different Crane selection screens

Session screen for OHBC, RTG, and RMG



Session screen for STS

Appendix C.
Pool Session

The type of session, and visualized page, depends on the pooling setting, see figure FIXME. When using RCOS the user can put the program on automatic and the cranes will reload and load the containers automatically. However, the RCO has to help or take over in case the automatic crane needs help. It will send a MI to remote control systems. The type of session and visualized page depends on the pooling settings. Set the 'Pooling' button to:

- Enabled (green highlight), to get an overview of Manual interventions (MI) requested by cranes.
- Disabled (gray/no highlight), to get an overview of the Cranes to manually establish a connection to an available crane, even if an MI is requested by that crane.

When pooling is enabled, it is possible to manually select an active MI or to have MIs automatically assigned. Set the 'Auto' button to:

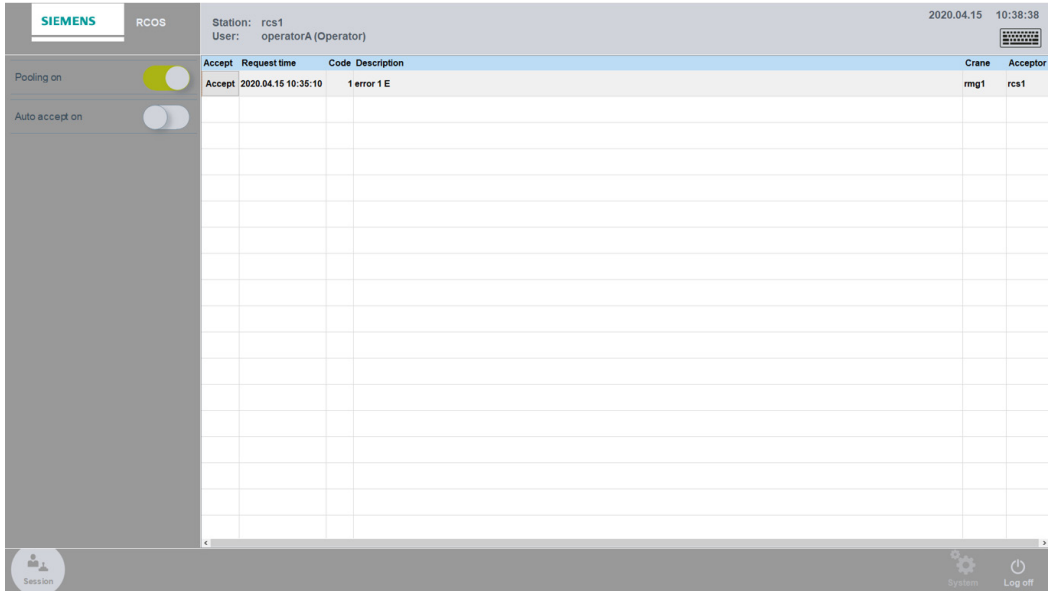
- Enabled (Green highlight), to get MI's automatically assigned.
- Disabled (gray/no highlight), to manually select an available MI.

Manual Intervention requests are exclusively assigned to Operator Remote Control Stations having Pooling enabled based on the following criteria:

- Operator skill level
- Idle time of Operator

To accept or release an MI the RCO can press the hardware RCS control or RCS release on the physical desk. This is indicated by a blinking RCS control/ release button, with an accompanying message on screen whenever possible.

This screen used toggles instead of a single button. A toggle provides an extra indication, place of button, about the state of the button. Moreover, it is stated that the operator skill level and idle time is operator, which shows opportunities for a feedback system. The information is already being measured; however, it is not used in any other implementation in the UI.



Appendix D.
Task flow Harbor Rotterdam
Default screen

Appendix E.
Details functionality - Left monitor

1. For each camera a red border is shown to indicate high latency and/ or low frame rate alert.
2. Camera PTZ indicator functionality is predefined in the section 16 PTZ camera mode indicated by character A, M and O.
3. RCOS message to alert user for pressing RCS control after requesting a session. It also include permissive messages to assist operator during the session.
4. Camera information with Crane ID – Camera number – Current date – Current time

Appendix F.
Details functionality - Middle monitor

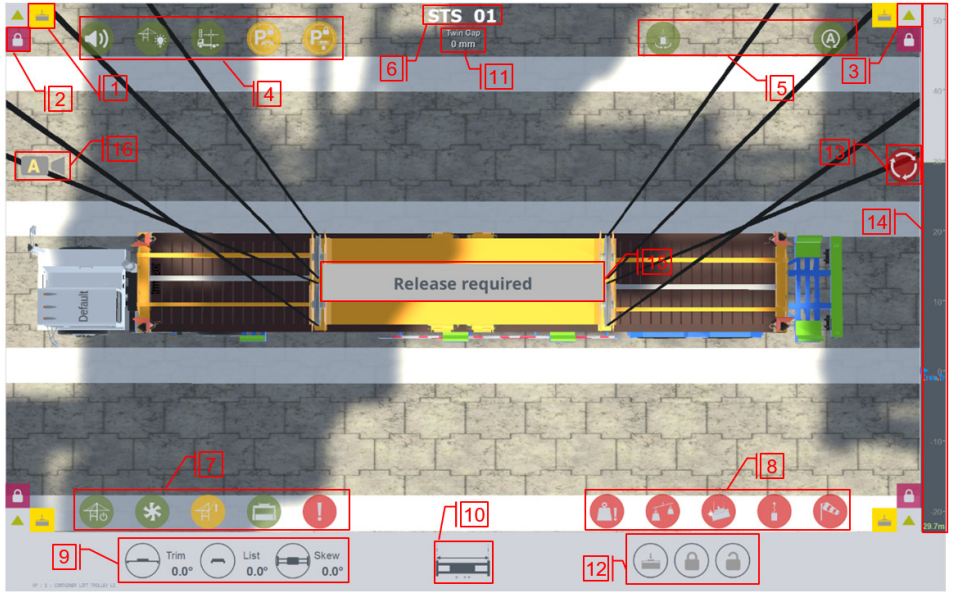
1. Landed indicator on all four corners of the screen and on the top/ bottom of the middle of the screen, when either the LandSide spreader or the WaterSide spreader is selected. Landed indicator on all four corners of the screen, the top and bottom of the middle screen and the center left, middle and right of the screen, when tandem spreader is selected.

2. Locked and Unlocked indicator on all four corner of the screen and on the top/bottom of the middle of the screen when either the LandSide spreader or the WaterSide spreader is selected. Locked and Unlocked indicator on all four corners of the screen, the top and bottom of the middle screen and the center left, middle and right of the screen, when tandem spreader is selected.

3. Flipper Up(Arrow Up)/ Down(Arrow Down) Indicator on all four corners of the screen when either the LandSide spreader or the WaterSide spreader is selected. Flipper Up(Arrow Up)/ Down(Arrow Down) Indicator on all four corners of the screen, the top and bottom of the middle screen and the center left, middle and right of the screen, when tandem spreader is selected.

4. Indicator from left to right on the top left of the screen
- Horn (Green)
- Flood Lights on (Green)
- Truck in position (Green)
- Gantry Parked(Green) / Storm Pins Down(Yellow)
- Trolley Parked(Green) / Storm Pins Down(Yellow)

5. Indicator from left to right on the top right of the screen
- Sway Control on(Green) / Sway Control Off(Yellow)
- Automation is On (Green) / Crane is ready to start Automation (Flashing Green)



6. Crane ID

7. Indicator from left to right on the bottom left of the screen
- Crane On (Green) / Crane Off (Red)
- Pump On (Green)
- Boom Up (Yellow) / Boom Down (Green)
- Man Lift Mode On (Green)
- General Fault (Red)

8. Indicator from left to right on the bottom right of the screen

- Overload (Red)
- Load Imbalance (Red)
- Snag load (Red)
- Slack Rope (Red)
- Wind Fault (Red) / Wind Warning (Yellow)

9. Trim List Skew indicator, Turns green when TLS stored position is reached

10. Spreader Size indicator

11. Twin Extend and Retract indicator with Twin Gap in millimeter

12. Landed, Lock and Unlock

13. Emergency stop indicator

14. Hoist Height bar Indicator

15. Pop up for operators input this pop up can indicate two things. The first pop up message, will be displayed when the lashing operation is ongoing and indicates that the lashing platform needs to be released. The second pop up message, is displayed when the platform generate a CAT0 fault in this case an intervention from the operator is required in the form of a reset.

