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UNIVERSITY OF GOTHENBURG

Real-time kinematic data visualization

Designing for customization and a variety of user groups

Master's thesis in Interaction Design & Technologies

FILIP LINDAHL EMIL LUNDGREN

MASTER'S THESIS 2019

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Department of Computer Science and Engineering
CHALMERS UNIVERSITY OF TECHNOLOGY
UNIVERSITY OF GOTHENBURG
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Abstract

A substantial challenge in the field of motion capture is displaying kinematic data in real time in a meaningful way for users. There are distinct user groups and businesses often have a wide range of clients in separate areas. This thesis investigated the opportunity to have a unified way of displaying data to the respective user groups. The main approach for investigating the possibilities was through a customizable dashboard where users can display what kinematic data to illustrate and how. The project was carried out through an iterative design process alongside with agile development sprints for the purpose of producing code. The design process was done in a total of three iterations of research & requirements, design alternatives, prototyping and evaluation. User tests were performed on employees of Qualisys. The final results and findings of the project includes a fully functional interactive prototype which enables users to customize how they want to see kinematic data in real time. The results also include a set of users stories which can serve as the basis for the purpose of future development.

Keywords: Motion capture, MoCap, real-time feedback, dashboard, customization.

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Abbreviations

GUIs Graphical User Interface. 34

QTM Qualisys Track Manager. 1, 16, 22, 23, 30, 45–47, 52, 53, 57, 66

TFS Team Foundation Server. 17

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1

Introduction

Motion capture systems has in recent years seen an increase in popularity. One of the key problems in the field of motion capture right now is the ability to provide information and visualization to their users without the data having to be captured (e.g recorded) first. An example of why this becomes a problem is in animation studios. As of today the actor/actress has sensors on their body while a director directs the scene which gets recorded and captured. The recording then later gets sent to the animation specialists who reviews and submits feedback regarding missing data or whether the recording had problems and the scene needs to be shot again. This is one practical example of the problem with having to capture kinematic data first. The field of motion capture has seen a lot of these problems in a variety of the different user groups and thus lies a need for the ability to be able to view the measurements in real-time.

A lot of companies now exist in the field where the largest one in Sweden is called Qualisys. Qualisys is one of the leading providers of precision motion capture and 3D positioning tracking systems for engineering, biomechanics, animation, virtual reality, robotics, and movement sciences. Qualisys has offices all around the world with its headquarters in Gothenburg. The company provides a full solution for Mo-Cap which includes cameras and a software which can integrate force plates, EMG, eye trackers and a number of other devices. The software which is called Qualisys Track Manager (QTM) can be seen in Figure 1.1 and the hardware that Qualisys offer can be seen in Figure 1.2.

1. Introduction

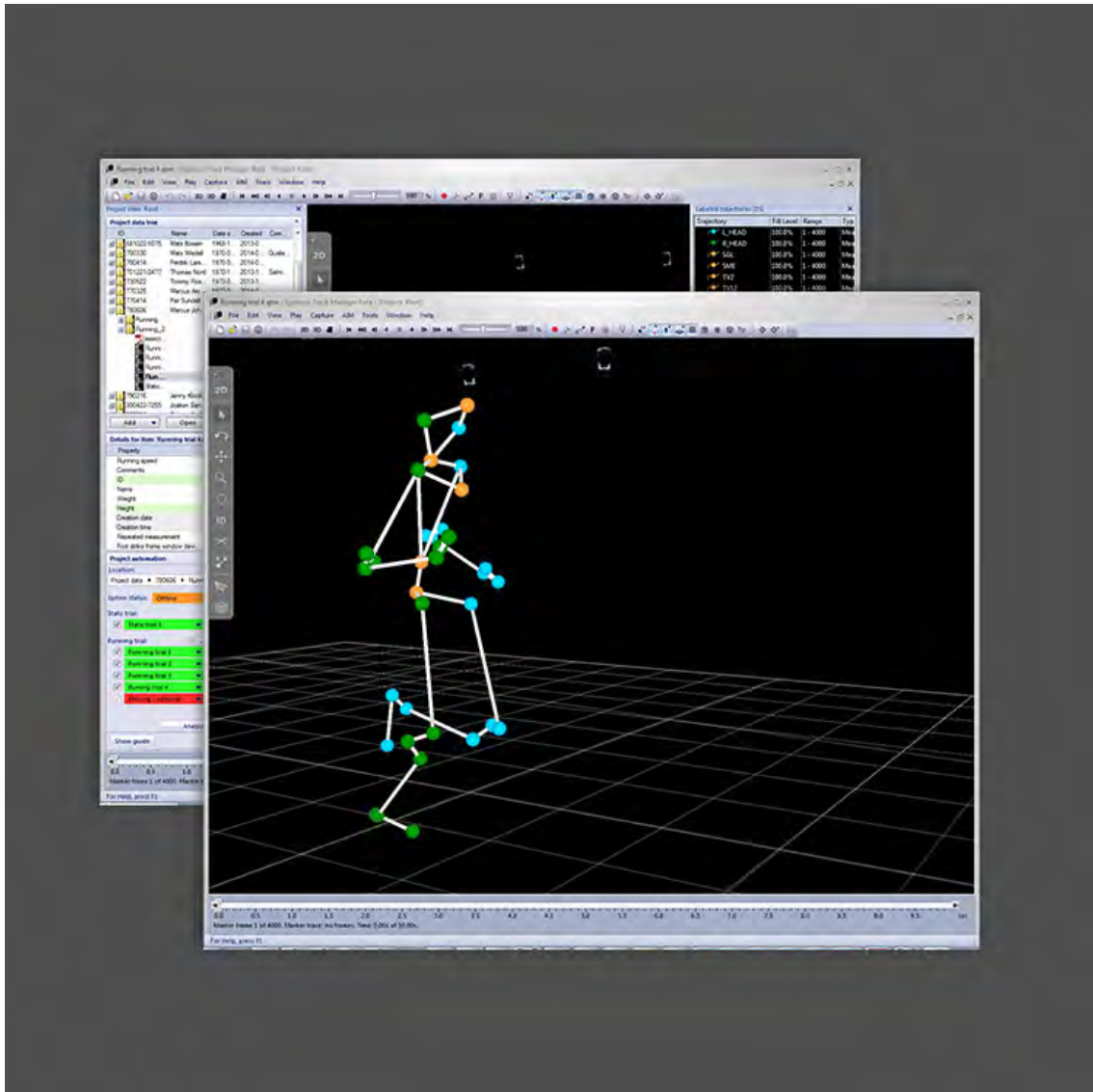


Figure 1.1: Qualisys track manager: sensors and gui displaying markers with labels and project settings [32]



Figure 1.2: Miquis camera: smallest Qualisys camera for a wide usage area [31]

As stated the company provides a lot of different solutions and modules to fit their user needs.

This chapter will further introduce the project and what it aims to accomplish. The chapter also provides an overview with reference to how the project was carried out.

1.1 Motivation

The subject that this project aims to investigate is meant to help people create information visualizations based on quantitative data. The result is meant to be intuitive and easy to grasp so that users with different technical backgrounds are all able to use it.

1.2 Aim

1.2.1 Assignment

The problem we are trying to solve has both a technical aspect as well as a more design-focused aspect. Our main focus will be the design aspect where we explore how you design a dashboard that can be used by means with reference to disparate fields. The end-users within these different fields have varying degrees of understanding of the software they are using, and the resulting data. Our results should be equally useful for all those users.

In order to gain a better understanding of the potential users and their use-cases the group examined how the users are gathering and analyzing, how they present, and how they would like the data presented.

This report will not go in to detail about the technical aspects of the problem were solved.

1.2.2 Intended outcome

The level of completion that is expected from the companies side of things is at least having a functional real-time feedback platform that will work as a proof-of-concept. The proof will be a web-based platform that is able to receive data from Qualisys Track Manager and then display the data to the users in the most basic manner. Intermediate level of deliverable assuming a working proof-of-concept include designing and implementing the platform in such way that users can setup and customize dashboards without programming skills, having novel widgets and furthermore developing prioritized requirements.

1.2.3 Research question

"What guidelines should be considered when designing an information visualization interface for kinematic data streamed in real time to enable personalization?"

2

Background and previous work

2.1 Research methods

In his 1993 research paper "Research in Art and Design" Christopher Frayling presents three different ways of combining design and research. [13]

Research *into* art & design is the most common and perhaps the most "classical" research method. It's used to research areas such as the history of the field or different theoretical perspectives such as economical, ethical or political perspectives[13] that can be applied to design. It will not be used for this thesis.

Since there is some debate how to properly use and improve the method Research *through* art & design[14] we have chosen a few aspects to focus on. These aspects are development work and action research[13]. Development work is 'customising a piece of technology to do something no-one had considered before and communicating the results'. The action research is 'where a research diary tells...of a practical experiment in the studios and the resulting report aims to contextualize it. Both the diary and the report are there to *communicate the results*'.

Research *for* design places emphasis on an artifact that is produced as a result of the research. The research in itself is difficult to present, but instead the knowledge is embedded in the design of the artifact[13].

For our thesis work we take inspiration from both Research *through* design and Research *for* design. The development work is exemplified by the designs and implementations that have been created. The action research is recorded as our iterations in the report where the design choices are presented and motivated, as well as how we prototype every step. The artifacts created support and help with presenting our ideas and decisions taken.

2.2 Motion capture process

Motion capture deals with several different stages for capturing data. This process have the ability to be divided into preparation, measurement, reconstruction, tracking, identification and post-processing. This thesis will focus mainly in regards to the post-processing stage but a short description of all the stages will be provided in order for the reader to obtain an understanding of the whole process of using motion



Figure 2.1: Overview of the motion capture process and its four stages according to Moeslund and Granum.

capture. The process can be seen in Figure 2.1. Preparation deals with setting up the motion capture hardware, software and dealing with calibration and configuration. Measurement deals with reconstructing the motion sensor data and visualizing the markers in real time. Reconstruction stage deals with reconstructing the motion sensor data and visualizing the markers in real time. The tracking stage deals with the process of matching the reconstructed representations of the capture subjects at one time instance to the respective reconstructions at a future time instance. Identification stage deals with identifying and assigning labels to the different tracked reconstructions in order to easily match them to the physical capture subjects. The last stage which is post-processing is application-specific. What this means is that it can either be to export data into a particular format or it have the ability to be a more complex matter such as in bio-mechanical applications where the location and orientation of joints of humans are derived from motion capture data. This stage also deals with missing or faulty data [12]. As stated the thesis will focus in regards to this stage and the reason for this is that the vision from Qualisys is to provide a new post-processing application to provide to their customers.

2.3 Information Visualization

To facilitate the design of an information visualization dashboard it is helpful knowing how humans search for information that is relevant to them. According to Ware [35] two fundamental activities are performed when a person wants to find something in a visualization. First, the person formulates a query in their mind about what they need to find to solve their problem. And secondly they conduct a visual search of the visualization to find that solution.

To aid the user with finding what is relevant to them, Ware gives two guidelines.

Design graphic representations of data by taking into account human sensory capabilities in such a way that important data elements and data patterns can quickly perceived[35].

Important data should be represented by graphical elements that are more visually distinct than those representing less important information[35].

When looking at a visualization *saccadic movements* are performed. A saccadic movement is a rapid eye movement which occur when moving from fixation to fixation. To reduce saccadic movements, and thus reduce the cost of a visual search, the visualization display should be as compact as possible while still providing visual clarity.

While performing saccadic eye movements the user is less sensitive to visual input, a phenomenon called *saccadic suppression*. This means that certain events have the ability to be missed more easily if they occur while the user is moving their eyes. This is important to consider when needing to grab the attention of the user to alert them of an event [35].

For something to be able to be found quickly the interface must provide the user a way to quickly find it. For our dashboard that means providing the user a way to clearly label their data. For more time-sensitive data the saccadic suppression must be considered and so the color of the visualization changes to quickly grab the attention of the user so proper adjustments can be made.

3

Methodology

This section will give the reader insights to how the work is structured and carried out. It will also allow stakeholders to assess whether or not the research question and goal can be achieved and offer a reliable outcome.

Different frameworks provide the user with sets of tools to approach and solve a set of problems. They enable the designer to use methods that have been tried before and have some backing by either science or the community as being effective for solving different design problems.

In Figure 3.1 the different sections can be seen throughout the project.

- D1 - Deliverable 1 - Photos from user environment
- D2 - Deliverable 2 - Interview transcript (notes), user stories
- D3 - Deliverable 3 - Sketches, Mockups, Wireframes, High-fidelity prototype, Interactive prototype
- D4 - Deliverable 4 - Evaluation of D3
- D5 - Deliverable 5 - Sketches, Mockups, Wireframes, High-fidelity prototype, Interactive prototype
- D6 - Deliverable 6 - Evaluation of D5
- D7 - Deliverable 7 - Sketches, Mockups, Wireframes, High-fidelity prototype, Interactive prototype
- D8 - Deliverable 8 - Evaluation of D7

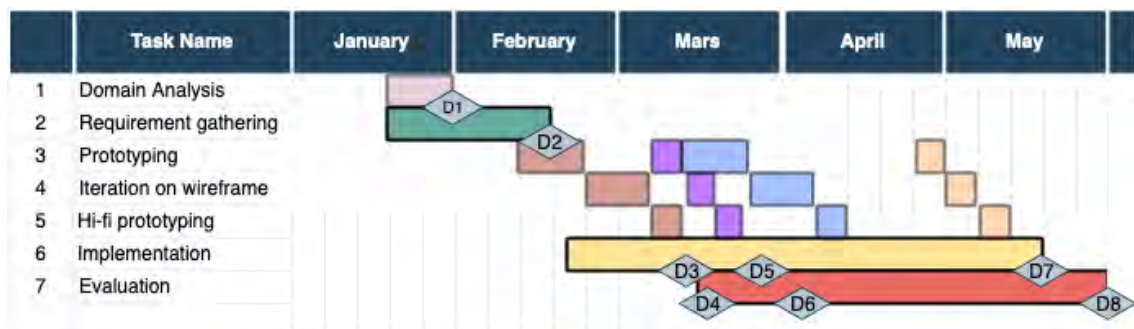


Figure 3.1: Gantt chart - Design process with deliverables

3.1 Requirement gathering

In this section the process for gathering and generating requirements will be covered.

3.1.1 Domain analysis

To gain an understanding of what environments the dashboards could be used in, the users supplied the designers with pictures. The users were different domains and the supplied photos showed different things such as lighting conditions and what kinds of equipment the users have at hand. This can be used in the design process to help decide, for example, if theming is necessary to make the dashboards easier to use in a dark or light room.

3.1.2 Semi-structured interviews

In order to learn more about the problem the students will focus on gathering information through interviews. The questions that will be asked is going to be focused on gathering both quantitative and qualitative data.

The interviews with the end-users are going to be conducted through either phone calls or through a form. To get the best result it would have been better to have face-to-face interviews but due to the timeframe of the project this will not be the case. With the internal contacts at the company face-to-face interviews were performed. During those interviews one of the designers was conducting the interview and the other was taking notes. The interviews will follow a semi-structured format where a set of questions are sent to the participants. If we feel that there is some more information to gather from any user a follow-up email with further questions will be sent to willing participants. In this further questioning the main focus will be on "Why". For example "Why do you dislike that feature?", "Why do you like that part?"[11].

The qualitative data should provide a deeper understanding of how the product is used, what the accompanying domain needs for it to be useful, what can't be extrapolated and other domain specific questions[6].

The quantitative data will be used to get a broader overview of how the existing users are using the current systems, what issues they are having with it, available on several different devices, etc, but also the age of the users, technical experience, and other things helping us determine the demographic of our product.