16. PTZ camera mode indicated by character A, M and O

- Automatic (A) is when camera follows the crane movement and set the current view angle and zoom of the camera automatically.
  Manual (M) is when camera is controlled by mini secondary controller as explained in Table 8 and Table 6.

- The camera to be controlled manually must be preselected from the touch panel.
- Overview (O) is when camera is preselected from touch panel and toggled to overview (An overview of the working zone covered by PTZ camera which will be configured as per the operational requirements) by pressing yellow button on left joystick

Appendix G.
Details functionality - Right monitor

When connected to a crane the operator has access to the to the "Status" page, the various parameters, represented by numbered red squares.

1. The status information of the tandem spreader with Gap – Offset – Relative skew.

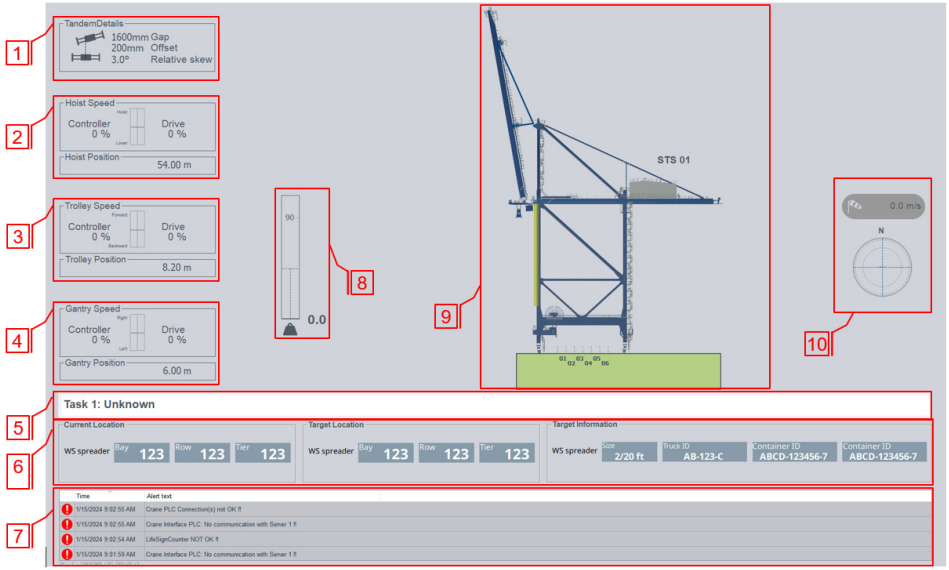
2. Hoist Setpoint and Position Indicator.

3. Trolley Setpoint and Position Indicator with Current Ship row and truck lane indicator.

4. Gantry Setpoint and Position Indicator.

5. Manual intervention task messages will appear when the operator's intervention is required to continue the automated move. MI descriptions indicates the requested action from AA. In case a new message is received, i.e. after a MI has been resolved and a new MI is triggered while still connected, then a red border is blinking for a short period to get user attention. Once user resolves the MI, Auto On button will start blinking green. The crane indicates to RCOS user that it can continue the automated movement and user can press Auto On button, the green LED will stop blinking and stays illuminated. RCOS desk will go into view only mode and all the controls will be disabled except fault reset and emergency stop. Now Operator has a choice to either release the desk using RCS release button or continue monitoring the operation via cameras on the desk.

6. Crane current job description with current(bay – row – tier), target (bay – row – tier) and target information (truck ID – size – container ID) from QMS. Row will be replaced by truck lane information when the current or target position is on the truck lane. Container ID, container size and truck ID is also shown to the operator. If the current location matches the target location the indicator will turn blue.



When twin mode is active the target information shows two container ID's for spreader left and right.

7. A short list of the alarms on the crane. The detailed status of the alarms can be found in the Alarms Tab on the Touch Panel.

8. Weight indicator displays the current lifting weight in tons.

- Boom angle is displayed during the boom up and down

9. The trolley spreader movement and boom Up / Down are shown in the crane side view. In addition to the crane side view, give the operator graphical information to help with the operation, including such:

- Free height after which no obstacle are expected in the trolley travel direction.
- Hatch height indicates the current hatch height of the ship.
- Catwalk height indicates the current catwalk height.
- Ship Bay Scan Profile.
- Boom angle is displayed during the boom up and down movement.
- Boom up and down is indicated by flashing boom intermediate position with arrow sign for direction of movement.
- Source and target location of the container is indicated by orange and green bar.
- Truck lane is indicated by the truck lane number on the bottom of the crane side view.
- Ship row numbers are also indicated on the bottom depending on the ship configuration.

10. Wind Speed Indicator displays current wind speed in relation to the global north plane, as well as wind warning and fault indicators.

Appendix H.
Color Scheme Siemens & guide ruiles

Dos and don'ts

Do

Use the shape only with its given proportion.

Do

Use the complete shape and the given spacing within a shape.

Do

Always use the shapes with its given colors. Shapes are only colored in Bold Green and/or Bold Blue.

Do

Shapes can be combined with cut-out images.

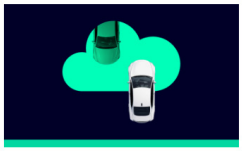
Do

Shapes can be used as image masks. The mask can consist of an image or objects, people, landscapes, and abstract photography.

Do

Shapes can be combined with images.

Dos and don'ts



Do

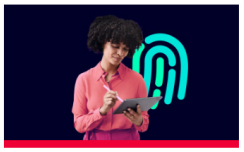
Please be sure the image element is cut out cleanly and interacts logically with the shape.

Do

Cut-outs can feature people, products or architecture. They must be images, not illustrations.

Do

Use images that have a flat perspective.



Don't

Don't use outfit colors that clash with layout colors. Also, don't use images with strong shadows or highlights, or that lack enough contrast with the background.

Don't

Don't use low-quality images (grainy/pixelated).

Don't

Don't use images with extreme perspectives.