3.1.3 KJ-technique

To work through the qualitative data from the interview the KJ-technique was performed. This technique is a consensus-building exercise which helps the team to form work through a vast set of ideas and information. The technique allows the team to externalize, organize and then prioritize information that the team members have. One of the main benefits of KJ compared to traditional meetings is

that the technique assures everyone to focus and deep-dive on the same task at the same time. The KJ technique is done in silence and all participants write down their insights and opinions. More concretely the process is as follows, the group starts out by determining a focus question and then individually and silently put information onto sticky notes on the wall. After a sufficient amount of time has passed the sticky notes are grouped into similar items and then named. The final step is done vocally where the group votes and ranks the most important groups. The KJ Technique helps with making sure everyone gets a chance to express their opinions while also minimizing the risk of influencing the other participants[21]. Not influencing each other, or focusing too much on one area was crucial since the design team only consists of two people so the KJ-technique was beneficial to help maximize the amount of output from the team.

3.1.4 User stories

The output from the KJ-technique was turned into user stories. The user stories were made by structuring different interactions that will be made with the product that we are designing. The user stories are written on the form "As a customer, I want to be able to interaction X so that I can outcome Y."

3.2 Prototyping

In this section the different methods for prototyping will be explained.

3.2.1 Mockups/Wireframing

During the earlier stages of prototyping, low-fidelity prototypes and sketches were made. Even though these kinds of prototypes might not look too alike the final product, they do provide the same functionality. The benefits include that they are simple, cheap and quick to produce/modify [20]. The reason for choosing to do this is to test functionality e.g system functions, users functionality need and the interactivity e.g input-, output-, feedback- and information behaviour. More precisely sketching and certain wireframing tools such as Balsamiq [1] was used. Sketching is a low-fidelity prototyping tool that relies on hand drawn-sketches [20]. The reason for choosing sketching is because it is highly efficient way of testing the functionality of a design. The reason for digitalizing the sketches in a wireframing tools is because it increases "readability" of the sketch. Even though it will be a low-fidelity prototype it will become easier for the user to understand what they are seeing. The negative aspect of transferring the sketches will be time.

3.2.2 Hi-fi prototype

For testing the design choices regarding appearance and spatial structure, high-fidelity prototypes will be made. The reason for doing this is mainly to get a clear picture over how the final product will look. This will be done in a digital design toolkit like Sketch [2].

3.3 Evaluation

This section will cover what forms of evaluation were performed and what stage of the design they were performed in.

3.3.1 Usability testing

To find problems with the design usability tests are going to be performed with participants either being end users or belonging to groups that reflect and understand the end users and their goals. The usability tests will be performed for each design iteration. The tasks that will have to be performed in the tests will reflect what the users' goals with the system. The participants will be presented with a scenario that helps put the tasks in a real world context but will not try to guide the users to complete the task in any particular way. [22]

The tests should help with identifying if there are tasks that can't be completed in a reasonable amount of time or if the user needs to try several different approaches to complete the task. They should also help identify things such as if the participant feels surprised or confused by the design. The usability tests will be designed for the *Concurrent Think-Aloud* protocol. This means that the participant will try to explain what they are doing, thinking and feeling while working with the tasks. [23]

3.3.2 Heuristic Evaluation

In order to perform a heuristic evaluation relevant heuristics have to be chosen. When choosing heuristics there are a lot of different sources to choose from. For this thesis we considered Nielsen's heuristics from Usability Engineering[28], Gerhardt-Powals ten Cognitive Engineering Principles[15], Weinschenk and Barkers 20 heuristics and guidelines from Designing Effective Speech Interfaces[36] and lastly Schneiderman's Eight Golden Rules of Interface Design[33]. The occurrences of a heuristic or a variation of it were then counted. If a heuristic touched upon similar subjects as another one it counted as two occurrences of the broader heuristic. The results were put into a table which is in the Appendix at A.2.

At this point, the different heuristics were weighed against each other while considering our thesis subject and what Qualisys prioritizes. The heuristics that were chosen to focus on were Nielsen's 10 heuristics but with "recognize, diagnose and recover from errors" exchanged for Weinschenk's & Barker's "Accommodation". The decision was based on the occurrences and Qualisys' priorities which include the end-results having some marketability. An attractive design can help a great deal when pitching or trying to sell an idea, this is why "Aesthetic and minimalist design" was kept as a heuristic even though it had the same amount of occurrences as "recognize, diagnose and recover from errors". Accommodation was added to provide an extra focus on using a language that is consistent with QTM, which is necessary for our application. Since QTM has users from several different fields it is important to



Figure 3.2: Design guidelines - List of heuristics

keep the terminology correct to minimize confusion.

The final list of heuristics can be seen in Figure 3.2.

3.4 Designing Behavior and Form

3.4.1 Preventing Errors and Informing Decisions

In the early days of web-design a significant portion of a graphical interface was taken up by dialogues and messages telling the user what they did wrong. This is not the case anymore as the industry has moved more towards using rich modeless feedback. One of the reason for this change is technical enhancements, high-resolution displays and high-quality audio systems. These components has not been utilized to the extent that it is capable of (except for games). This means that subtle status information is never communicated to the users even though there lies an importance in giving constant feedback, mostly positive but also negative [7].

The most important modeless feedback is called rich visual modeless feedback. It gives in depth-information about status or attributes of a process/object in the application. The visual aspect of it deals with making use of pixels on the screen. Modeless because the information is always readily displayed [7].

Another way of dealing with user errors is undo instead of confirm. The problem with implementing quality undo actions lies in following the mental model of the user. Why this is a more suitable solution than previous mentioned is because humans don't generally want to admit/believe that they make mistakes, e.g the personas mental model does not include error on his part. The solution then becomes to abandon the idea that an user can make a mistake and consider every action that the user does to be valid [7].

A well designed and implemented undo works throughout the application and undoes the last action made, regardless of how that action was made.

3.4.2 Designing for Different Needs

The thesis was focused on building a dashboard which should be suitable for different needs. The needs can according to Cooper et al. be broken down into learnability and help, customizability, localization and globalization, and accessibility. This thesis focused on the customizability aspect because that lies most in line with the end goal. There exists mainly two ways of dealing with customizable interfaces which are, personalization and configuration. [8]

3.4.2.1 Personalization

This deals with the fact that people like to change the environment and things around them to suit themselves, regardless of which kind of user. The term personalization describes exactly this, it explains the decoration or embellishment of persistent objects. Tools for personalizing must be simple and easy to use, give a visual preview and allow undoing of the action in a simple manner e.g a dialog box that lets user change color should offer functionality for resetting everything to factory settings.

3.4.2.2 Configuration

When dealing with letting the users configuring their own interface it is important to not let the user hinder their own navigation. Configuration is more desirable for experienced users and is a necessity for expert users. The reason for this is because after users have established a working set of functions, they will want to make those easier to find in order to increase speed and ease.

3.5 Interaction details

3.5.1 Designing for the web

The end goal from Qualisys side is a web-application that is customizable. Since the web-application is a product to be used by Qualisys there is a possibility that they want to iterate upon it and keep developing it. A popular set of design guidelines was chosen. The reason for this is to improve the efficiency of development and to ensure that the result will be of great quality. The guidelines have been studied and developed in order to deliver a visual language for their users that defines principles of innovative design. The guideline will be chosen in order to ensure working design on both desktop and mobile.

3.6 Definition of scope

The project was carried out over an estimated period of 20 weeks. The work was primarily going to be carried out at Qualisys headquarters in Gothenburg, Sweden. The companies responsibility in the project regarded project- and requirement-management. The design part of the project was performed with a custom design process which can be seen in Figure 4.3 and the coding part of the project was performed following the agile process of defining tasks.

The company has, as stated before, a variety of customers in different application areas. During the research & requirements phase of the project two user groups was chosen to focus on. The decision to focus on Running and Vessel was made by the company with the motivation that these user groups define the majority of there clientele.

Another aspect that was focused on was the design aspect of the problem at hand. With the project comes a lot of technical difficulties which includes being able to connect to the stream over different networks. This aspect was not something that we focused on with the reasoning that the technical depth does not align with the requirements for a master thesis in Interaction Design. The design aspect of the project was the main focus for we. Key questions included how we could design and implement a dashboard that could be used across different fields and still be equally as useful for all users.

3.7 Process and Methods

During the planning we decided that the project was going to be carried out in an iterative design process where the different stages was going to be, research & requirements, design alternatives, prototyping and evaluation. The reason for having an iterative process was due to the fact that this way of working seemed most suitable. This because the end product was going to be a single application. During planning we also decided what the different outcomes was going to be. The early phases was going to deliver photos from user environment, interview notes, user stories. This in order to get the project going. After that sketches, mockups and wireframes was going to be delivered in order to test the functionality of the design. High fidelity prototypes was then designed in order to test the aesthetics. Another important deliverable that was planned from the beginning was code, this because it was unclear if the application could be made into something useful or not so the solution had to be practically tested. This would in turn also deliver both code and styling assets (css). After sufficient prototypes had been done a usability report would be obtained from the running application.

The final results from the project is an web-based application/platform that is able to receive and visualize data from QTM. Furthermore the platform was designed and implemented in such a way that users could customize their dashboard.

3.8 Implementation details

The client side of the webapplication was written in Angular which is a one of the most used typescript-based frameworks for building client applications in HTML and TypeScript. It allows the developer to implement core and optional functionality as a set of TypeScript libraries that's imported into the app [4]. The benefit of choosing this kind of framework is the fact that it makes it easier to develop cross platform applications.

The server side of the application was written in NodeJS which is a JavaScript runtime built on Chrome's V8 JavaScript engine [29] and with ExpressJS which is a fast, unopinionated, minimalist web framework for NodeJS as the routing of the application [10]. MongoDB which is one of the most popular database for cross platform applications [27] was used in order to create, read, update and delete data.

Alongside with these frameworks & libraries Angular Material [5] - Material Design components for Angular was used to implement the front end. Material Design is a visual language that synthesizes the classic principles of design with the innovation of technology and science [17]. The reason for choosing Material Design as the leading design principles was because the principles are highly maintained and one of the largest design principles for web applications. It is also the leading principles for the operating system Android [16].

The benefit of making the project into an web application and not a desktop executable or similar is as stated before that it works cross platform and no installation is needed. To serve the application the platform as a service (PaaS), Heroku was used. Heroku is a cloud application platform that lets the developers build, run, and operate their applications entirely in the cloud. A benefit of using heroku is also that the platform after a successful build assigns a domain to the project [19].

In order to obtain data from the Qualisys Track Manager software the company had written an API.

3.8.1 Tools

Different tools were used in order to design and administrate the project. Adobe Photoshop [3] was used sparsely for high-fidelity prototypes but mainly for the purpose of editing images. The tool used primarily for high-fidelity prototypes was Sketch [2]. To make low-fidelity prototypes the wireframing tool Balsamiq [1] was used.

The administrative tools for the project functioned as a way of keeping the everything on track. For code maintenance Microsoft Team Maintenance Server [26] (also known as TFS) was used which covers the entire application life cycle. For managing none confidential information, Google Drive [18] was used between us and our thesis supervisor. Slack [34] and Microsoft Teams [25] were used as the main communication channels between us, our supervisor and the company.

4

Execution and Process

This section describes the process used to design and evaluate the Customizable Dashboard. How information was gathered and how the iterations were evaluated and what insights were gained from those evaluations. In Figure 4.1 a summary of the flow over the design alternatives and their corresponding prototype outcome can be seen. What also can be derived from the figure is if the design alternative made it to the next phase.

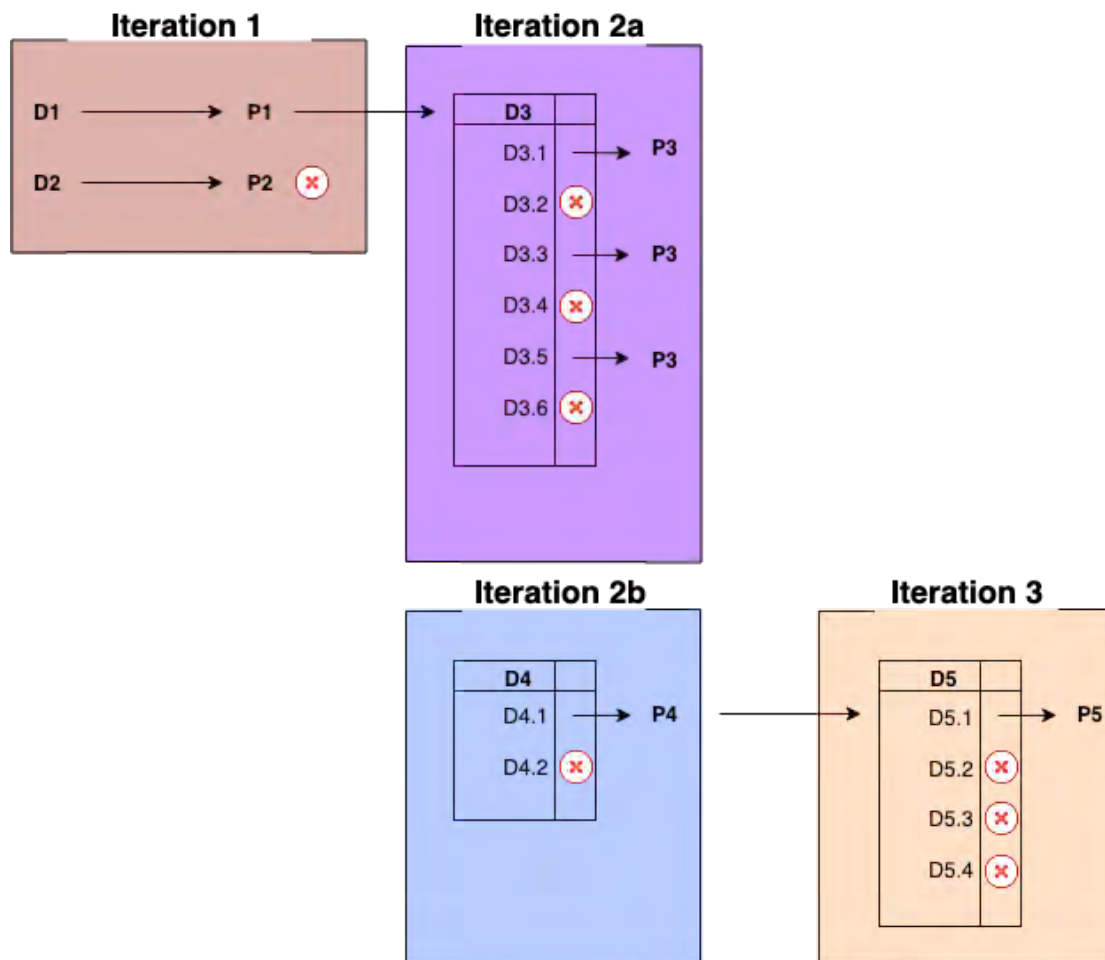


Figure 4.1: Diagram overview of the design alternatives and their progress throughout the design process.

4.1 Background analysis

The background analysis was done with the focus of gaining an understanding of how the project was going to be carried out with regards to design phases. A suitable design process model had to be chosen in order to keep the project on track and to gain an understanding and insight about the design area. The coming section will go into details of how the start of the project dealt with these issues. We decided to go for an own design process model which later also was compared to a model from literature.

4.1.1 Formative Studies

We chose the design process model from Beyond Human Computer Interaction [20]. The reason for choosing this design process model as a guideline was because the guidelines were a) familiar to the thesis writers and b) seemed to fit the work in a suitable manner.

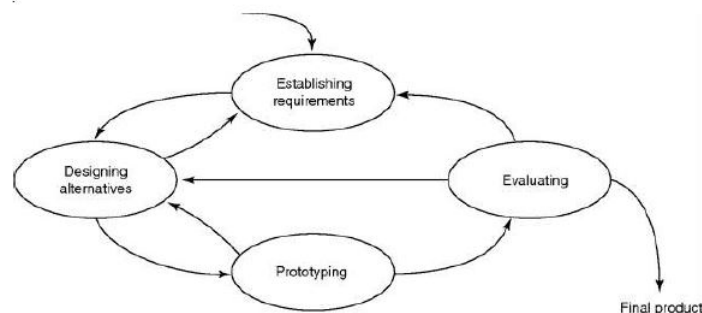


Figure 4.2: Human centered design process model - Preece [30]

The actual design process was not completely alike the one chosen. In figure 4.3 our design process can be seen which clarifies how the work actually was carried out.

As seen the work was carried out in iterations. The benefits of working in iterations include that the working method is fast, efficient and every iteration will move towards what the user actually want. The largest disadvantage of using iterations is that this way of working is time inefficient.

4.1.2 Comparison to Human centered design process model

Because the different design process models do not look alike, clarifying what differs is relevant. The comparison is going to regard our own design process 4.3 and the design process model from the literature which can be seen in Figure 4.2 [30].

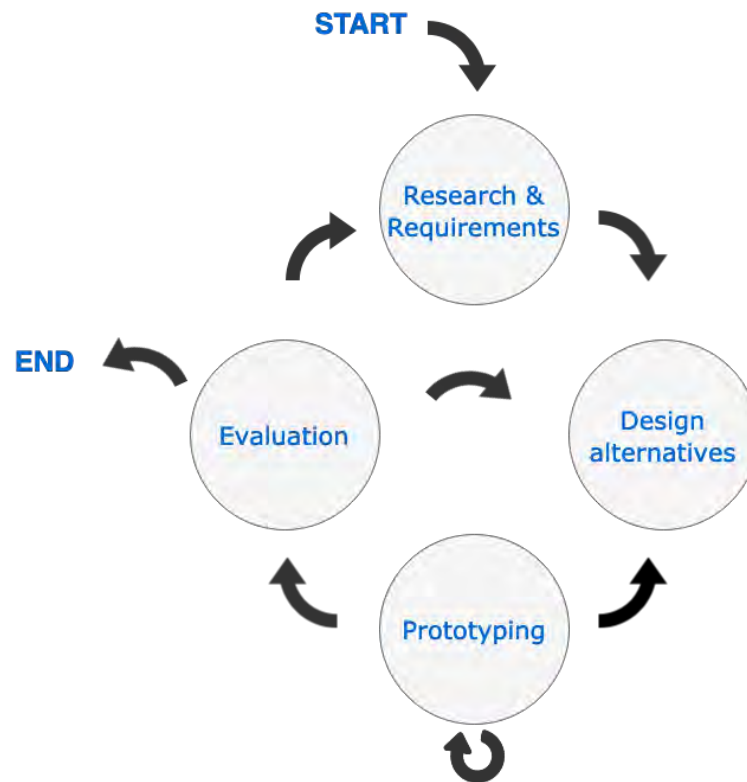


Figure 4.3: Own design process

Model	Similarities to own	Differences to own	Potential problems
Design process literature	The process of establishing requirements, checking design alternatives, prototyping and evaluation. The order is quite similar.	One mayor difference was that stage iterations were only done in the prototyping stage for us. The HCI model is much more iterative.	Because the process is connected in several ways and not sequential a "problem" might be the structure and the ability to keep track of everything
Own design process	-	-	Implemented in a chronological sense. Even though iterations was used no feedback went "back" in the chain. A consequence of this is that you have to do more iterations than needed because feedback comes in the next iteration.

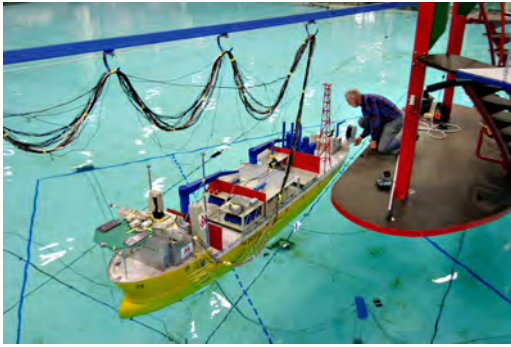
4.2 Iteration 1

The first iteration was done with the main focus of understanding and designing for the whole picture. In order to do this we first gathered information about the user environment. This was done by obtaining photos from where and how the different systems were used and then interviewing users and experts in the field. The result from this was user stories which defined the system. We had no prior knowledge about QTM thus time was invested in learning how the software actually worked. This was done by calibrating, putting markers on one of the team members and then recording different movements and playing around with the recordings in the software.

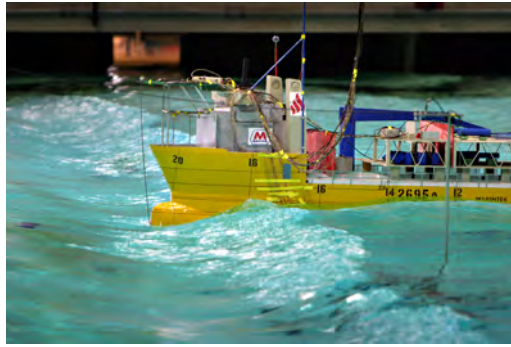
After sufficient amount of knowledge had been gained different alternatives which covered the whole system was sketched out. After deciding which to follow one of the alternatives both low- and high-fidelity prototypes was made. An interactive prototype was then implemented to see that the design worked in a practical manner as well. The last stage of iteration one was focused on evaluating the designed system and to see if any function was missing. This was done both with a feedback session and usability testing.

4.2.1 Research & Requirements

The main focus of this phase was to understand the domain. To gain a further understanding of the domain a research phase was planned. In this phase we studied photos from the user environment and spent time learning how QTM works. Interviews were then conducted with people from the respective user groups and the data from those interviews were then later used to create user stories.



(a) Vessel Sintef marintek



(b) Vessel Bølge marintek

Figure 4.4: Research & Requirements - Photo study

(a) Running Raleigh



(b) Running

Figure 4.5: Research & Requirements - Photo study

Photos from user environment

Initially we conducted a photo study in order to understand how the system worked in a user environment. The benefit of using this design research method is that the method is self reporting and exploratory which means that the participants photo-document aspect of their everyday life and interactions. This provides the designers with insights into user behaviour and priorities [24]. The chosen participants were both vessel and running related as this was the user groups that was going to be focused on. The result from the photo study was qualitative data in the form of a set of pictures. More practically the study was conducted by receiving contacts from each user group and letting them send pictures from their everyday interaction with Qualisys and QTM. The acquired photos from the vessel user group can be seen in Figures 4.4a and 4.4b.

The acquired photos from the running user group can be seen in Figures 4.5a and 4.5b.

Interviews

In order to gain knowledge about the domain and the task ahead, interviews were held. The interviewees were chosen in order to cover the two different target groups (Marine and running), this included software engineers, chief technology officer (domain and product vision), senior motion capture specialist (which has a lot of contact with end-customers). The interviews were done by having one person directing the

interview and the other person taking notes. The reason for doing this was because full focus should be directed towards the interviewee and directing. This way of conducting an interview makes the conversation flow more easily. After introducing us and presenting to the interviewee why they were chosen and what the purpose of the interview was questions was asked. The questions asked are given in Table 4.2.1:

Interview Questions

How long have you worked here at *insert company*?

What does your service regard?

What tasks does your work include?

What domain do you work with (running/vessel)?

What type of contact do you have with the users of the product?

What kind of data do you use QTM to inspect?

What would you like to see in a portal that gives you access to data from QTM?

Could you describe what is frustrating in your process at the moment?

What kind of data would have been interesting to visualize?

What do you prioritize, user friendliness or data complexity?

USER STORY

As a Runner

I want to View real-time data compared to "goal data"

So that I can more easily work on my form.

I KNOW I AM DONE WHEN

- The web application displays a gauge
- I get visual feedback from the system
- I can input my own goal data

DOMAIN

- ☒ Design
- ☒ Front-End
- ☒ Back-End

Figure 4.6: Example of a user story

What can be derived from the interview questions is that the questions at the start of the interview was made more easy for the interviewee. This was done in order to make him/her feel more comfortable and at ease with the situation. After the questions was asked and we have sure that they do not have any questions the interviewee was thanked.

User stories

The result from the interviews were made into a set of user stories. These were written on the format: *As a ... I want to ... so that I ...* and edited on to a user story card. The format chosen is standard in Scrum and because the work towards Qualisys was done in Scrum and sprints, this was the format that seemed the most suitable. After they had been written they were further categorized and added to the product backlog. In Figure 4.6 an example of a user story can be seen.

The full list of user stories can be seen in Appendix A.1.

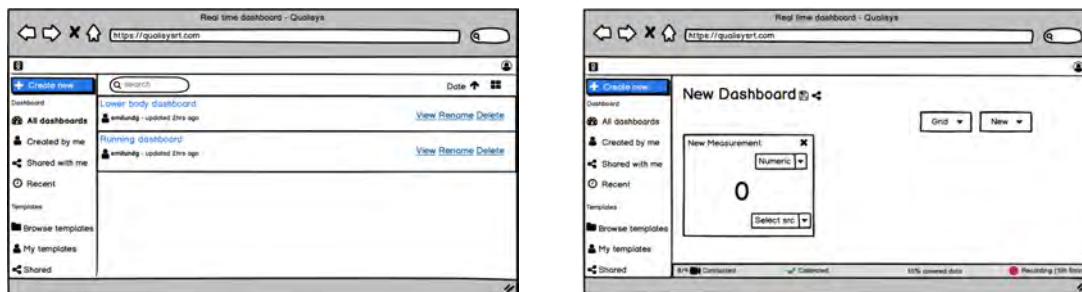
4.2.2 Design alternatives

Different design alternatives were made where all the versions met the requirements gathered from the previous phase. As stated before the work was done in iterations and except for the first iteration this stage marks a new iteration beginning.



(a) Design alternative 1 - Dashboard overview select widget type (b) Design alternative 2 - Dashboard overview select widget type

Figure 4.7: Design alternatives 1 & 2



(a) List of user dashboards (b) Overview over a selected dashboard

Figure 4.8: Iteration 1 - Low fidelity

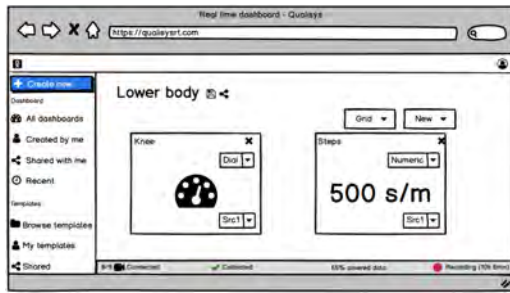
4.2.3 Prototyping

From the design alternatives, different prototypes were made. This was done firstly by making low fidelity wireframes in Balsamiq [1]. The purpose of making the low-fidelity wireframe was for testing functionality. To see that the users could find the information that they searched for and navigate in an expected manner. After this, high-fidelity prototypes were made from the refurbished low-fidelity ones. This was done with the purpose of getting an aesthetics that both we and the company found pleasing. After approval of the design an Interactive prototype was made in order to see that the design functioned in practice as well.

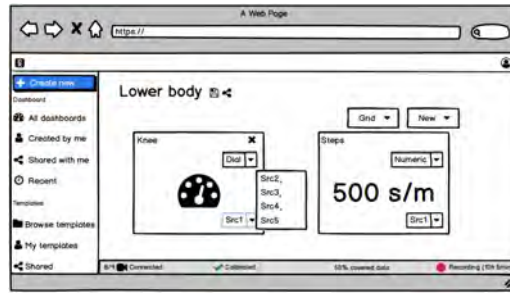
Low fidelity

The low fidelity sketches of the whole system can be seen in Figure 4.8a, 4.8b, 4.9a, 4.9b, 4.10a, 4.10b. The whole prototype was made in Balsamiq [1] with the focus of solving the functionality needs of the problem at hand. The design landing page is a list over created and accessible dashboards for the user. This can be seen in Figure 4.8a. The user can then choose to navigate to a specific dashboard which is displayed in Figure 4.8b. Here the user has an overview over what widgets have been chosen and next coming actions.

One of the next actions the user can take is to select a new data source for any of

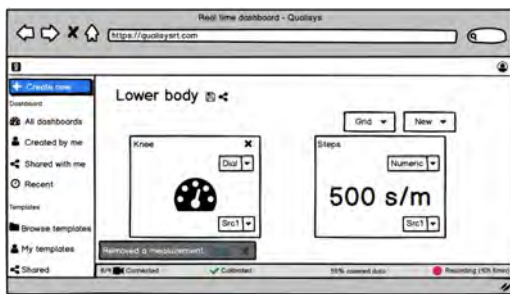


(a) Dashboard displaying numeric and dial widget

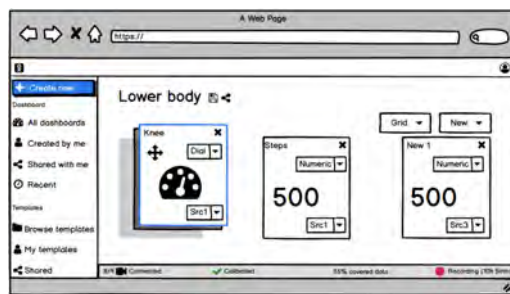


(b) Select data source

Figure 4.9: Iteration 1 - Low fidelity



(a) Undo action if card is removed



(b) Move dashboard card

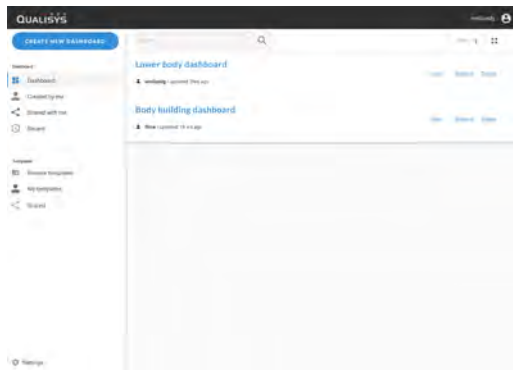
Figure 4.10: Iteration 1 - Low fidelity

the made widgets. This is shown in Figure 4.9b and is done by selecting a labeled marker in a dropdown list.

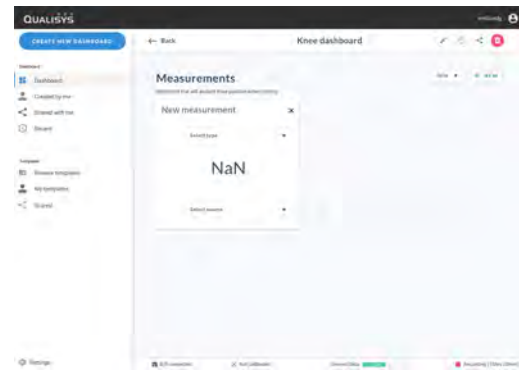
In order to be able to have a customizable dashboard the user had to be able to create, remove, move and edit widgets. When a user has removed a card they are prompted with a subtle toast providing the option to the user to undo their action. This can be seen in Figure 4.10a. The reason for having undo and not a confirm window is because the system should ideally assume that the user action is the intended one and not confirm that the action is right. One of the requirements of the system was that the user should be able to move widgets. This is done by the click & drag action on a card and can be seen in Figure 4.10b.