State: 2023-01-05

		Color name	Screen: RGB decimal	Screen: RGB hexadecimal	Print: CMYK	Pantone	HKS 3000+	Event and exhibition: NCS	RAL Classic	RAL Design	Sikkens 5051 Color Concept
Corporate gradients		Bold Dynamic Petrol*	**A** 0 255 185 **B** 0 230 220 organic, CTA and UI linear only	**A** 00ffb9 **B** 00e6dc organic, CTA linear only	–	Please download the gradient files here: https://brandville.siemens.com/en/design-elements/color-new/#gradients					
		Soft Dynamic Petrol*	**A** 0 215 160 only organic **B** 0 190 220 only organic	**A** 00d7a0 only organic **B** 00bedc only organic	**A** 60 0 50 0 only organic **B** 70 0 10 0 only organic						
		Deep Blue–Siemens Petrol	**A** 0 153 153 only organic **B** 0 0 40 only organic	**A** 009999 only organic **B** 000028 only organic	**A** 100 0 40 0 only organic **B** 100 90 30 75 only organic						
Primary colors		Siemens Petrol	0 153 153	009999	100 0 40 0	321 C	51 K	S 2555-B20G	5018	200 50 45	P0.40.50
		Light Petrol	0 193 182	00c1b6	70 0 37 0	2398 C	51 K-70-00	S 2040-B50G	–	190 60 35	N5.28.62
		Bold Green	0 255 185	00ffb9	–	3385 C	–	–	–	–	–
		Soft Green	0 215 160	00d7a0	60 0 50 0	2412 C	54 K-50-00	S 2040-G	–	160 70 30	L7.23.68
		Bold Blue	0 230 220	00e6dc	–	3115 C	–	–	–	–	–
		Soft Blue	0 190 220	00bedc	70 0 10 0	3545 C	48 K-60-00	S 1050-B	–	220 70 35	Q5.35.62
		Deep Blue	0 0 40	000028	100 90 30 75	5255 C	41 K-100-50	S 8010-R90B	5004	280 20 15	U3.15.11
		Light Sand	243 243 240	f3f3f0	0 0 3 8	9043 C	95 K-20-00	S 1000-N	9002	000 90 00	ON.00.83
Secondary colors		Dark Sand	170 170 150	aaaa96	0 0 20 43	7537 C	95 K-80-00	S 4005-G80Y	7030	100 70 05	H1.05.54
		Soft Sand	197 197 184	c5c5b8	0 0 12 30	2330 C	95 K-60-00	S 2005-G60Y	7038	100 80 05	G6.04.66
		Bright Sand	223 223 217	dfdfd9	0 0 6 18	Cool Gray 1 C	95 K-40-00	S 1002-G50Y	7035	000 85 00	HN.02.77
		Dark Yellow	247 198 0	f7c600	0 25 100 5	7408 C	4 K-100-10	S 1070-Y10R	–	080 80 70	F2.64.70
		Yellow	255 215 50	ffd732	0 15 100 0	Yellow 012 C	4 K-80-10	S 0580-Y	1018	085 80 80	F8.66.75
		Soft Yellow	255 226 112	ffe270	0 10 70 0	120 C	1 K-100-00	S 0550-Y	–	085 80 60	F7.40.78
		Dark Green	0 100 110	00646e	75 0 25 55	7476 C	51 K-100-50	S 5040-B20G	5020	210 40 25	P4.48.27
		Green	0 175 142	00af8e	85 0 65 0	339 C	54 K-70-00	S 2060-B90G	–	170 60 45	M3.51.44
		Dark Blue	0 85 124	00557c	100 60 30 10	7700 C	46 K-100-50	S 4550-B	5019	240 40 30	S0.47.28
		Blue	0 135 190	0087be	80 30 10 0	7689 C	46 K-80-00	S 2060-B	5012	240 50 40	S0.50.50
		Dark Purple	85 59 163	553ba3	85 100 0 0	268 C	36 K-100-00	S 3555-R60B	–	310 30 40	W3.32.30
		Purple	128 92 255	805cff	60 80 0 0	2583 C	33 K-60-10	S 2050-R50B	–	310 60 35	W7.23.48
		SoftPurple	180 168 255	b4a8ff	25 35 0 0	2635 C	35 K-40-00	S 1030-R60B	–	300 80 15	V6.11.70
		Deep Blue 80%	51 51 83	333353	80 68 30 55	533 C	41 K-100-30	S 7020-R70B	–	280 20 20	U0.30.16
		Deep Blue 60% / Dark Gray	102 102 126	66667e	60 48 20 40	2376 C	41 K-60-30	S 6020-R80B	–	270 40 15	U1.14.39
		Deep Blue 40%	153 153 169	9999a9	38 28 12 20	2163 C	41 K-30-30	S 3020 B	–	250 60 10	S2.14.54
		Deep Blue 20% / Soft Gray	204 204 212	ccccd4	20 13 5 12	537 C	41 K-20-00	S 2010-R80B	–	260 80 10	U1.06.71
		Deep Blue 10%	229 229 233	e5e5e9	10 6 0 10	9381 C	41 K-10-10	S 1010-R70B	–	270 85 10	U0.07.76
		Red	239 1 55	ef0137	0 100 75 0	199 C	23 K-100-10	S 1085-Y90R	3018	020 50 58	B7.53.35
		Dark Orange	236 102 2	ec6602	0 70 100 0	166 C	7 K-80-30	S 1080-Y60R	2010	050 50 78	D6.66.53
		Orange	255 144 0	ff9000	0 45 90 0	2011 C	6 K-70-30	S 1080-Y20R	–	070 70 70	E7.67.63
Skin tones		Skin 1	90 40 40	5a2828	40 80 65 60	–	–	–	–	–	–
		Shade 1	65 30 30	411e1e	50 80 65 70	–	–	–	–	–	–
		Skin 2	140 80 70	8c5046	30 65 60 35	–	–	–	–	–	–
		Shade 2	100 60 55	643c37	45 70 60 50	–	–	–	–	–	–
		Skin 3	155 100 75	9b644b	30 55 60 25	–	–	–	–	–	–
		Shade 3	100 65 50	644132	45 65 70 50	–	–	–	–	–	–
		Skin 4	231 160 107	e7a06b	5 40 60 0	–	–	–	–	–	–
		Shade 4	211 131 79	d3834f	20 55 75 0	–	–	–	–	–	–
		Skin 5	255 205 170	ffcdaa	0 25 35 0	–	–	–	–	–	–
		Shade 5	235 175 135	ebaf87	5 37 50 0	–	–	–	–	–	–
		Skin 6	255 225 184	ffe1b8	0 12 32 0	–	–	–	–	–	–
		Shade 6	236 195 153	ecc399	0 25 40 8	–	–	–	–	–	–
Hair tones		Hair 1	0 0 0	000000	0 0 0 100	–	–	–	–	–	–
		Hair 2	50 30 20	321e14	60 75 75 70	–	–	–	–	–	–
		Hair 3	150 95 45	965f2d	50 70 100 0	–	–	–	–	–	–
		Hair 4	180 90 10	b45a0a	0 65 100 30	–	–	–	–	–	–
		Hair 5	195 160 40	c3a028	28 35 100 0	–	–	–	–	–	–
		Hair 6	223 223 217	dfdfd9	0 0 6 18	–	–	–	–	–	–
		Hair 7	243 243 240	f3f3f0	0 0 3 8	–	–	–	–	–	–
		Hair 8	255 255 255	ffffff	0 0 0 0	–	–	–	–	–	–

Appendix I.
All UI Design Principles

1. **Aesthetically pleasing:** Visually pleasing composition, attractive to the eye. It subtly communicates its message with clarity and immediacy.

2. **Clarity:** The interface should be easily understood or perceived without confusion. Metaphors and analogies should be straightforward and grounded, while interface texts should be simple and clear of computer jargon.

3. **Compatibility:** Different elements of the user interface should work together or interact effectively without conflict or loss of functionality.

4. **Comprehensibility:** A system should be understandable, following a logical and meaningful order. Strong clues to the operation of objects should be presented. The steps needed to complete the task should be obvious.

5. **Configurability:** Simple personalization and customization through system configurations and reconfigurations enhances a sense of control, stimulates active role in understanding, accommodates personal preferences in experience levels, ultimately leading to a higher user satisfaction.

6. **Consistency:** A system should ensure similar components who share uniform appearance, functionality and operational behaviors. Actions should consistently produce predictable outcomes, and the function and positioning of standard elements should remain constant.

7. **Control:** Control is the feeling of being in charge, where one feels that the system is responsive to their actions.

8. **Directness:** Tasks should be executed directly with visible alternatives, minimizing the user's cognitive load and mental workload (AMX, 2012). Directness is best achieved through the object-action sequence.

9. Efficiency: Eye and hand movements should be used efficiently, with attention drawn to relevant screen elements when necessary.

10. Familiarity: Employing familiar concepts and language that are familiar for the user. Maintaining a natural interface that mirrors the users behavior patterns, and implementing real-world metaphors.

11. Flexibility: Indicating the system's ability to accommodate individual variations among people, allowing them to select the interaction method best suited to their circumstances.

12. Forgiveness: Mistakes are inevitable, thus a UI should be forgiving for common and unavoidable mistakes. People often learn through exploration and trial and error, so a UI that is overly sensitive will discourage people from interaction.

13. Predictability: The quality of being able to forecast or anticipate outcomes, behaviors, or events with a reasonable degree of accuracy based on past experiences, patterns, or established norms.

14. Recovery: Returning to a stable and functional state after experiencing an error. Easy recovery from action greatly facilitates learning by trial and error, and exploration.

15. Responsiveness: A user request must be responded quickly, which can be brought visually through changes in the mouse pointer shape, textually through messages, or through distinct sounds or tones.

16. **Simplicity:** Simplicity refers to the quality of being easy to understand and straightforward, avoiding unnecessary complexity. According to Uday Bhaskar et al. (2011) this can be done by five ways:
- Use progressive disclosure, hiding things until they are needed.
  - Present common and necessary functions first.
  - Prominently feature important functions.
  - Hide more sophisticated and less frequently used functions.
- Provide defaults.
- Minimize screen alignment points.
- Make common actions simple at the expense of uncommon actions being made harder.
- Provide uniformity and consistency.

17. **Groupings:** Grouping screen elements serves to establish structure and meaningful relationships, enhancing overall form and aesthetic appeal. Furthermore, past research indicates that grouping facilitates information recall and faster screen search.

18. **Groupings using white space:** Galitz (2002) advises ensuring sufficient separation between groupings by employing ample white space, while also urging careful consideration of the balance between screen white space and the need for page scrolling.