High fidelity

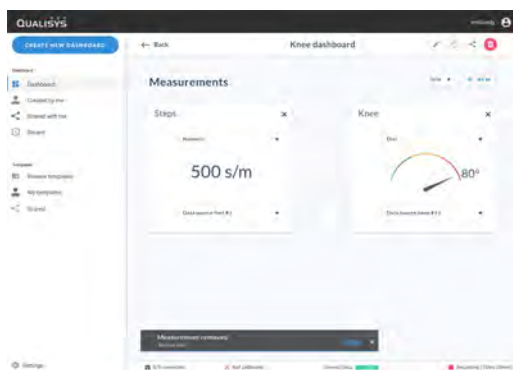
The high fidelity prototypes of the whole system can be seen in Figure 4.11a, 4.11b, 4.12a, 4.12b, 4.13a, 4.13b, 4.14a, 4.14b and was made with the focus of getting a pleasing and acceptable look & feel of the system. We followed the material design guidelines as much as possible but another factor that was important was to minimize visual excise and providing a clean, minimalistic interface for the user. In Figure 4.11a the list of user dashboards can be seen. The theme of the application was made to follow Qualisys color code and took inspiration from their demo running application. In Figure 4.11b the overview of a particular dashboard can be seen. In order to ensure that primary/destructive actions were easy to find, another color than the secondary (white) was used. This can be in the navigation bar where creating a new dashboard is blue. This can also be seen on the trashcan icon button



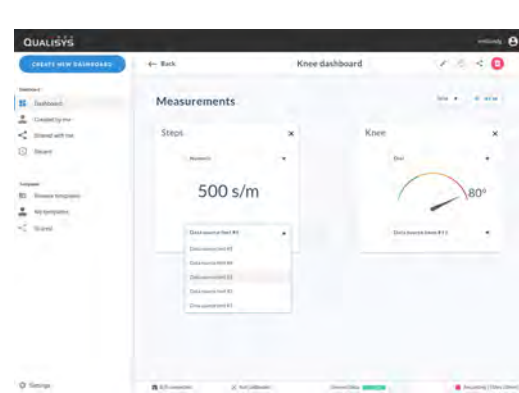
(a) List of user dashboards



(b) Overview over a selected dashboard

Figure 4.11: Iteration 1 - High fidelity

(a) Dashboard displaying numeric and dial widget

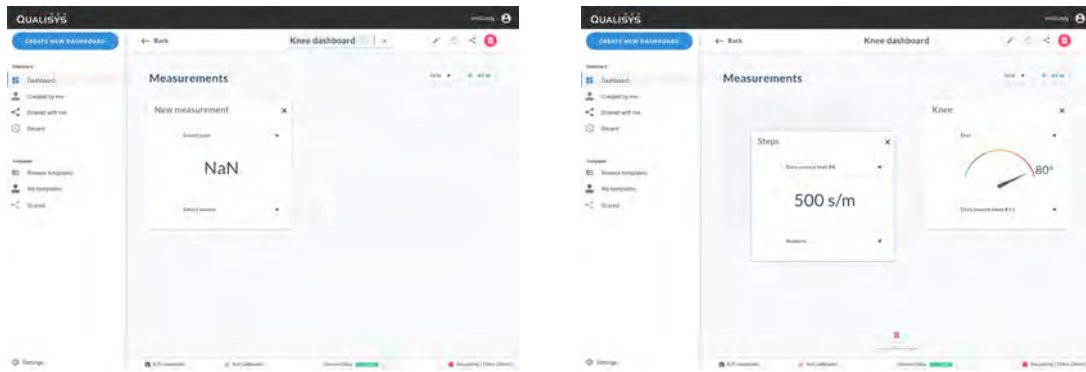


(b) Select data source

Figure 4.12: Iteration 1 - High fidelity

for removing a dashboard where the color correlates to danger - red.

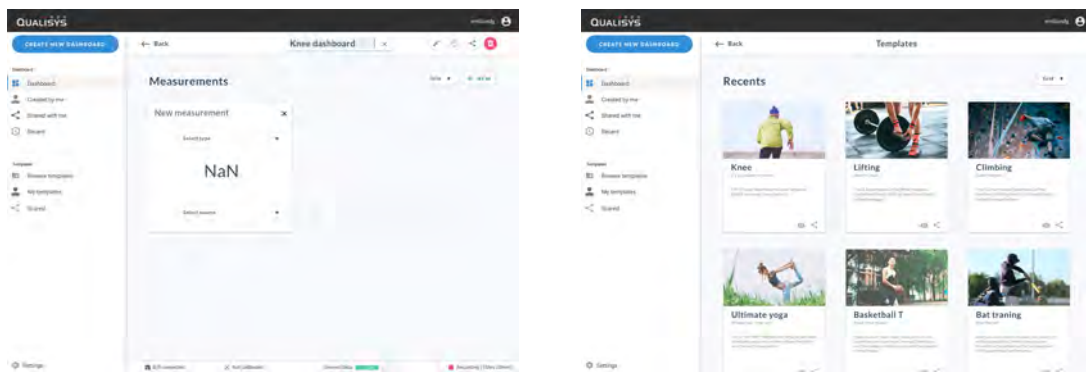
We focused the designs on the two widget types being made into a proof-of-concept first which contained a numeric widget and a dial widget. This can be seen in Figure 4.12a. When selecting a data source the design uses visual modal feedback to ensure that the user know what item they are hovering at. This can be seen in Figure 4.12b. In Figure 4.13a undoing of an action can be seen. The background of the toast is made into a primary color in order to draw attention to the action for the user. The undo text-button is in the primary color blue and underlined which indicates that the button can be clicked on. In order to provide feedback when moving a card we chose to display where the card initially came from. This was done by making the original position area darker than the background and can be seen in Figure 4.10b. In order to rename a dashboard we provide the user with several ways of accomplishing this. Next to the title of the dashboard the user can choose to click on the edit icon which then highlights the current dashboard name indicating that the name can be changed. Another way of doing this is by clicking the dashboard name directly. This interaction can be seen in Figure 4.14a. A requirement that we obtained of the system was that the user should be able to purchase dashboards made by other users e.g templates. This view can be seen in Figure 4.14b and is a basic



(a) Undo action if card is removed

(b) Move dashboard card

Figure 4.13: Iteration 1 - High fidelity



(a) Rename dashboard

(b) Template dashboard list

Figure 4.14: Iteration 1 - High fidelity

card list view.

Interactive prototype

Interactive prototypes were made during the first iteration. The first Interactive prototype worked as a proof-of-concept and implementing the design was not a priority. This prototype can be seen in Figure 4.15. The prototype shows two cards where the first one contains a dropdown for selecting what command to send to the software QTM. The second card is solely for displaying the frames received from the software.

The second Interactive prototype which can be seen in Figure 4.16 was done when data was able to be fetched in real-time. This prototype focused more on implementing the design from the high-fidelity prototype. Navigation was added in this stage as well.

4.2.4 Evaluation

Evaluation was done with a feedback session, heuristic evaluation and usability testing. The feedback session was carried out by our company supervisors towards the rest of their application development team and the feedback from that was provided directly to us. What became evident from this feedback session was firstly that the

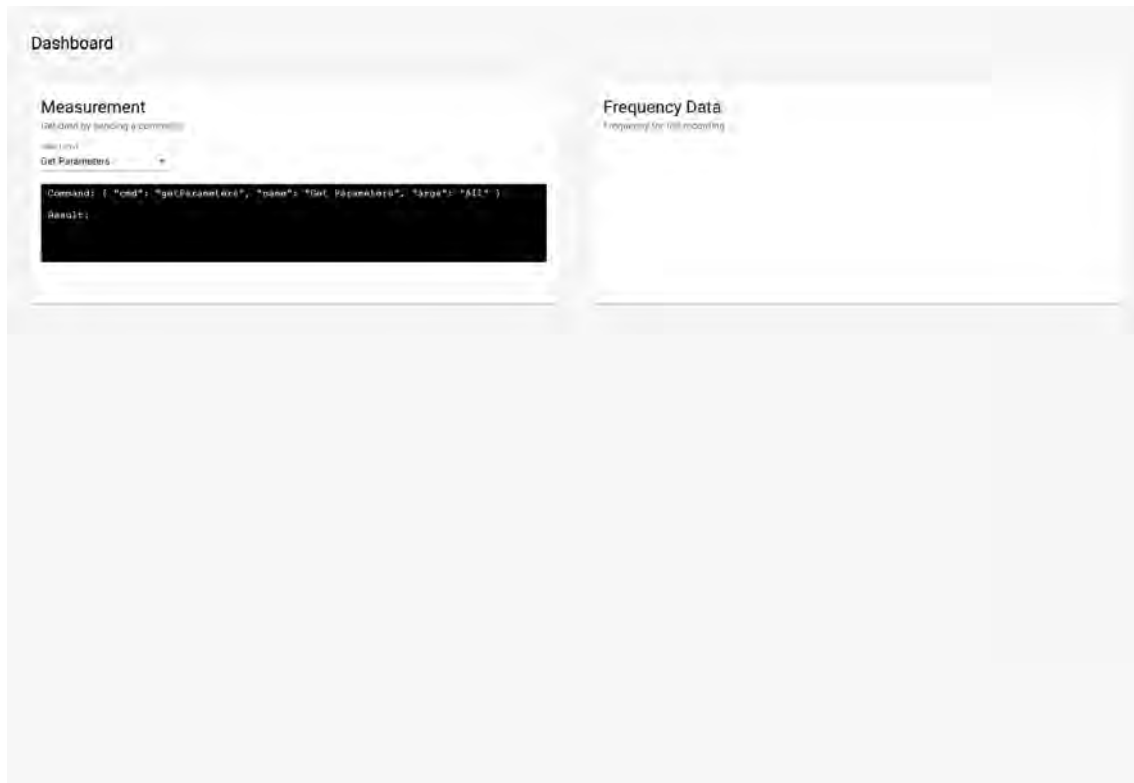


Figure 4.15: Iteration 1 - Interactive prototype - Dashboard overview version 1

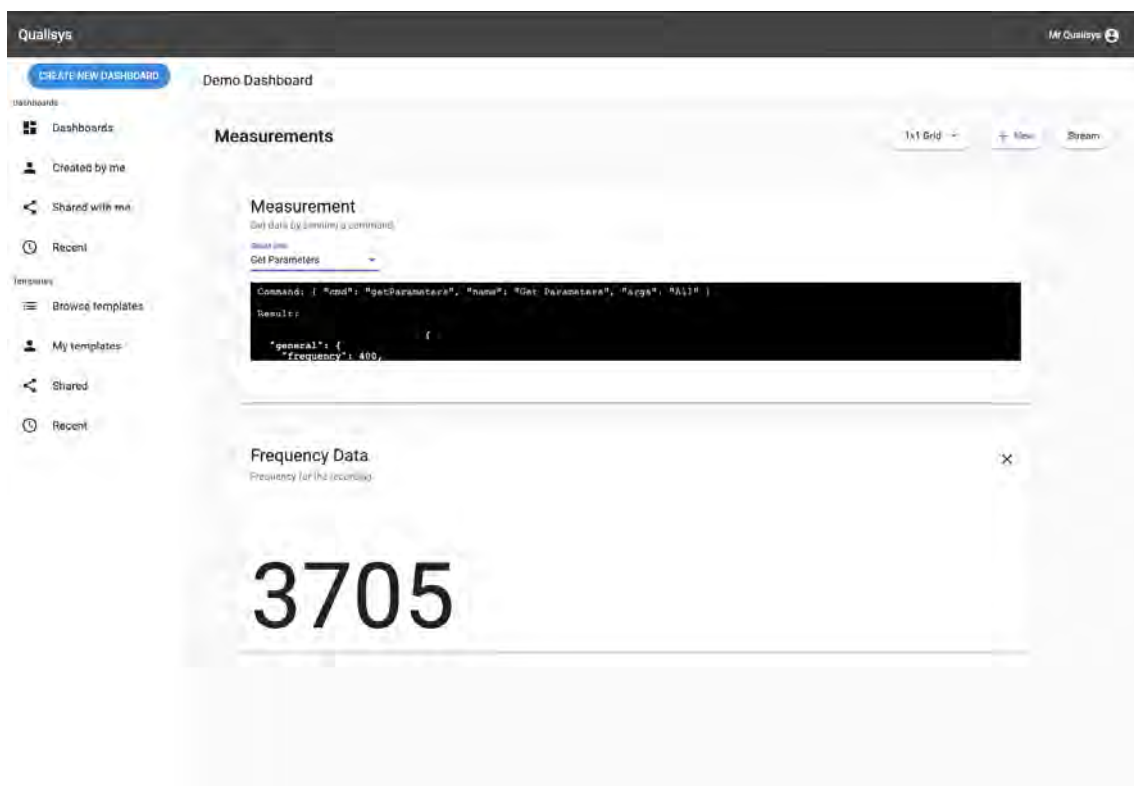


Figure 4.16: Iteration 1 - Interactive prototype - Dashboard overview version 2

menu took up to much space. This because they deemed it unnecessary to take focus away from the dashboard and as much space as possible was needed. The second most important takeaway from the feedback session was the fact that we had missed what selecting a data source in practice meant. The designed showed a much more straightforward approach but in reality there could be over a 100 markers and different categories.

The heuristic evaluation was performed individually by the two thesis writers. The heuristics used are shown in the Methodology chapter in figure 3.2.

System status feedback	Modeless feedback about current recording. Clear indicators showing what object you are manipulating. Clear indicator when removing objects.
System and real world match	Nothing strange.
User Control	Undo for deleting cards.
Consistency and Standards	"Drop your files to delete" is wrong and inconsistent with the action. Files aren't deleted but cards are. Status bar - What isn't calibrated? QTM? Web app?
Error Prevention	No errors encountered.
Recognition rather than recall	Navigation is always visible. Mostly clear icons. Rewind clock icon is unclear.
Flexibility and ease of use	Access to recently used dashboards and templates. No accelerators for moving or deleting cards.
Aesthetic & minimalist design	Minimal use of colors. Neutral colors used. Almost no unnecessary information presented.
Help and documentation	No help or documentation offered.
Accommodation	Users familiar with QTM disagree with term 'Measurements' found on dashboard. It is in conflict with terminology found in QTM.

The usability testing was conducted through a various set of use-cases and observing the users interact with the prototype. Usability testing of single users was done compared to a group because of the web-application most likely being used by one person at a time (even though several people might be observing). Before the testing had started, instructions were given out where the user were told to Think-Aloud.

In Figure 4.17 testing of the functionality of the low-fidelity design can be seen. The testing subject was given a pen with the motivation that showing intended actions would become more intuitive. What became evident during the testing was that the pen seemed to help the users a lot with navigating the wireframes. During

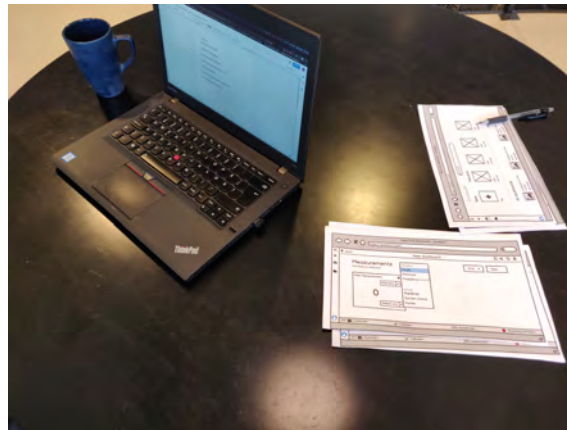


Figure 4.17: Iteration 1 - Testing functionality of low-fidelity

the usability testing one of the thesis writers took notes and the other one focused on instructing and directing the test.

The different scenarios were:

1. Browse and find a knee template.
2. Navigate back to list of dashboards
3. Create new dashboard and then rename it
4. Change source to angle and select marker 1
5. Create a new measurement
6. Remove the newly created measurement and bring it back.
7. Move the first card to last position in the same row

The key takeaways that we got from the different sessions was that the user could complete most of the tasks without problem, the terminology used in the designs was used in the wrong context for the internal terminology of the company which caused confusion and that the users got stuck/were confused as to what changing the data source meant.

4.3 Iteration 2a

Iteration 2a began without a research and requirements phase. The reason for this is because from the evaluation stage of iteration 1 the new requirements were brought forward. The iteration started out with sketching out different design alternatives. The key problem that we faced was how to select a data source and what this meant. The general process was to sketch out an idea, check with the company supervisors if the groups idea held up in practice and then refine and make them into low-fidelity wireframes. High-fidelity prototypes was then made in order to pin point the new look and feel of the application. The main focus here was to integrate the new solutions into the already existing prototypes in a more seamless way. Iteration 2a corresponds to the D3 stage in Figure 4.1. After the new design had been established an interactive prototype was made in order to guarantee that the design had been made in such a manner that the solution was going to be practical sufficient.

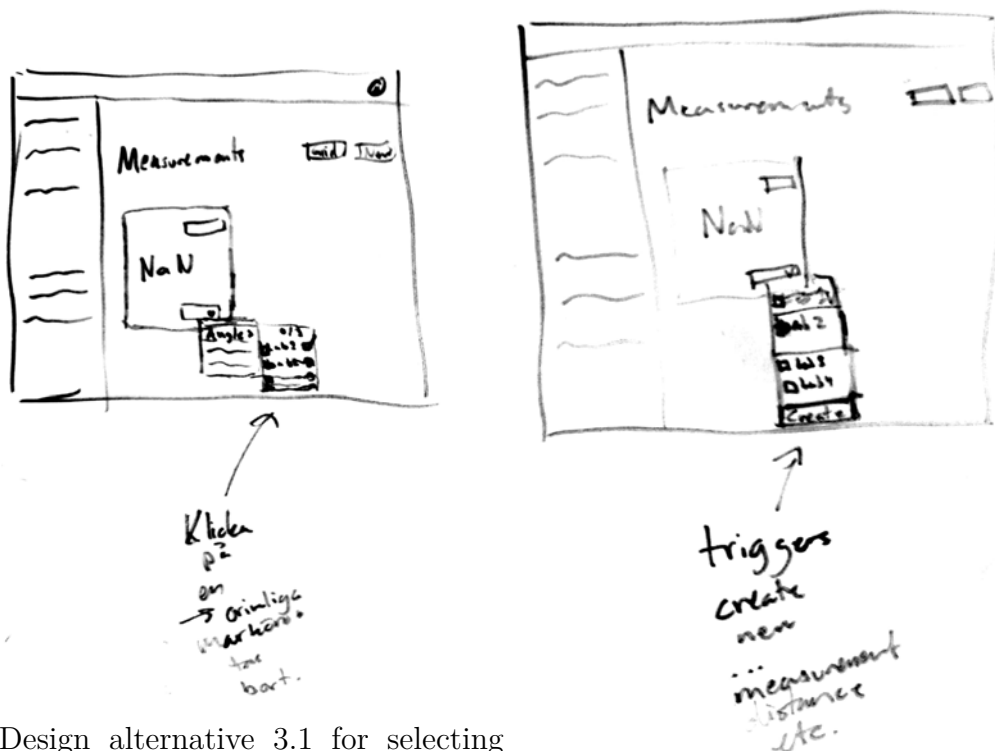
4.3.1 Design alternatives

The different design alternatives was made with the focus of refining and redesigning the key takeaways from iteration 1 and can be seen as design alternative 3 in Figure 4.1. The tasks could further be divided into defining a new flow for selecting data source, finding a solution for a more subtle navigation and going through the terminology used ensuring that it would match Qualisys. When designing the new flow the solution came down to basically two alternatives, either the user was going to choose which markers they wanted to apply an action to OR the action was going to be chosen first and then the relevant markers. These alternatives corresponds to D3.1 and D3.2 in Figure 4.1 and can be seen in Figure 4.18a and 4.18b.

After feedback from our company supervisors the alternative that was chosen to further design was alternative D3.1. The reason this alternative made more sense to move forward with was because the navigation when designing for GUIs should go from a wide into a narrow perspective.

The second design alternative pair dealt with trying to solve the navigation bar taking up a substantial amount of space. These alternatives corresponds to D3.3 and D3.4 in Figure 4.1 and can be seen in Figure 4.19a and 4.19b.

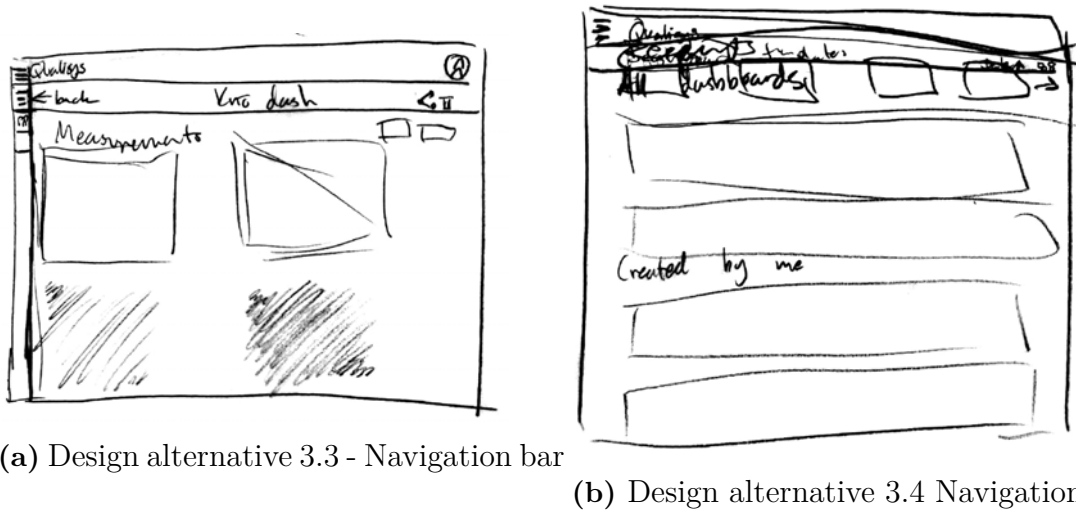
Even though design alternative D3.4 takes up less space than alternative D3.3, the latter was chosen to move forward with with the motivation that navigation should



(a) Design alternative 3.1 for selecting data source - action first then markers

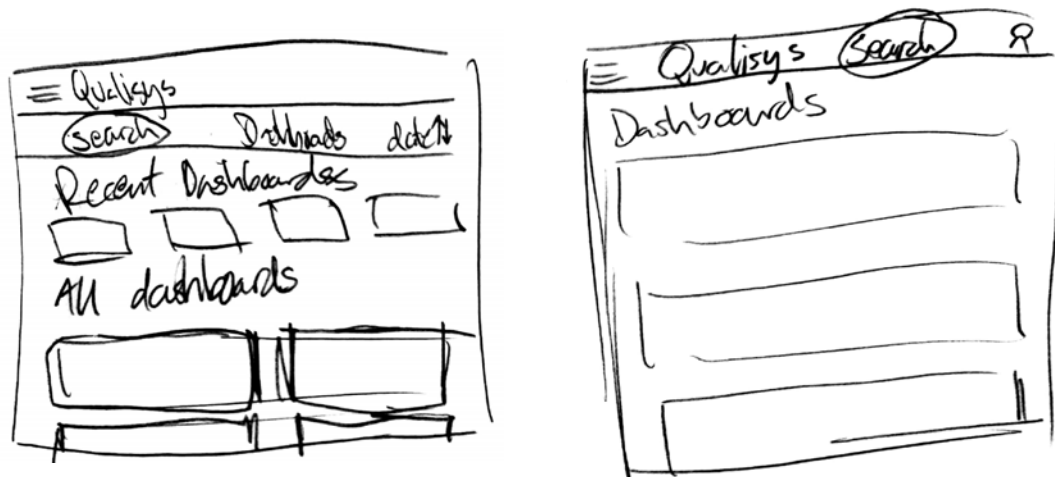
(b) Design alternative 3.2 for selecting data source - markers first then action

Figure 4.18: Design alternatives 3.1 & 3.2



(a) Design alternative 3.3 - Navigation bar

(b) Design alternative 3.4 Navigation bar

Figure 4.19: Design alternatives 3.3 & 3.4

(a) Design alternative 3.5 - Structure of different dashboards

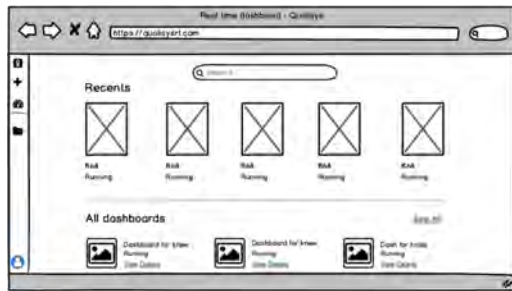
(b) Design alternative 3.6 - Structure of different dashboards

Figure 4.20: Design alternatives 3.5 & 3.6

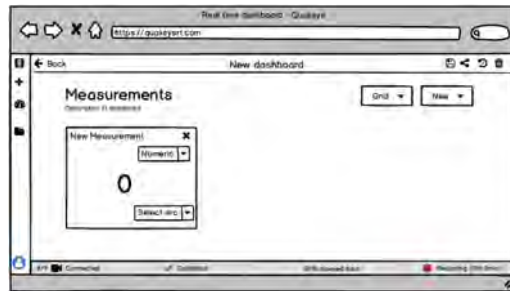
be visible at all times in order to ensure that the user always know where they are and how to navigate further.

The third design alternative was designed in order to solve how different dashboards should be visible to the user. We took inspiration from how the software iTunes work with labeling and displaying content. The different alternatives corresponds to D3.5 and D3.6 in Figure 4.1 and can be seen in Figure 4.20a and 4.20b.

We decided to move forward with design alternative D3.5 with the motivation that the user would most likely want to have easy access to their most recent edited or used dashboards at the top and that they should not fear scrolling through the rest of the content.



(a) List of user dashboards



(b) Overview over a selected dashboard

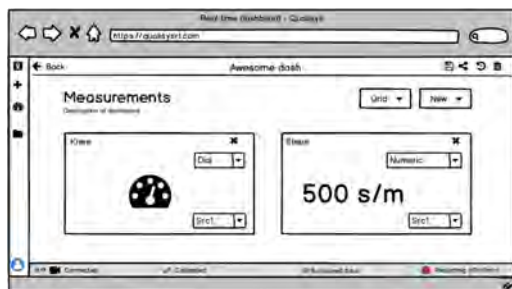
Figure 4.21: Iteration 2a - Low fidelity

4.3.2 Prototyping

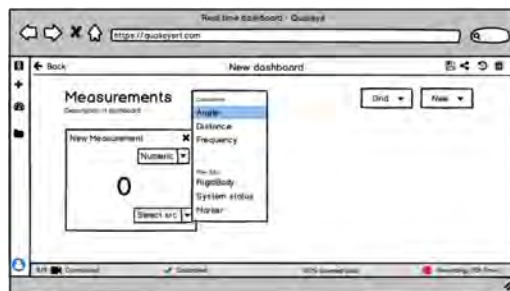
Low fidelity The low fidelity prototypes of iteration 2a can be seen in Figures 4.21a, 4.21b, 4.22a, 4.22b, 4.23a, 4.24a, 4.23b, 4.24b. They were done in order to solve the functionality problems discovered in the evaluation of iteration 1. In Figure 4.21a the new list of user dashboards can be seen. The design is similar to the one made in iteration 1 with the difference of providing more ways to navigate through them for the user. This is done by grouping (recently used dashboards and all dashboards) and enabling the user to search for a specific dashboard. In Figure 4.21b the new overview over a specific dashboard can be seen. The main difference here is the fact that the navigation bar to the left of the screen is much smaller. This makes the content of the dashboard more in focus, as the content should be.

An advantage which can be seen by having the navigation bar much smaller can be seen in Figure 4.22a where the cards are much larger than they were before. One of the major feedback from Iteration 1 that we obtained was that selecting source had no practical meaning. The updated version can be seen in Figure 4.22b and now groups the content into calculations and raw data.

The newly added second part of selecting source can be seen in Figure 4.23a. The design also allows for the user to navigate between the different markers by searching and if the chosen part from Figure 4.22b allows multiple markers to be selected, a checkbox is provided. In order to move a card the design still takes advantage of the click & drag action which can be seen in Figure 4.23b.

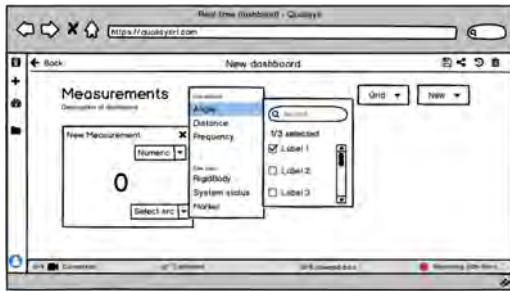


(a) Dashboard displaying numeric and dial widget

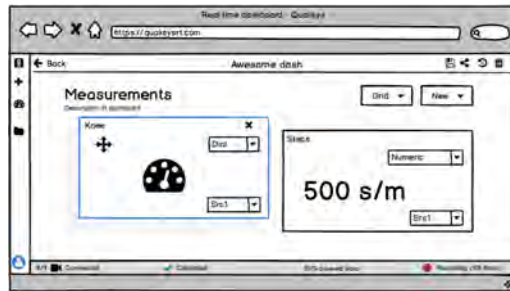


(b) Select data source

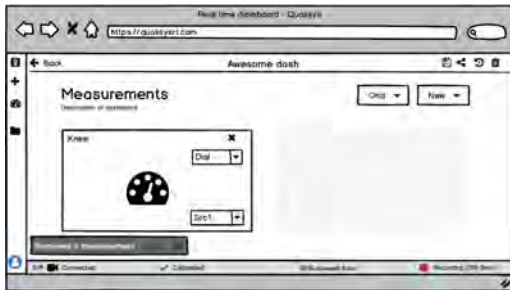
Figure 4.22: Iteration 2a - Low fidelity



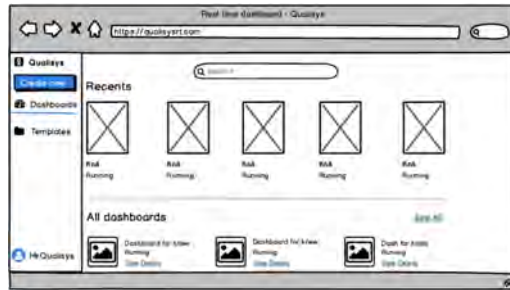
(a) Select data source extended



(b) Move dashboard card

Figure 4.23: Iteration 2a - Low fidelity

(a) Undo action if card is removed



(b) Menu open on hover

Figure 4.24: Iteration 2a - Low fidelity

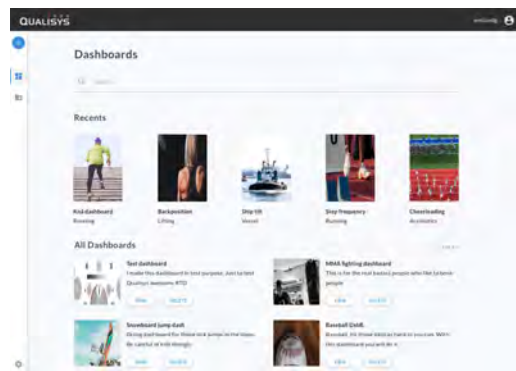
The undo action when a card has been removed can be seen in Figure 4.24a and solves the design problem in the same way as Iteration 1. One of the key new functionalities of Iteration 2a compared to Iteration 1 is the hidden menu. We decided that because completely hiding the menu is bad practice the navigation should be visible at all times. This was solved with a custom design solution where the menu is partially hidden. The fully expanded can be seen in Figure 4.24b and is triggered on hover.