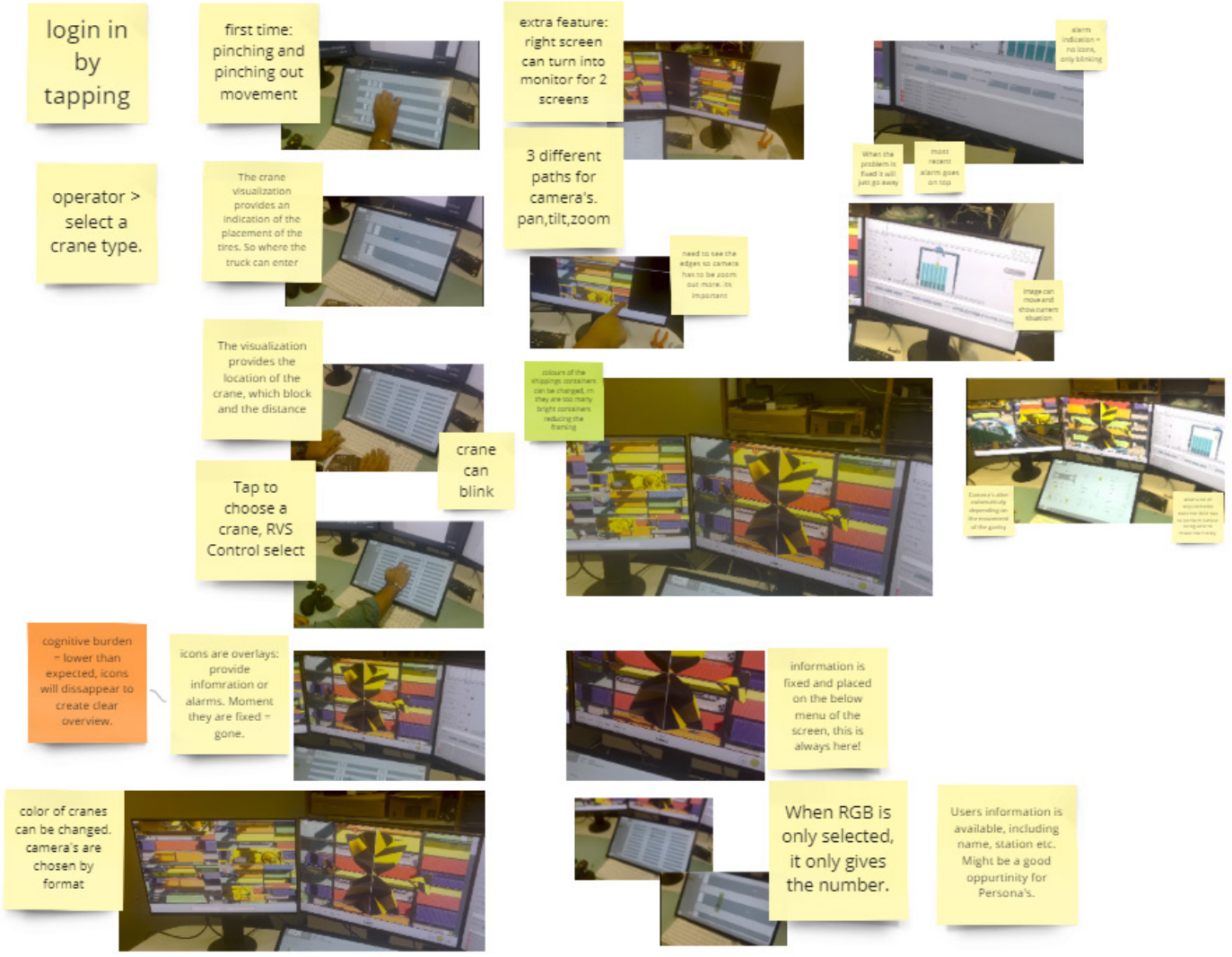
19. **Grouping using borders:** According to Galitz (2002), when grouping with borders, it is recommended to (a) utilize line borders for: (i) directing attention towards groupings or related information, and (ii) guiding the eye across the screen.

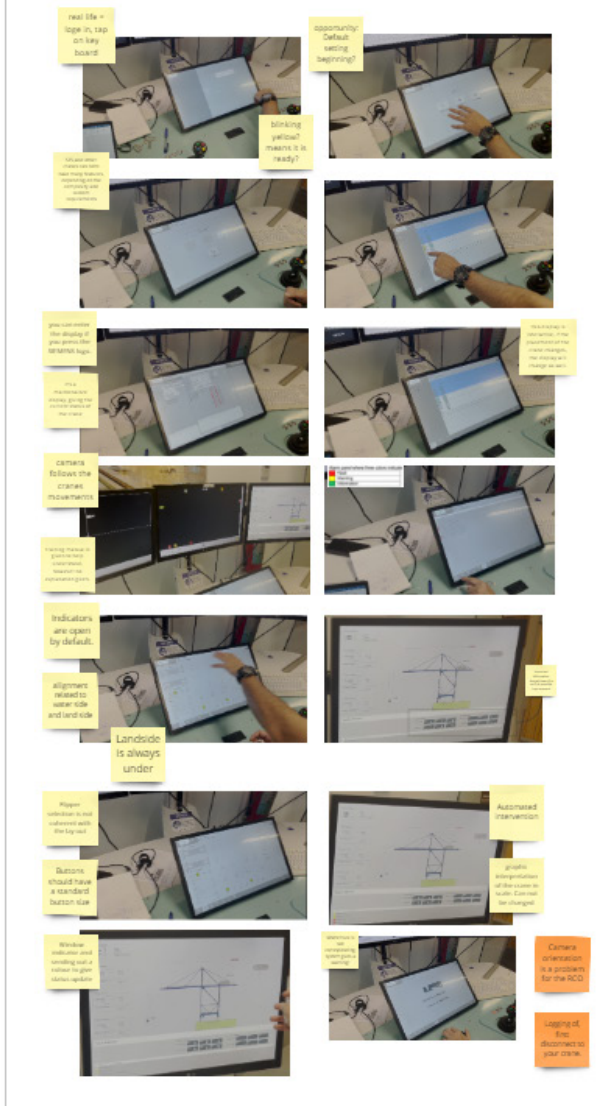
20. **Focus and Emphasis:** According to Galitz (2002), it is recommended to use a visual emphasis technique to draw attention to the most significant or prominent elements of a screen. An emphasized element should stand out in contrast to the rest of the screen, capturing the user's attention.

Appendix J.
Gestalt principle: Common Fate

The Common Fate principle states that objects that move together are perceived as grouped or related.

Appendix K.
Observations step 1





Appendix L.
Gannt Chart

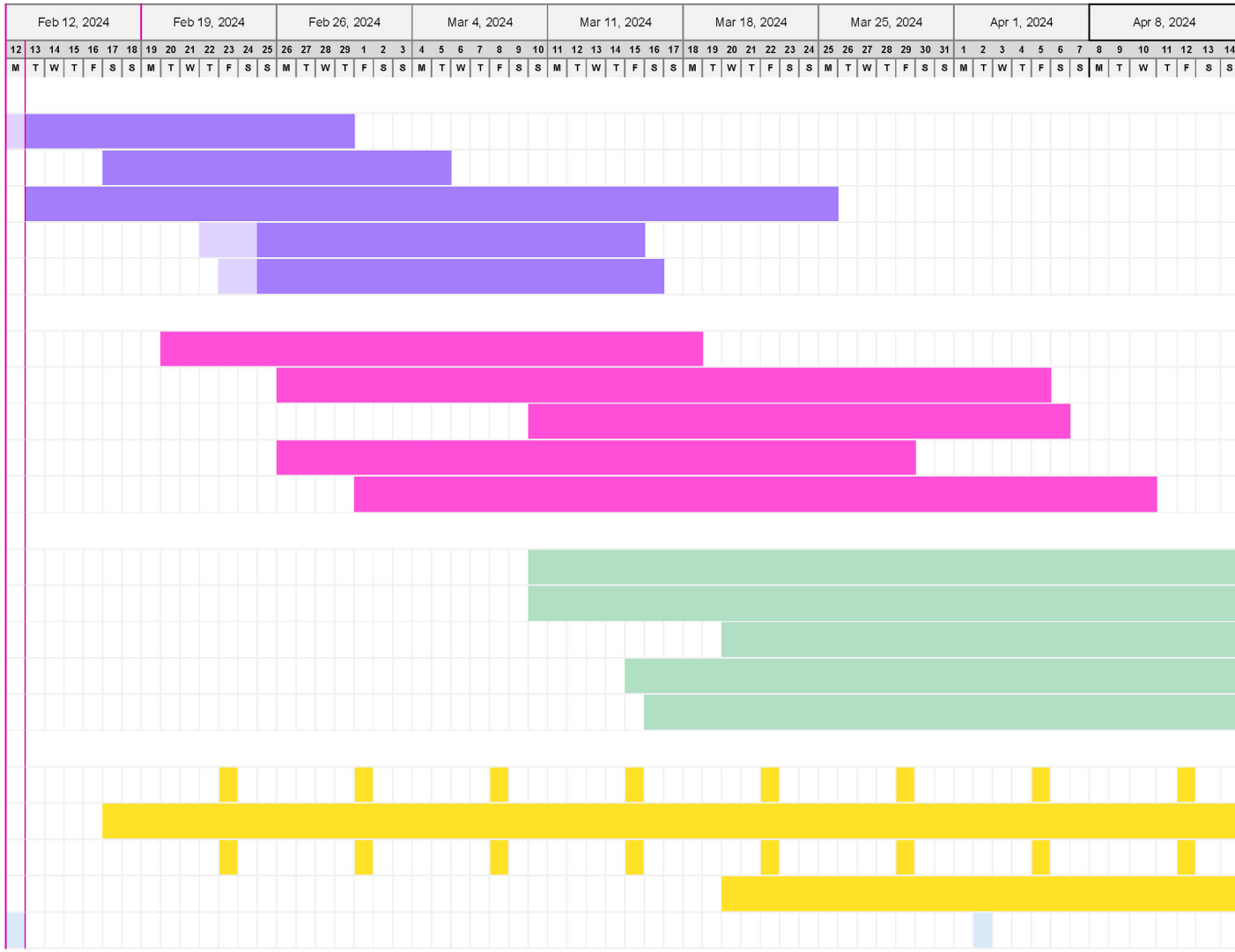
User Interface for Cranes

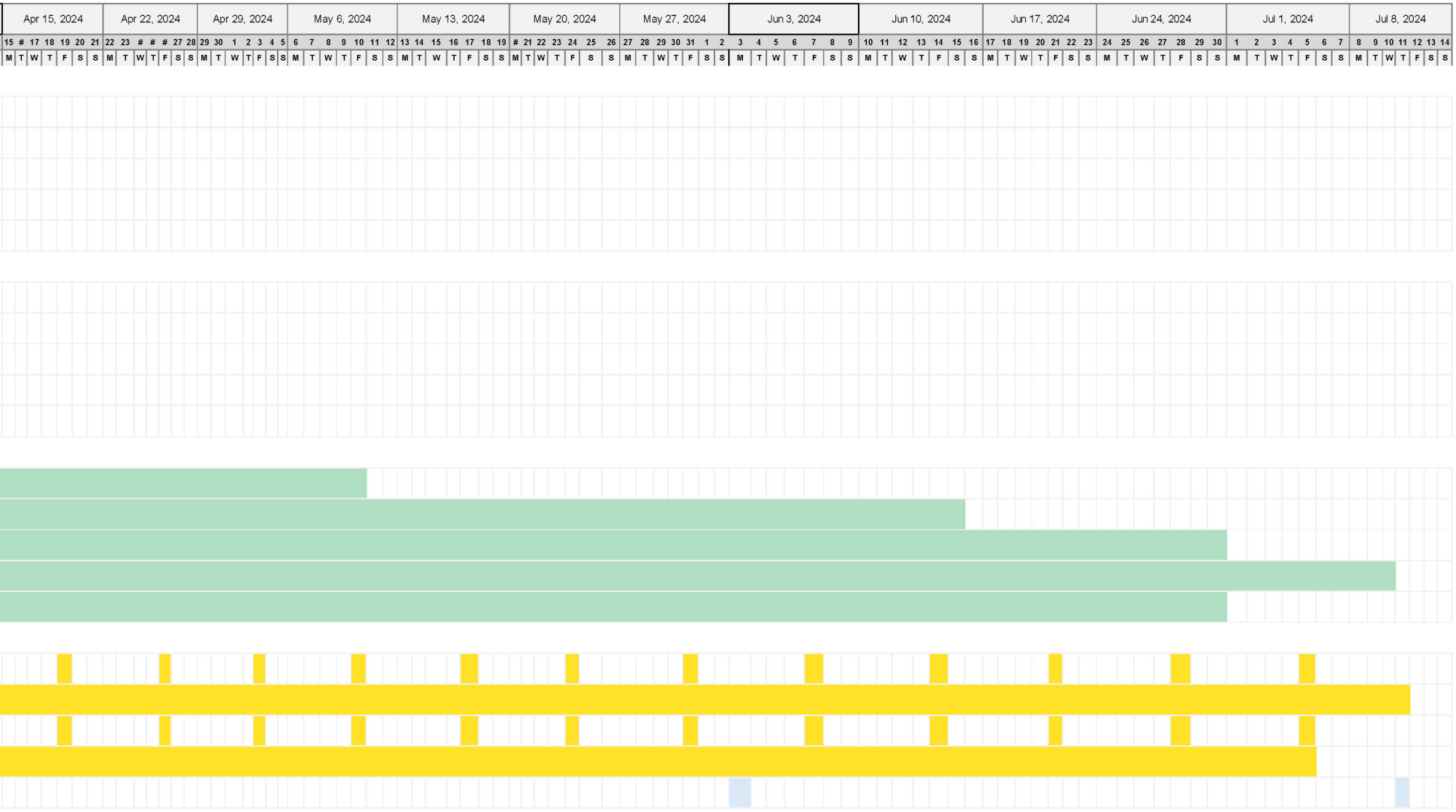
Jos van der Velden — Siemens & TU Delft

total hours: 880

Project start: **Mon, 2/12/2024**

TASK	hours	PROGRESS	START	END
Initiation				
Define goals		10%	2/12/24	2/29/24
Define methodology		0%	2/17/24	3/5/24
Starting literature research		0%	2/13/24	3/25/24
Identify limitations		15%	2/22/24	3/15/24
Identify opportunities		10%	2/23/24	3/16/24
Market investigation				
Stakeholder analysis		0%	2/20/24	3/18/24
User interviews		0%	2/26/24	4/5/24
Ergonomic studies		0%	3/10/24	4/6/24
Field research		0%	2/26/24	3/29/24
Product need & wishes		0%	3/1/24	4/10/24
Conceptualization				
Brainstorm		0%	3/10/24	5/10/24
Concept ideation		0%	3/10/24	6/15/24
User testing		0%	3/20/24	6/30/24
Technical documentation		0%	3/15/24	7/10/24
Prototyping		0%	3/16/24	6/30/24
Evaluation				
Evualtion moment (feedback)		0%	every Friday	end of the week
Update report		0%	2/17/24	7/11/24
Evaluate progress		0%	every Friday	end of the week
Testing and validation		0%	3/20/24	7/5/24
Presentations & Meetings		0%		




Apr 15, 2024
Apr 22, 2024
Apr 29, 2024
May 6, 2024
May 13, 2024
May 20, 2024
May 27, 2024
Jun 3, 2024
Jun 10, 2024
Jun 17, 2024
Jun 24, 2024
Jul 1, 2024
Jul 8, 2024

Appendix M.
Raw Notes Harbor Rotterdam

. Test room Observaties 6-3-2024 Harbor Rotterdam

Training table: prints van physical remotes, right side of the user interface has a covered button
2 screens on the top of the RCOS table as well. Audio mic is placed on the right side of the touch screen.

2 Key boards are located on the table,. Alarm is bell is located above the top screen?
Both arm path are located pretty far from each other.

RCOS configurator has 10 features here?

Collin is momenteel op 8:31 een werk volgorde QC088 aan het toevoegen. Manual intervention. Geven info als volgt:

88 I Laden 88 I AGV 065 I 40 FT I 8'6 FT I Direct I Off Std I

Alles in de Harbor Rotterdam UI maakt gebruikt van flat icons. Buiten bereik wordt ook aangegeven door een pijl. Flippers SZ, Flippers Zij-kant, Flipper ALLE.

Nieuwe weiger knop (flat) icon aangevraagd!
Wordt direct naast het nummer 88 geplaatst. Geen px ruimte tussen gelaten. Andere functie wordt aangegeven met een L, M en een R (Hulpje voor de machinist) 20 Ft L en 20 Ft right, meet op wat precies de afstand er tussen op en brengt naderhand gelijk weer terug naar 0 punt.

Radio wall scherm, frequente scherm van wat ze aan het lossen zijn. Het rechter scherm is het oeu scherm, daar kan je zelf de exception handle wegwerken.

Steeds meer klachten over vermoeiheid door scherm. Let op met licht van andere kamers. Ze werken nu steeds 1.5 uur achter elkaar. Vol met de automatiek, 15 a 18 containers per uur met alle RCOS running in de kamer. !!!!

Harbor Rotterdam efault state shows: date; time; right above. Above the selection of cranes there is an i displayed. The crane without a name under it (name = operator) shows purple/pink appearance. Second to the right the crane shows a white appearance with a tik under it, meaning the manual actions are done?