High fidelity

The high fidelity prototypes of the whole system can be seen in Figures 4.25a, 4.25b, 4.26a, 4.26b, 4.27a, 4.28a, 4.27b, 4.28b. The general look & feel of the application is still the same compared to Iteration 1 with some minor exceptions. In Figure 4.25a and 4.25b the updated user dashboard list and dashboard overview can be seen.

In Figure 4.26a the updated view containing both numeric and dial widget can be seen. In Figure 4.26b the initial dropdown of selecting a source can be seen. The dropdown still provides the user with modeless visual feedback but also indicates that the user can navigate further down in the list structure. We decided to provide checkboxes for the user which when selected will turn into the primary color blue. In Figures 4.27a and 4.27b renaming a dashboard and moving a card can be seen. These views were updated to have the new navigation but otherwise remained basically the same.

In Figures 4.28a and 4.28b undoing an action and opening the menu on hover can be seen. Opening the menu is done by hovering and is also the newly added stage from Iteration 1.



(a) List of user dashboards

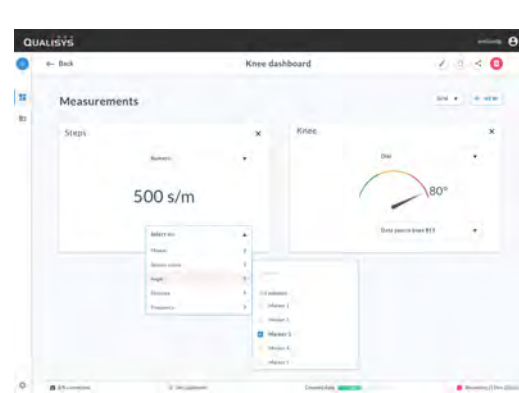


(b) Overview over a selected dashboard

Figure 4.25: Iteration 2a - High fidelity



(a) Dashboard displaying numeric and dial widget

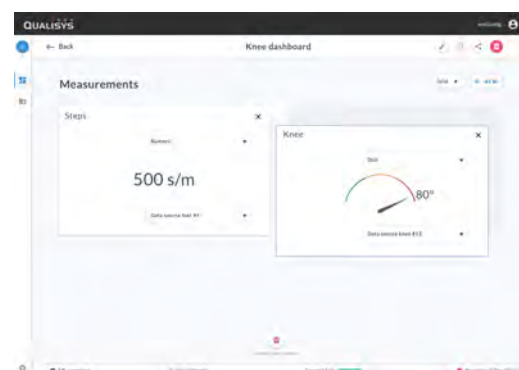


(b) Select data source

Figure 4.26: Iteration 2a - High fidelity



(a) Rename a user dashboard



(b) Move dashboard card

Figure 4.27: Iteration 2a - High fidelity

4.3.3 Evaluation

Heuristic Evaluation The heuristic evaluation was performed as described in Iteration 1.



(a) Green car used in the Advanced engineering fair



(b) Red car used in the Advanced engineering fair

Figure 4.29: Iteration 2b

with the stakeholders that they were in the lines of the expected result. After this had been done, low fidelity and later high-fidelity prototypes were made to ensure functionality and look & feel. In the later stage of this iteration we attended the Advanced Engineering 2019 fair [9] held in Gothenburg to provide Interactive prototype support and make sure that everything went smoothly. We deemed this as an excellent time to evaluate the prototype and observe how the users were interacting with the prototype.

4.4.1 Design alternatives

The different design alternatives were made with the focus of displaying the needed data in one view and can be seen as design alternative 4 in Figure 4.1. The task that the different solutions were about to solve was how to display a lot of data in one view without scrolling in a pleasing manner. The different alternatives correspond to D4.1 and D4.2 in Figure 4.1 and can be seen in Figure 4.30a and 4.30b. Alternative D4.1 is similar to the design alternatives from iteration 3.1 with the reasoning that the solution was already in the existing design.

Even though we advised against it because information would be almost impossible to grasp in real time with that solution, alternative D4.1 was chosen to move forward with. The reasoning behind this was that the solution suited the user requirements more. A benefit of choosing D4.2 was that this alternative had a quick and easy way for the users to find out one of the most important data which was the distance between the cars. Instead of having a title separating the different cars from each other the stakeholders instead wanted to use the two pictures in Figure 4.29b and 4.29a to illustrate what car belonged to which card. This was included in the upcoming stages. A comparison between the different alternatives shows that the chosen alternative does not have any navigation methods. This because navigating to other dashboards was not going to be needed thus the need for navigation, saving and deleting dashboards did not exist.

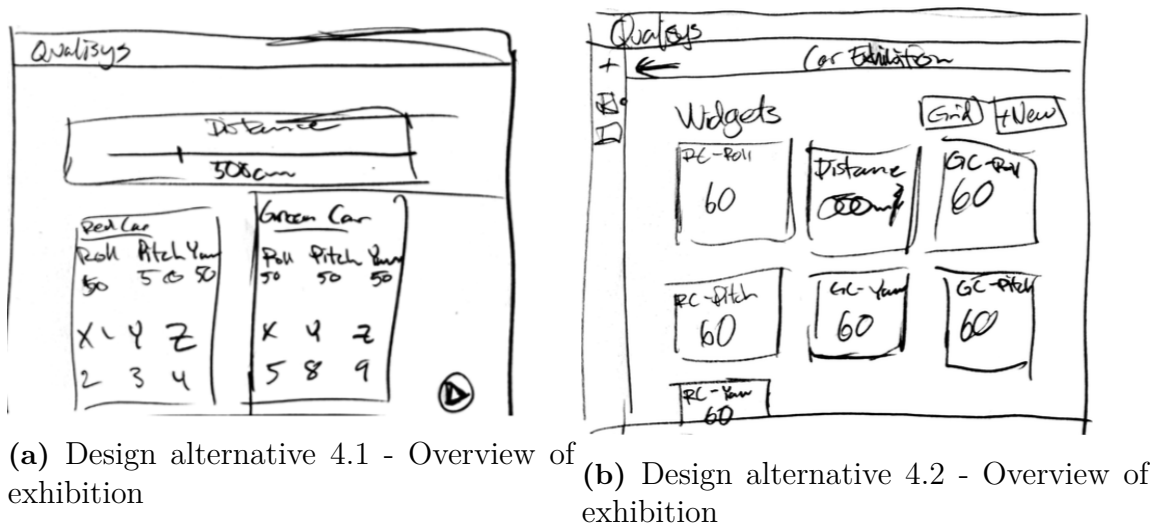


Figure 4.30: Design alternatives 4.1 & 4.2

4.4.2 Prototyping

Low fidelity

In Figure 4.31 the overview for Iteration 2b can be seen. This overview was made with the focus of providing a solution that was as simple as possible, meaning, no navigation and basically no interaction. The only user interaction that we provided through the design was a play/pause button in order to start and stop streaming data. At the top a slider can be seen which provides the user with additional feedback of the distance between the two objects.

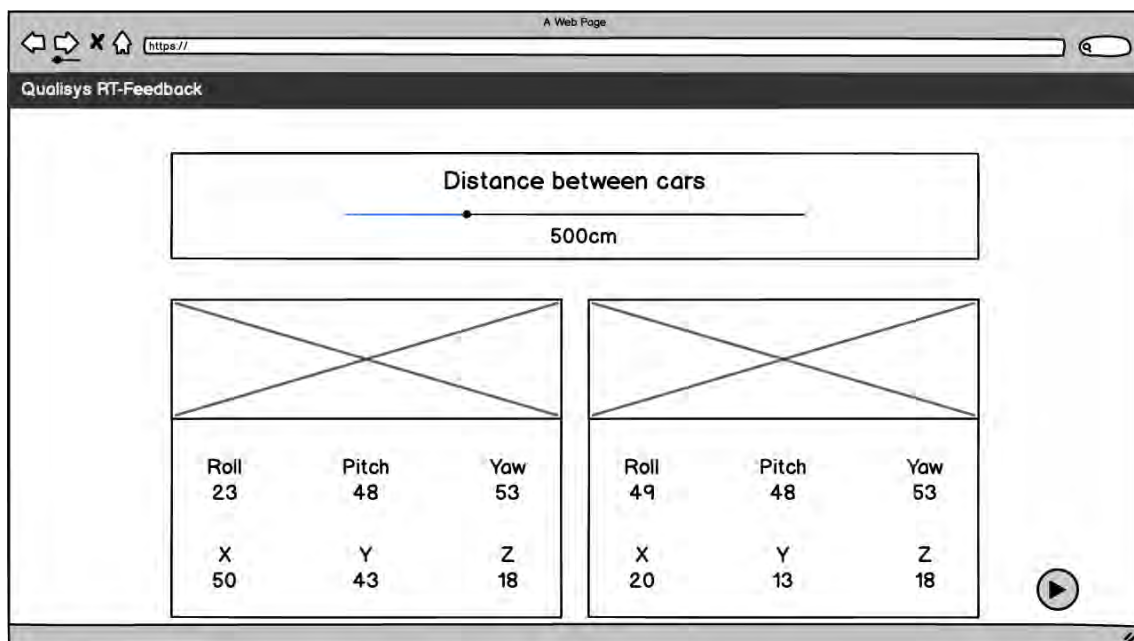


Figure 4.31: Iteration 2b - Low fidelity - Overview

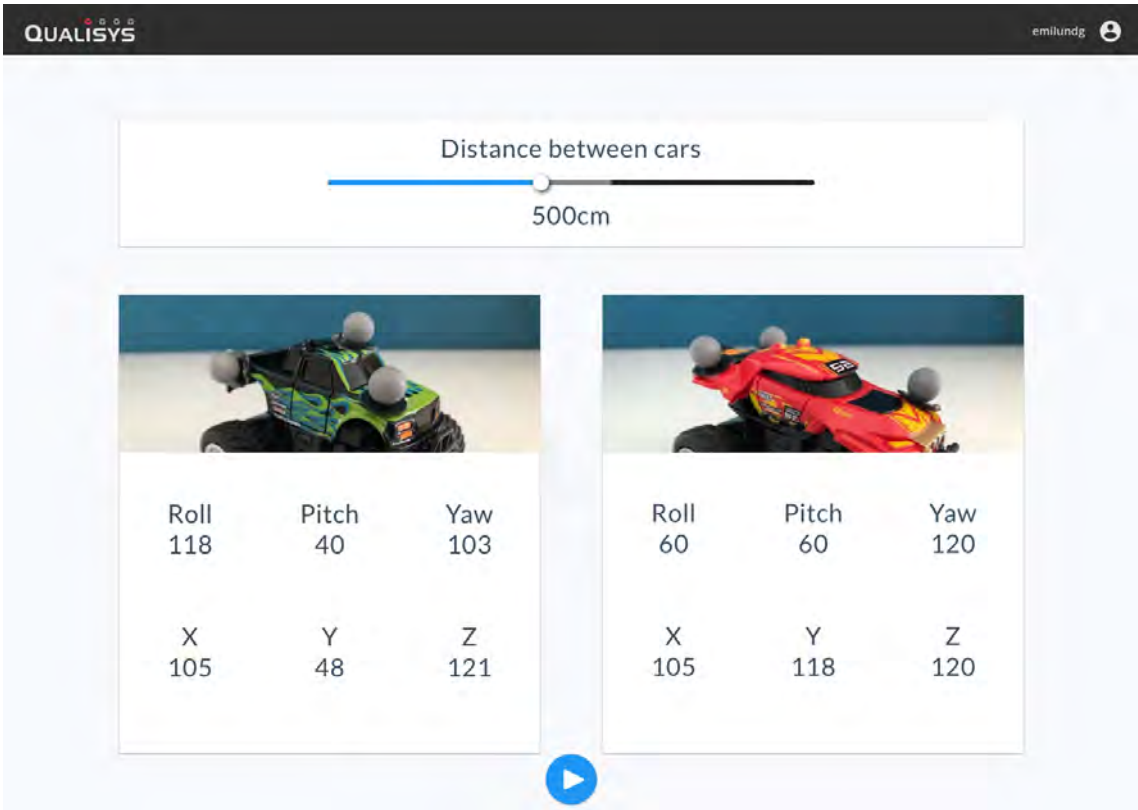


Figure 4.32: Iteration 2b - High fidelity - Overview

High fidelity

In Figure 4.32 the high fidelity version of the prototype can be seen. The design uses primary colors to highlight useful data and actions for the users.

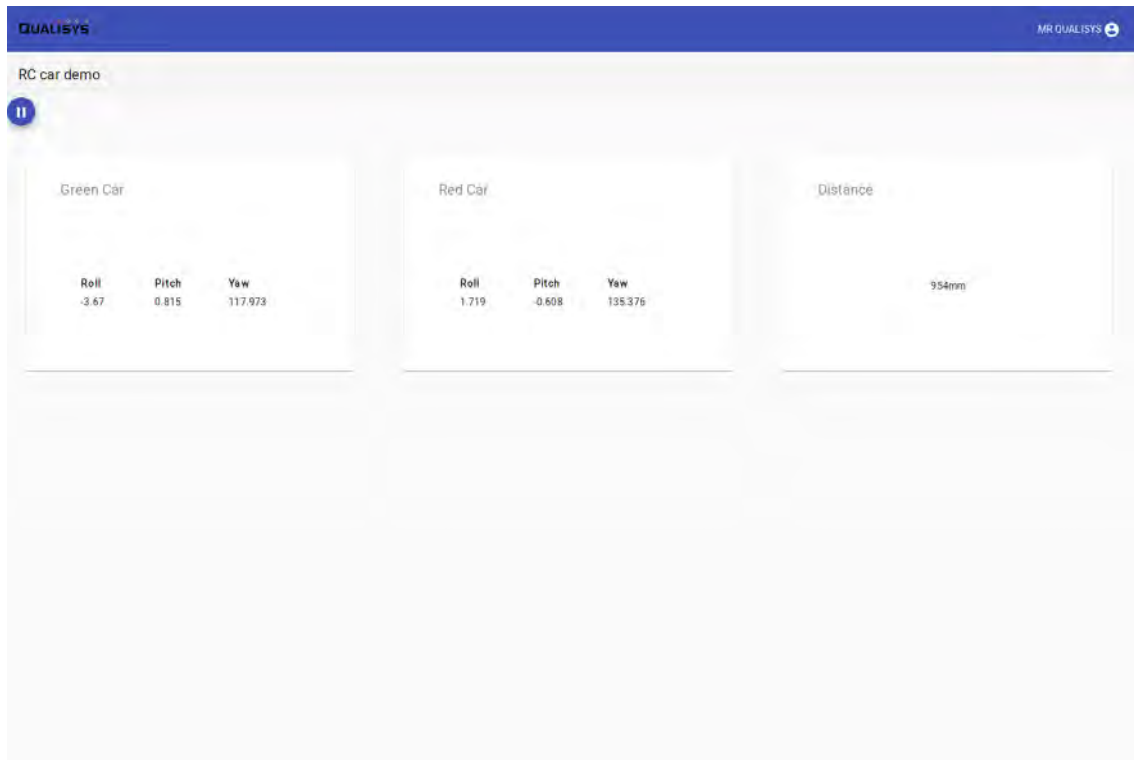


Figure 4.33: Iteration 2b - Interactive prototype - Functionality

Interactive prototype

Additional prototypes that was made during iteration 2b was Interactive prototypes. The reason for implementing the design into code was that the company was going to attend the fair and wanted a working example for displaying real-time data on a monitor. Another reason for implementing was that we thought of this as an excellent opportunity to evaluate the design in action. The Interactive prototypes started out by making sure that the functionality was there and not focusing so much on implementing towards how the high-fidelity prototypes looked. In Figure 4.33 the working Interactive prototype for the functionality can be seen.



Figure 4.34: Iteration 2b - Interactive prototype at Advanced engineering and automotive exhibition streaming live data from QTM

4.4.3 Evaluation

The Interactive prototype of iteration 2b at the exhibition can be seen in Figure 4.34. One of the key take-away from the exhibition was that focusing the cards on one data (e.g Yaw) is ideal. Focusing on more than one data source when the data is changing a lot in a short period of time is difficult. To prohibit this excise the cards will have one source visible instead of several. Worth noting is that the exhibition interactive prototype was tailored to fit this use case and we already had this in mind. After we had attended the exhibition additional evaluation was done in form of a technical meeting. At the company tech meets are held where the different technical teams inform each other about what is going on. During one of these meetings we had prepared a presentation which can be seen in Figure 4.35 of the exhibition prototype which included how the design process was done and a live demo of the interactive prototype.

The feedback we got from this stage regarded a lot of technical aspects but there was also discussions about the different usage areas of the prototype and what visualizations can be interested to look at. The feedback on different visualizations included more novel widgets in the area of 3D and AR/VR.

Heuristic Evaluation The heuristic evaluation was performed as described in It-

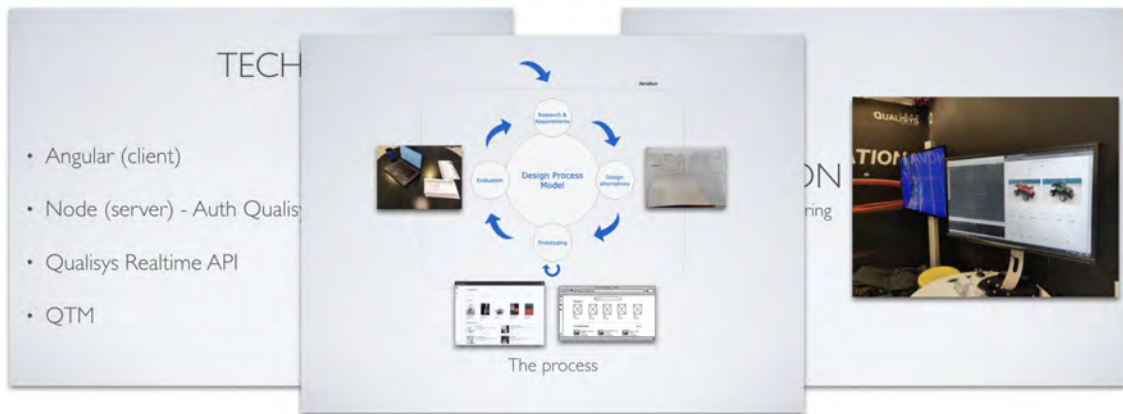


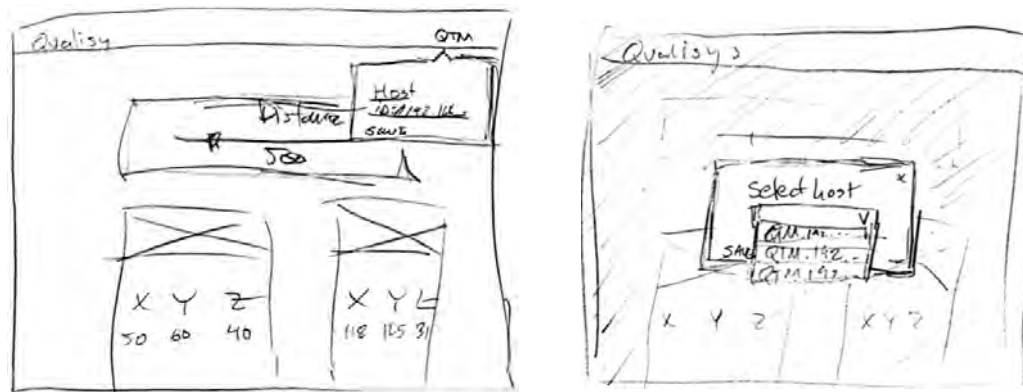
Figure 4.35: Iteration 3 - Evaluation - Presentation at technical meeting

eration 1.

System status feedback	Limited, only QTM status is provided.
System and real world match	"regular" terminology used, units of measurements that are easy to grasp as well.
User Control	Feel slightly powerless, can only control start and stop stream.
Consistency and Standards	Unclear what roll/pitch/yaw is in presented in, but degrees are assumed.
Error Prevention	Limited amount of actions, hard to trigger errors.
Recognition rather than recall	Pictures illustrating cars, no recall required.
Flexibility and ease of use	Efficient but not flexible at all.
Aesthetic and minimalist design	Nice looking design, but not enough room around data. Hard to focus when making a quick glance.
Help and documentation	No help or documentation in-app.
Accommodation	Language reflects language used in whole eco-system.

4.5 Iteration 3

Iteration 3 started without a research and requirements phase. The reason for this was because the iteration was a continuation of iteration 2b. Iteration 3 can be seen in Figure 4.1 and corresponds to stage D5. The iteration was needed because the company was going to attend a fair in Canada and the interactive prototype had to be changed in order to make the setup of the application more intuitive. The key problem that we faced was how to select where the data was going to be streamed from, e.g, what IP address QTM was broadcasting data at. We started out with making different design alternatives to see which solution was going to be the most suitable for the problem at hand. A key factor in deciding which design alternative



(a) Design alternative 5.1 - Select QTM host (b) Design alternative 5.2 - Select QTM host

Figure 4.36: Design alternatives 5.1 & 5.2

to move forward with was the amount of time left of the thesis. The fair was going to be held in May and we had other things to focus on as well. We prioritized a solution that would reach the interactive prototype stage in time. After a solution had been picked low and high fidelity prototypes was made in order to assure functionality and look & feel of the new solution. After a high fidelity prototype had been done, an interactive prototype was made. A prominent factor that differs from the other iterations was that we did not have time to evaluate the design in this iteration. The reason for this was because of the time left not being sufficient enough.

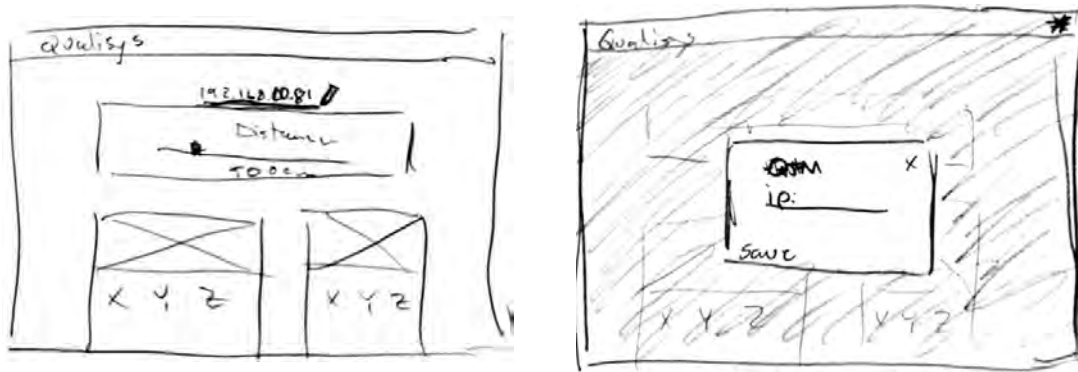
4.5.1 Design alternatives

The different design alternatives was made with the focus of generating a solution for the key problem and can be seen as design alternative 5 in Figure 4.1. The task could further be divided into making the user set an IP address to QTM in a easy and intuitive manner. When designing the new solution 4 different alternatives was made which all included different ways of solving the task at hand. The alternatives correspond to D5.1, D5.2, D5.3 and D5.4 in Figure 4.1 and can be seen in Figure 4.36a, 4.36b 4.37a and 4.37b.

The chosen alternative to move forward with was design alternative 5.1. The motivation behind this was that the solution was a intuitive way to manage the settings of the application and the implementation of the Interactive prototype could be made in a reasonable amount of time. The optimal solution would have been more like design alternative 5.1. The reason for this is because that solution finds the ip addresses of computers running QTM on the same network and lists them to the user. The reason for not choosing to move forward with this solution was because we would not have time to implement the Interactive prototype.

4.5.2 Prototyping

Low fidelity



(a) Design alternative 5.3 - Select QTM host

(b) Design alternative 5.4 - Select QTM host

Figure 4.37: Design alternatives 5.1 & 5.2

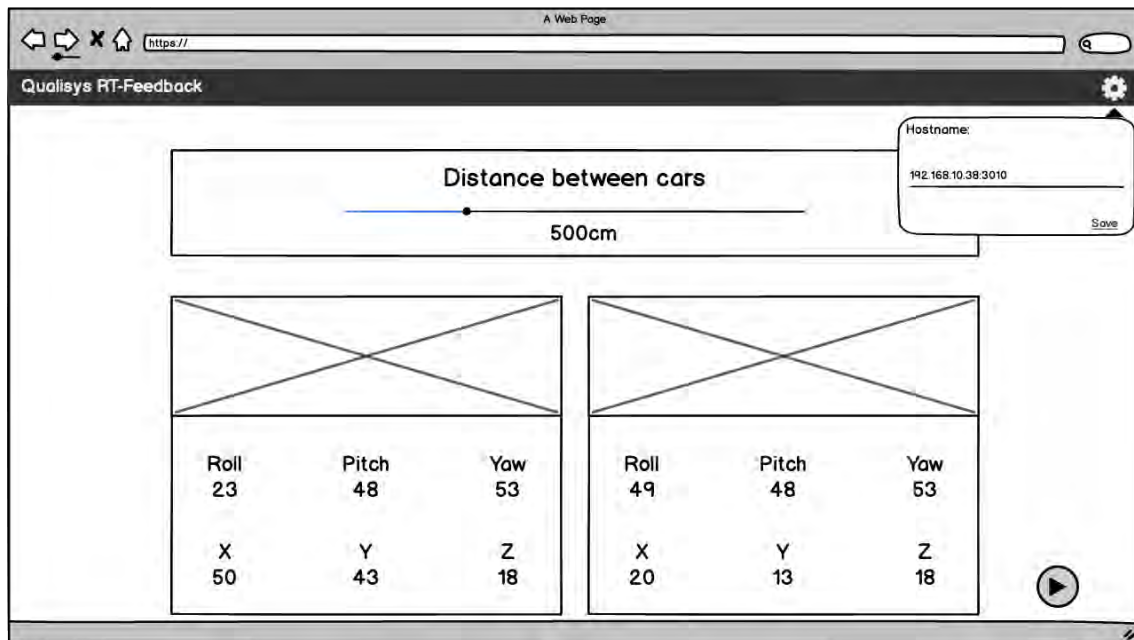


Figure 4.38: Iteration 3 - Low fidelity - Select QTM host

In Figure 4.38 the low-fidelity prototype of selecting a host can be seen. This design was made with the focus of having a realistic implementation goal considering functionality while at the same time providing the user with an intuitive way to enter the ip address of the running QTM software. The solution that we decided to go with provides the user with a dropdown menu with an input field.

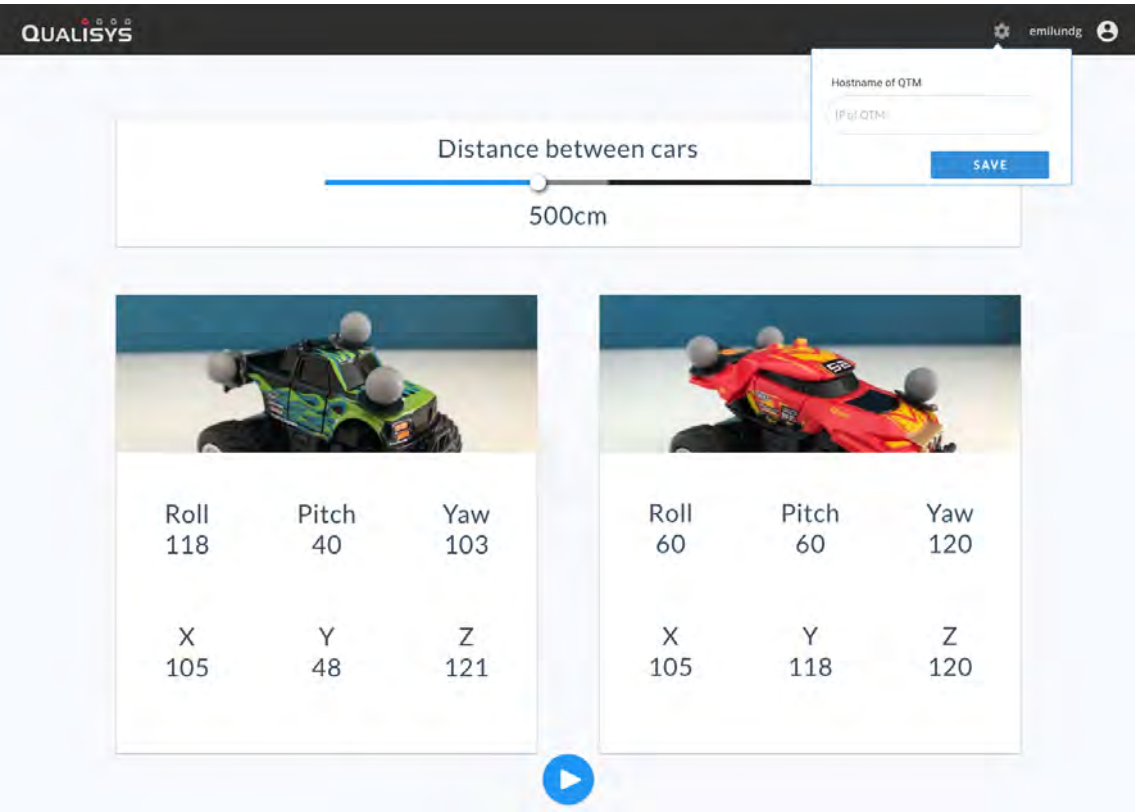


Figure 4.39: Iteration 3 - High fidelity - Select QTM host

High fidelity In Figure 4.39 the high fidelity prototype of Iteration 3 can be seen. We chose to use the cog-wheel icon indicating settings because this icon deemed the most familiar to users to change this kind of settings.

5

Results

This section will go into detail about what the final result of the customizable dashboard were. This includes the final set of guidelines from the project but also the code prototype, e.g, web application will be explained in its whole and will later be explained through key features to cover the rest. The last part of the result deals with presenting the last evaluation of the system.

5.1 Guidelines

During our different design iterations we realized that there are different things that need to be focused on or considered when designing a user interface that is to be used by users from different domains but still share a common application. We have chosen what we feel are the most important guidelines to follow when designing and summarized them into the following figures:

general

General guidelines for the thesis

Nº 1

If the stakeholders work process usually is quite software engineering oriented, make sure to emphasize the importance of a solid design process.

Nº 2

Feedback from stakeholders is highly valuable, make sure to include them in all of the different stages in the design process.

research

Guidelines regarding the research phase of the thesis

Nº 3

Investigate and research the different domains to gather what can be designed, implemented and also reused for all domains.

Nº 4

Familiarize yourselves with the common application and the terminology used (even if that application won't be actively used by the end user).

design alternative

Guidelines regarding the design alternatives of the thesis

Nº 5

Start out with making a lot of different design alternatives and then either keep up the amount for upcoming iterations or decrease but do not start small and escalate.

prototype

Guidelines regarding the prototyping phase of the thesis

Nº 6

Be sure to investigate other options for prototyping, the most obvious choice might not always be the most valuable one.