Middle monitor: shows multiple overlays (flat icon) which are approximately 1 by 2 cm. colors corresponds with red and Harbor Rotterdam green/blue. System shows real camera image. When selected white crane turns green!. Left screen shows 5 different angles of camera's. Manual camera button is half visible, half transparent. Width of the spreader is showable in the lower bar of the middle screen. Middle monitor shows right square around camera and shows display on the touch screen.

Ranj – gaming company, toen het begon, eerste Pilot in Dubai. Maar toen ook begonnen. Cogntieve burden is nog groot bij de vele schermen. Het gaat in principe alleen die twist locks. Presenteer alleen de positie van de twist locks. Waarom moeten we in die containers eigenlijk in beeld brengen?

ICONS Relevante icontjes worden alleen ingeschakeld . werkelijke hoogte verschil moet accurater zijn. Werkelijke hoogte van de spreader en de last eronder. Ligt aan je last, wat je rek is natuurlijk.
Waarom laten we de maximale hoogte zien van op de display. Gebruikers maken niet gebruik van alle infromatie die wordt gedisplayed. Ergo daarom de cancel knop, je kan soms de verkeerde container pakken. Hoogte van de

container meten = zekerheid. Voor de laad cyclus is het beter om de precieze hoogte te weten.

Lossen lastiger: container oppak en een klein beetje weg rijd. Klein beetje cad rijden kan je gelijk een gat opmeten het in je traject verwerken.

Wanneer heb je welke informatie nodig? Wat presenteer ik en wat is nuttig?

Overall: Zekerheid van de huidige hoogte. Punt lasers worden er momenteel gebruikt. Ze kunnen niet vooruit kijken, eb en vloed hebben invloed. Punt lasers zitten aan de trolley,

Haptic feedback: waar heeft het toevoegde waarde, snel en onbewust bewerken. Toggle knop voor beide flippers en twist lock. De bediening mag niet over complex worden ivm veiligheidsmaatregelen.

IPAD met touchscreen met HDMI. Opdrachten gaan geven, eerdere gevallen zijn gelijk wel initiatief aan de slag gegaan. Een haartje op: deel van de twistlocks los, weergeven op display. Lift assistentie.

Aandacht van gebruiker fout gegaan, tonnen schade. Layence dipslay wat er precies gebeurd, begeleid de gebruiker meer. Harder contrast in het midden scherm ivm mist. Haptic feedback, communicatie over de lijn. Geluiden gaan onder de communicatie door. Maar ze hebben al een head set op.

Pre determined movement (10inc) with an specific movement.- already tested, still positive but we need to stay close to the reality. In an certain way they get used to .

Latency indication should be more clear for the users.

Blinking yellow indication icon, number blinks, 2 20ft.
Consistency with entire user interface, regarding width and height.

Appendix N.
High-fi Test plan 1

Test setup

First show the previous UI of the RCOS system. Give a short explanation about the system and what it is used for. Furthermore, a short explanation about the styles of UI will be given, explaining why certain things look minimalistic etc. The following questions will be asked in an open conversation, in that way we give the user to space to think out loud:

- What is your first impression when you see the current User interface of Siemens?
- Is it clear for you which buttons/features/widgets are interactive, and which
- What would you like to add?
- What would you change to the design of the User Interface?
- Are there features you personally prefer in a user interface to make the UI more user friendly?
- Are you familiar with the terms displayed on the screen?

Screen 1 Skeuomorphism

Questions:
- What is your first impression of the UI?
- What is your opinion about the appearances of the buttons.
- Is it clear which buttons are interactive, and which are an overlay?
- Do you perceive any information here as an overload?

Tasks:
- Turn on the cranes and select the Landside spreader.
- When you have selected the Landside spreader, determine the width of the landside spreader to 20.
- Turn on the PTZ 4 camera.
- Turn on the Waterside spreader and set the mode to two spreaders.
- You want the system to remember the distance between the waterside spreaders.
- You want to move the crane as a whole, which button do you need to press.
- You want to move the boom up, what buttons do you need to push.
- You want to switch to another User Interface.

Screen 2 Skeuo minimalistic

Questions:
- What is your first impression of this current User interface?-
-Could you look at this UI for 10 hours straight?
-What is preference, no night light or the usage of a night light, when conducting the tasks with this User interface.
-Do you find this User interface clearer compared to the other?

Tasks:
-Turn on the Crane.
-Select the Waterside spreader and put auto flipper on
-When both spreader are selected, put the width to twin. Is this indication on the button enough or do you wish something more?
-Put the TLS camera 3 on.
-You want the system to remember the distance between the waterside spreaders.
-You want the spreader to automatically go back to the stored distance between the spreaders.
-Remember the angle of 1 spreader and bring it back to that angle.
-While moving a spreader you crashed to a wall, the system wants you to stop, but you believe you can still conduct the task. How would you go past the system and still do it.

Screen 3 neumoprhism

Questions:

-What is your first impression of this current User interface?
-Could you look at this UI for 10 hours straight?
-What is preference, no night light or the usage of a night light, when conducting the tasks with this User interface.
-Do you find this User interface clearer compared to the other?
Tasks:

-Turn on the keyboard feature.
-Turn on both the cranes make sure all the flippers are selected.
-Make the Boom move upwards.
-Determine the angle and movements of two spreaders.
-The system gives a false alarm, you want to go forwards. How do you do that.
-Determine the distance between the landside spreaders and put on the hydraulic pump.

Screen 4 Neumoprhism minimalistic

Questions:

-What is your first impression of this current User interface?
-Do you find this User interface clearer compared to the other?
-Do you find it hard to use the user interface without the indications of icons.
-Do you prefer this lay out or do you prefer the other lay outs.

Tasks:

-Turn On the Landise spreader and set the width of the spreaders to twin.
-Turn on all the flippers of the waterside spreader.
-Make the UI remember the angle and position of both spreaders.
- Where is the helpdesk in this UI?
-Change the size of the Icons.
-Turn off the Waterside spreader and set the mode to 1
-Set the width of the landside spreader to 45 and turn on all the flippers to the waterside
-Turn on camera 1 of the ptz

Overview screens – end questions.

Which user interface would you personally choose as the main user interface.
Did you wish you were able to switch between UI's.
Are there particular features in a user interface you found helpful.
If you have to choose a top 4 regarding user friendliness. What would the ranking be and for which reason?
If you have to choose a top 4 regarding maintaining concentration levels high for an 8 hour period. What would the ranking be and for which reason?
If you have to choose a top 4 regarding aesthetics. What would the ranking be and for which reason?
If you have to implement a dark mode or dawn mode. What would the ranking be and for which reason?
Do you find it useful that you can alter the size of the icons?
If you have to choose a top 4 regarding 'the feeling of being in control'. What would the ranking be and for which reason?
During the entire test, I will interact with the test user and go deeper in comments he/she will make.

Appendix O.
High- fi Test plan 2

5/7/2024.

- Are there any features in the four designs you specifically like and would like to see back in the future designs?
- Any general comments about the previous designs.

Current UI Design

- Any comments about the current UI design of Siemens or features you desire to see back in the future designs.

Neumorphism Day Mode

- What is your first impression of this current User interface?
- Are there any things you particularly like about the User interface and particularly dislike about the User interface?
- Would you be able to look and interact with this user interface for 8 hours each day?
- Are there any unclarities?

Tasks:

- Can you turn on the Crane?
- Can you select the waterside spreader?
- Can you turn on the Pump for the Waterside spreader?
- Can you move the boom downwards?
- Can you select all the flippers of the Waterside spreader?
- Can you turn on the PTZ 6 camera?
- Can you please turn on the Dark mode?

Neumorphism Night mode

- What is your first impression of this current User interface?
- Are there any things you particularly like about the User interface and particularly dislike about the User interface?
- Would you be able to look and interact with this user interface for 8 hours each day?
- Are there any unclarities?

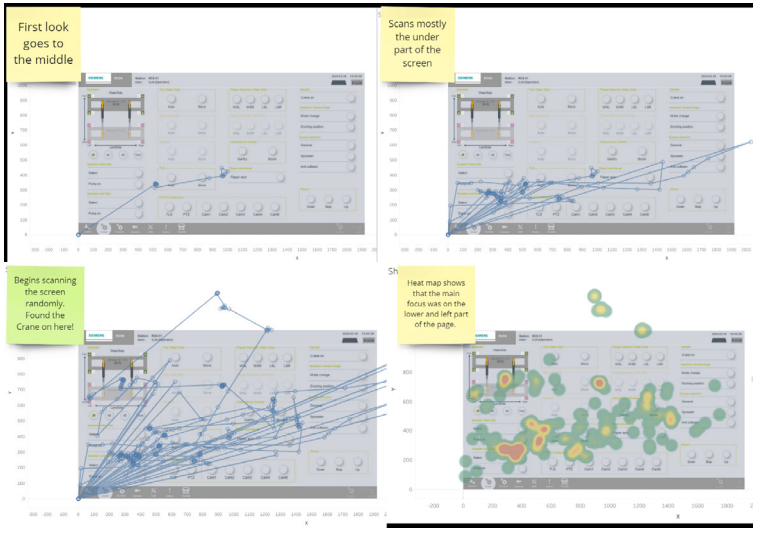
Tasks:

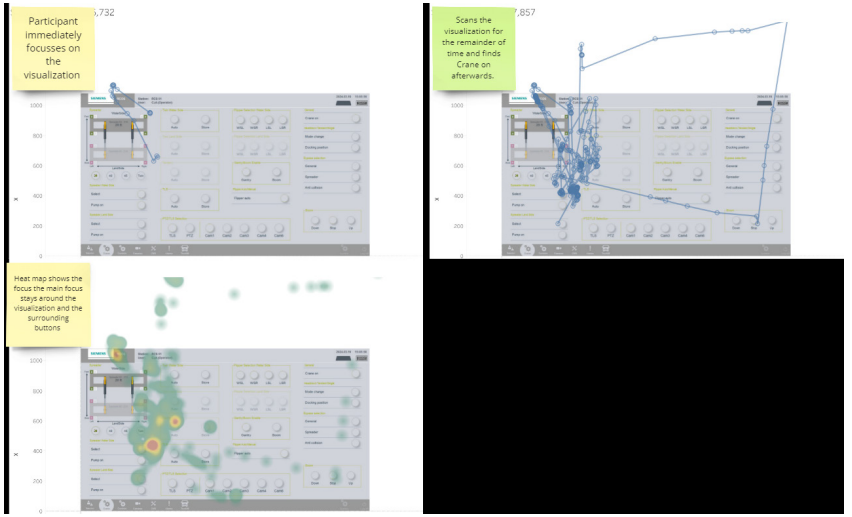
- Can you turn on the Crane?
- Can you move the Gantry?
- Can you change the mode to one spreader?
- The system gives a warning about a spreader. However, you decide you want to go past that. Which button do you want to press.
- Can you change the mode to two spreader?
- Can you select the Landside spreader?
- If you have a question about the system, specifically the settings of Waterside spreader. Can you think of a way how to interact with the UI to get information about the Waterside spreader?

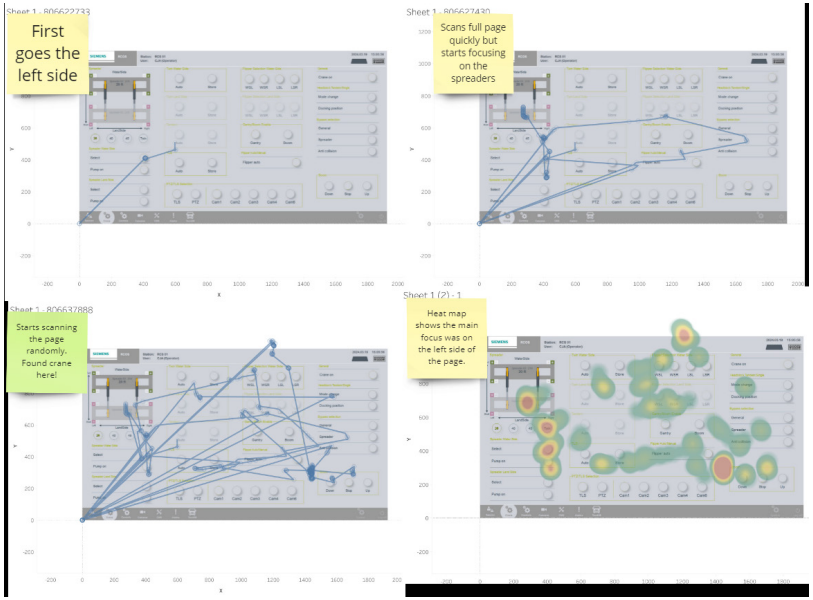
Neu minimalistic Day mode

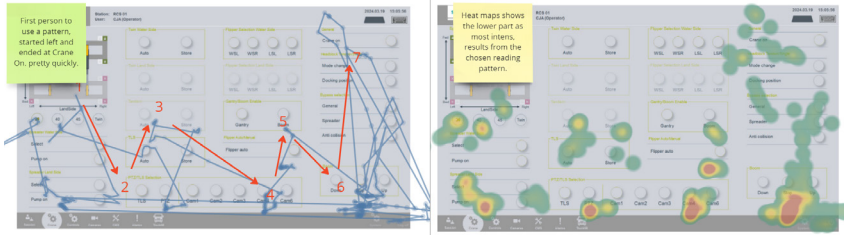
- What is your first impression of this current User interface?
- Are there any things you particularly like about the User interface and particularly dislike about the User interface?
- Would you be able to look and interact with this user interface for 8 hours each day?

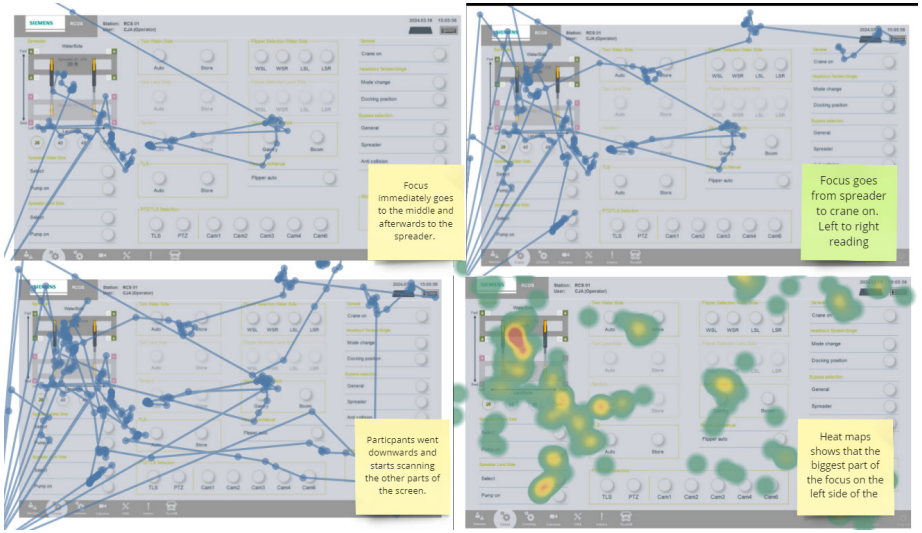
Appendix P.
Test results eye tracking old RCOS

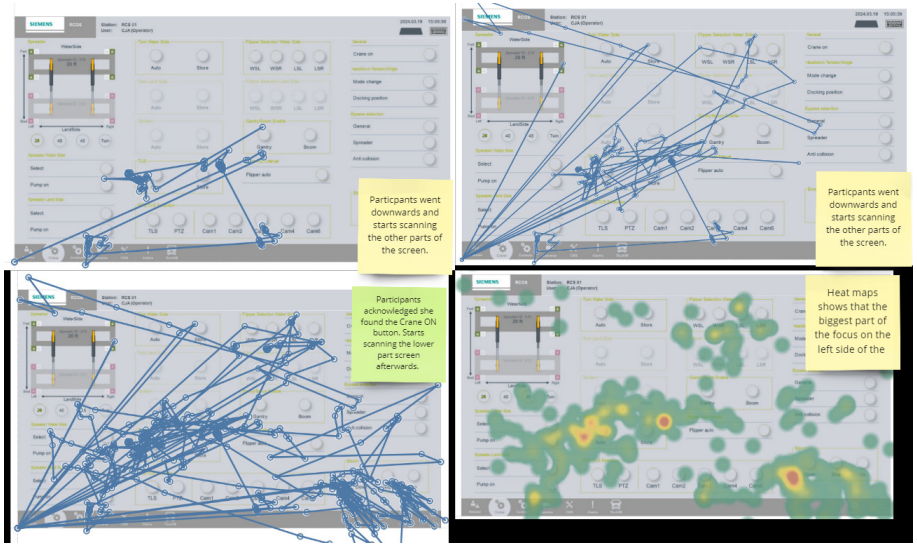




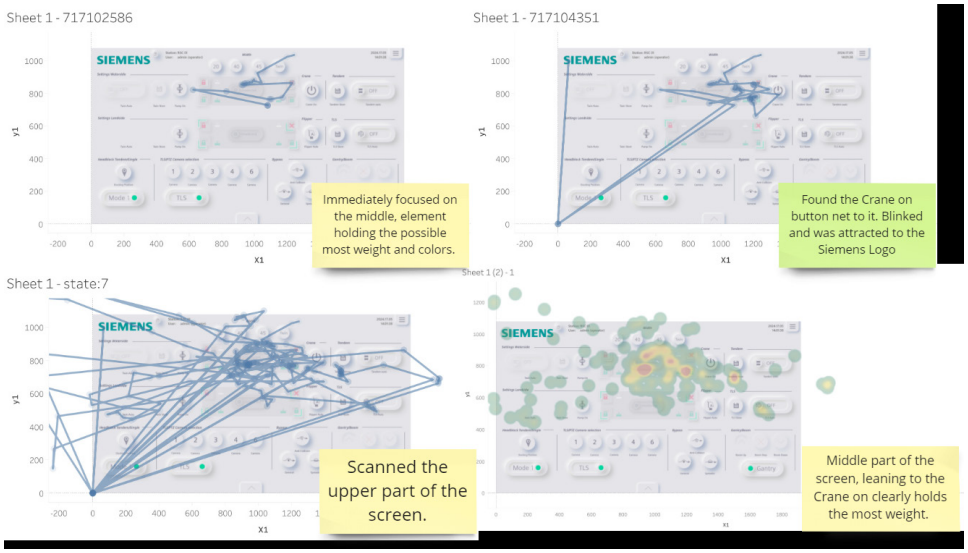


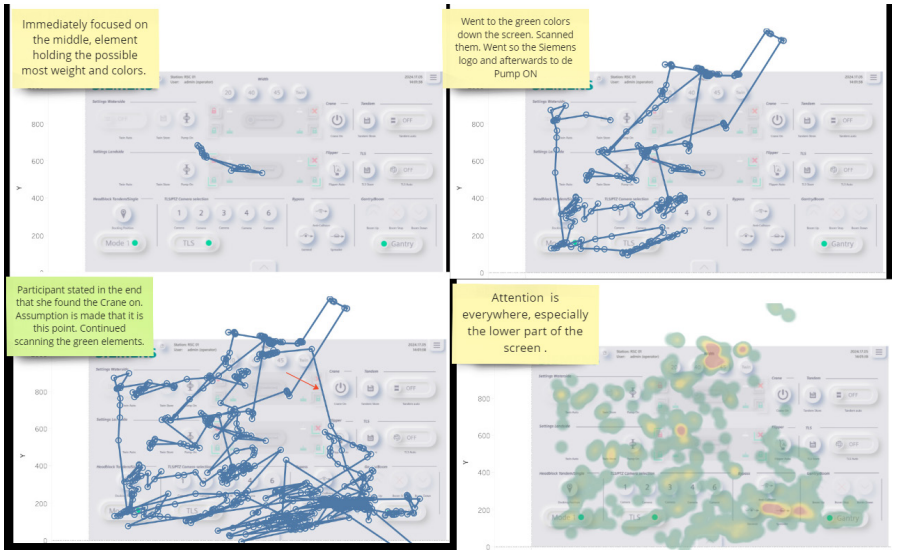


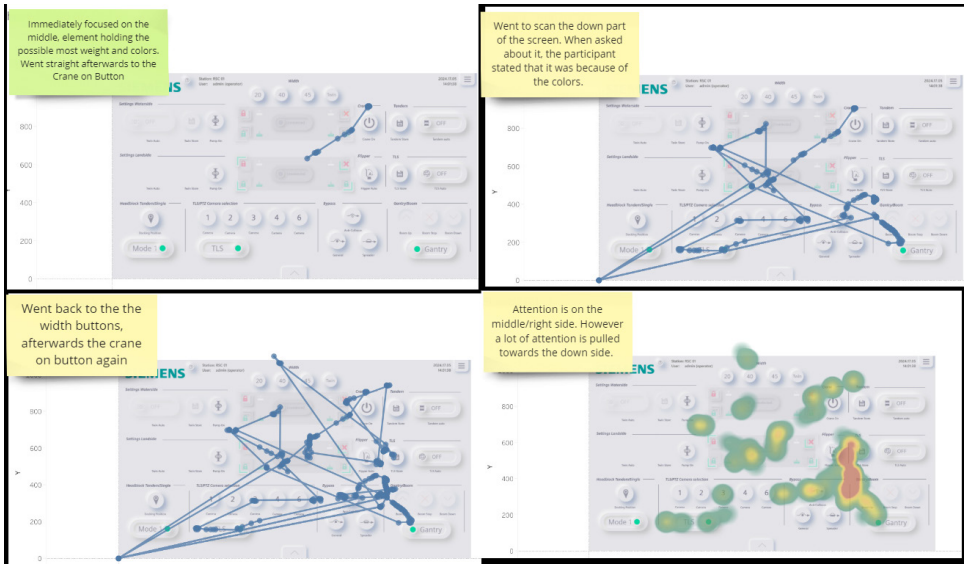

Focus immediately goes to the middle and afterwards to the spreader.
Focus goes from spreader to crane on. Left to right reading
Particpants went downwards and starts scanning the other parts of the screen.
Heat maps shows that the biggest part of the focus on the left side of the


Particpants went downwards and starts scanning the other parts of the screen.
Particpants went downwards and starts scanning the other parts of the screen.
Participants acknowledged she found the Crane ON button. Starts scanning the lower part screen afterwards.
Heat maps shows that the biggest part of the focus on the left side of the

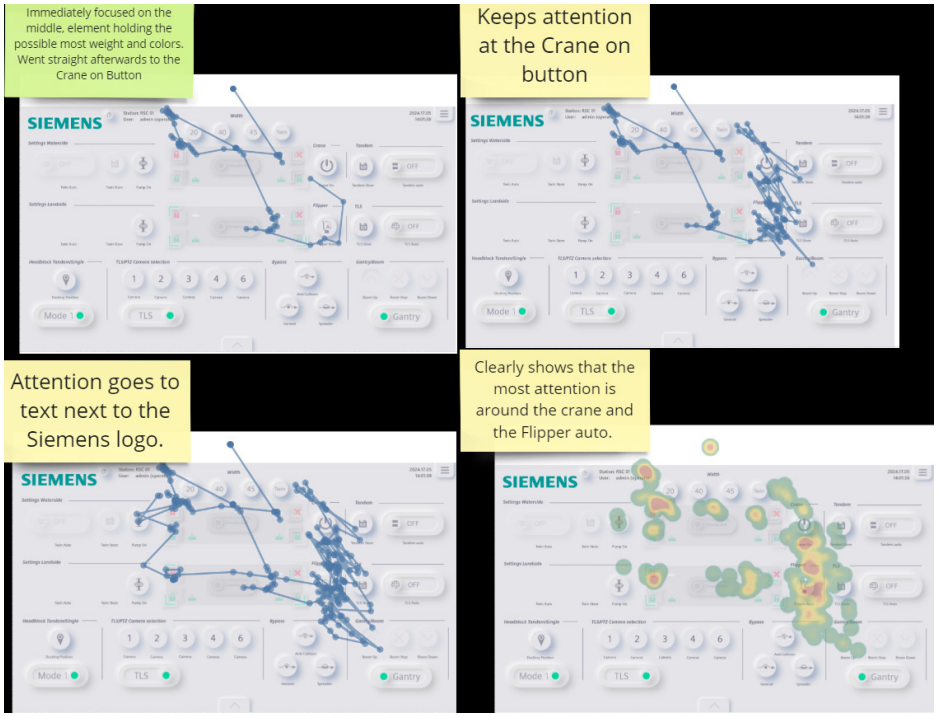
Appendix Q.
Test results eye tracking New RCOS








Immediately focused on the middle, element holding the possible most weight and colors. Went straight afterwards to the Crane on Button
Attention goes to the width button and possible the hamburger menu
Attention goes to the Siemens logo
The most attention is on the right Landside spreader.


Immediately focused on the middle, element holding the possible most weight and colors. Went straight afterwards to the Crane on Button
Keeps attention at the Crane on button
Attention goes to text next to the Siemens logo.
Clearly shows that the most attention is around the crane and the Flipper auto.

Appendix R.
AI images