Nº 7

Do not underestimate the value of a code prototype but be aware of the time inefficiency of using code compared to interactive high-fidelity prototypes.

evaluation

Guidelines regarding the evaluation phase of the thesis

Nº 8

Plan for performing a lot of usability testing with users from the different domains.

Nº 9

Plan for performing several tests with developers of the common application.

5.2 Artifacts

The second part of the result consists of a set of artifacts. The final product is called VFlow and this section will provide the reader with an overview of how VFlow looked in the end.

In Figure 5.1 the landing page of VFlow can be seen. The user is greeted with a list of dashboards which are accessible.

The thesis focused on acquiring different visualizations for the same data source. Through the user stories it became evident that at least three were of most significant. These were, 3D, numeric and a dial. All of these visualizations can be seen in Figure 5.2.

The user flow from a technical point of view is visualized and can be seen in Figure 5.3. The user interacts with the GUI of the code prototype (on the client side). When the user enters a dashboard the client asks for data in a particular format which QTM then responds with in real time. If the user signs in the client side authenticates through the applications server and then the authentication server of the company. All of the changes that the user makes to a specific dashboard is saved to the database.

5.3 Key requirements

In order for the final result to work there exists various key requirements. This section will explain what those requirements are and how the system interacts with

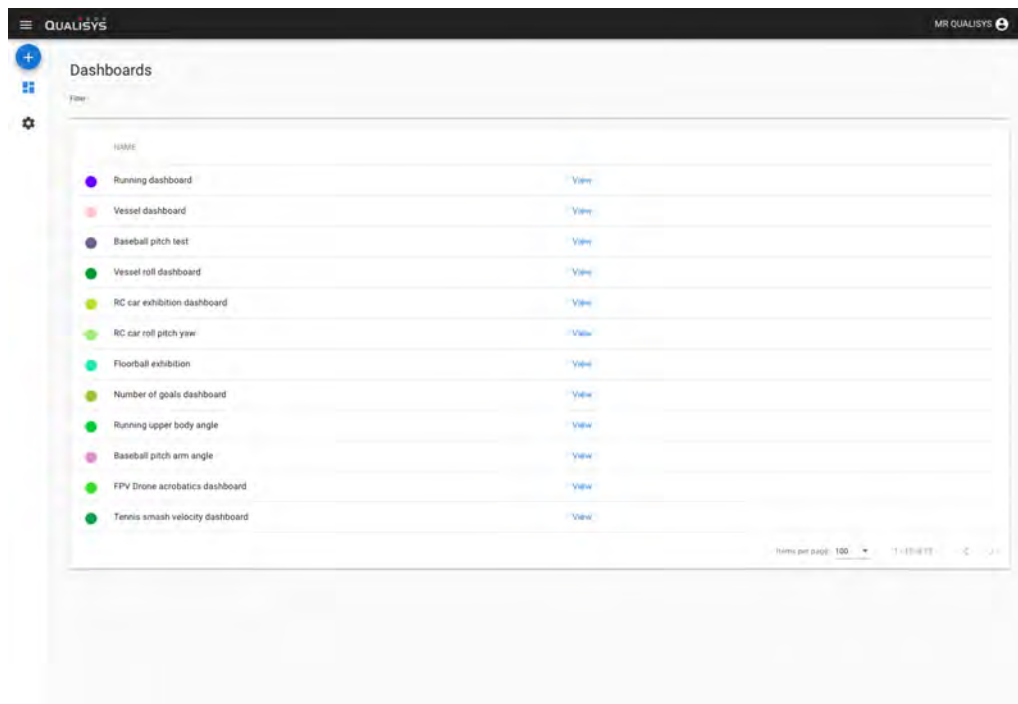


Figure 5.1: Final result - VFlow - Dashboard list overview

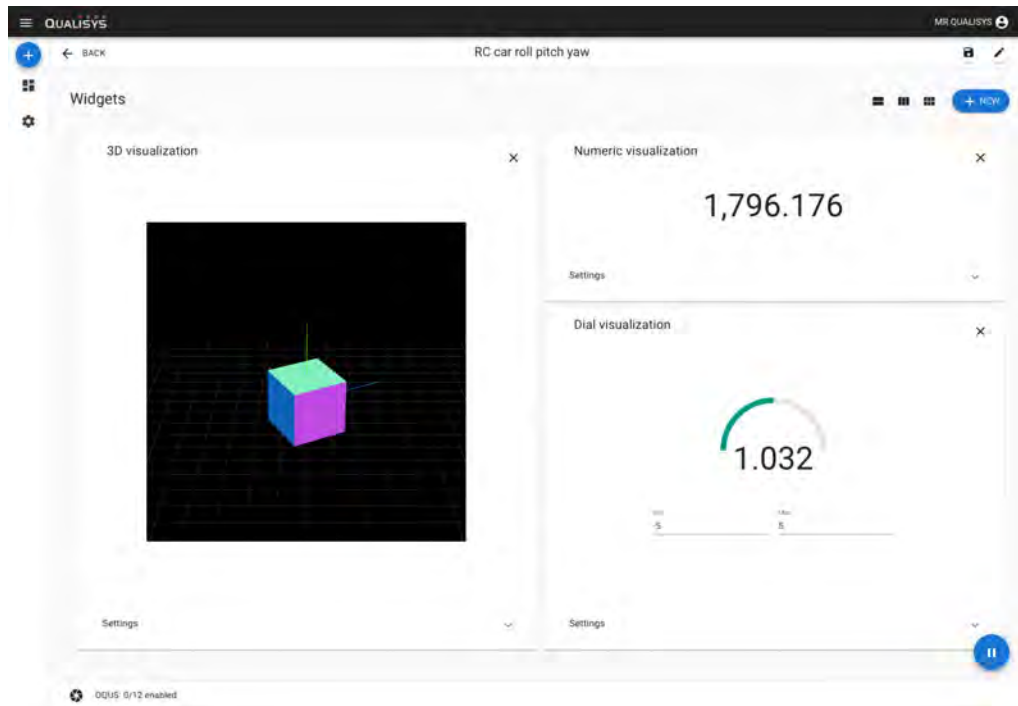


Figure 5.2: Final result - VFlow - Single dashboard all visualizations

them.

5.3.1 Real-time data

A requirement for the proof of concept was that the system was going to be able to stream data in real time. In the final result this is a key feature. The data is being captured from sensors and then registered in the software QTM. The user can choose to label the different markers but this is not a necessity for the concept to work. The user then selects a data source or combination of data sources from the customizable dashboard and the data is visualized in a preferred manner.

5.3.2 Configuration

A key requirement in order for the application to work is that the user should be able to choose where data is coming from. In order for the application to find QTM the ip address of the software is being used. In the final prototype the user can choose to navigate to a settings view where they are prompted with inputfields for entering IP address and port. In Figure 5.4 the settings view can be seen.

5.4 Key features

The final result also contain a set of various key features. This section will go into detail of what those features are and what value they provide to the user.

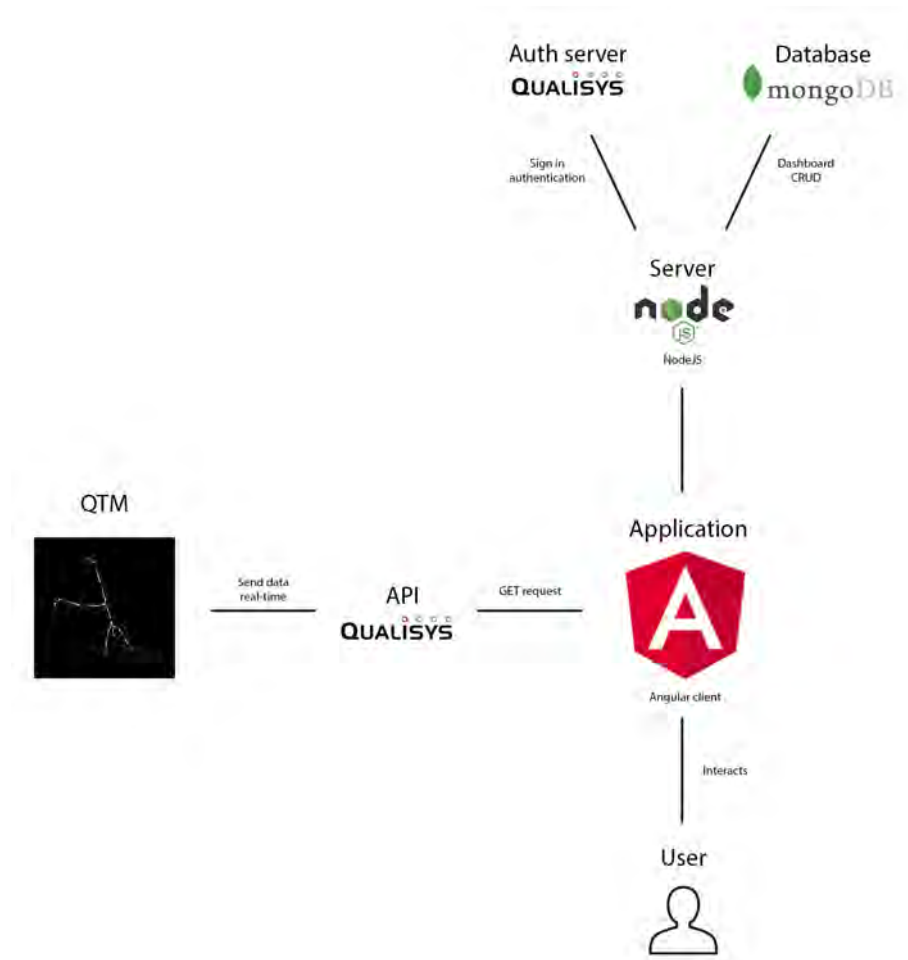


Figure 5.3: Qualisys - VFlow application structure

5.4.1 Visualization

There exists three different ways for the user to visualize data. The first one being 3D, the second one being a dial and the last one being numeric. In Figure 5.5 the 3D visualization can be seen. The 3D visualization is a cube with supportive axes helper. The helper is an axis object that visualizes 3 axes with 3 lines. The X axis line is red, the Y axis line is green and the Z axis line is blue. A mesh was also added in order for the user to more easily get a sense of the objects position in space. A typical use case for this kind of widget/visualization is e.g roll, pitch and yaw for an object.

In Figure 5.6 the dial visualization can be seen. The dial widget has a standard color of green but the user can choose to enter a range of values which is acceptable. The dial will then become red if the value is outside of the range and green if it is inside. A typical use case for this kind of widget/visualization is for displaying angles. This can be a runner wanting to display the angle of their arms when running or the angle of the upper body.

In Figure 5.7 the numeric visualization can be seen. This visualization is the most

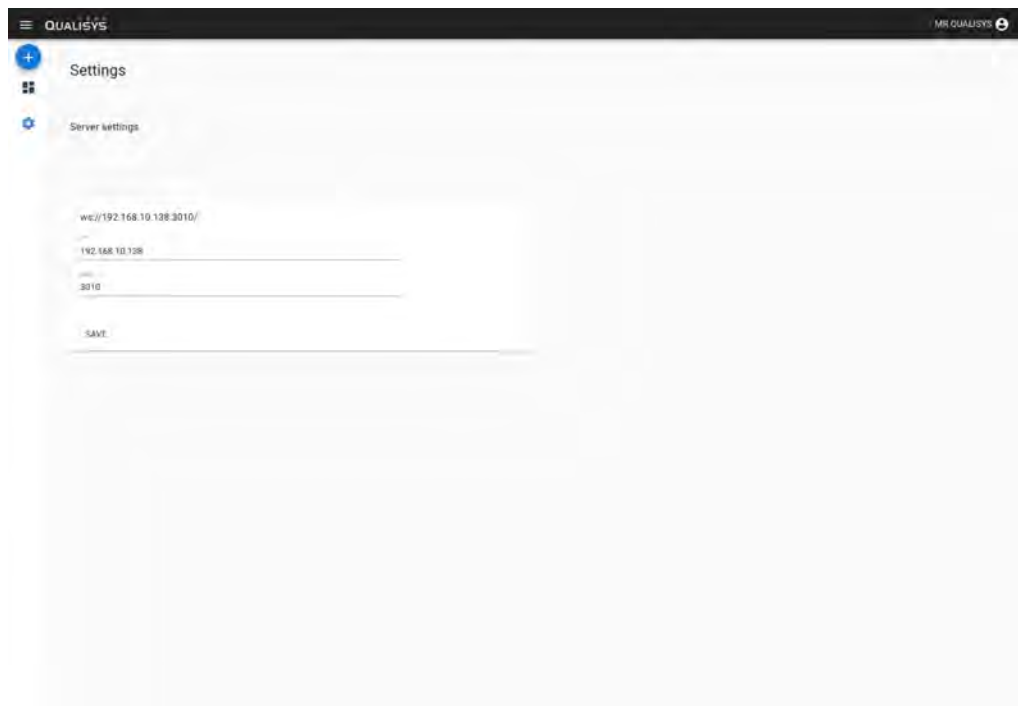


Figure 5.4: Final result - VFlow - Settings

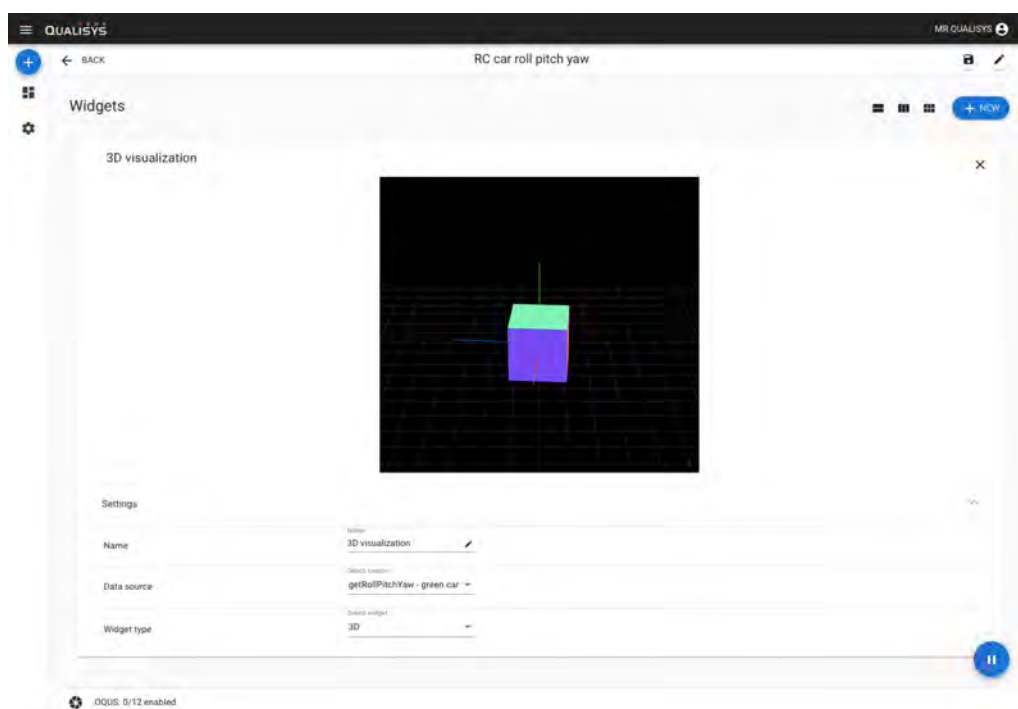


Figure 5.5: Final result - VFlow - 3D visualization

basic one but also the one that covers the most use cases. This kind of widget works both as a complementary widget to the other ones but also as a primary mean of visualization.



Figure 5.6: Final result - VFlow - Dial visualization

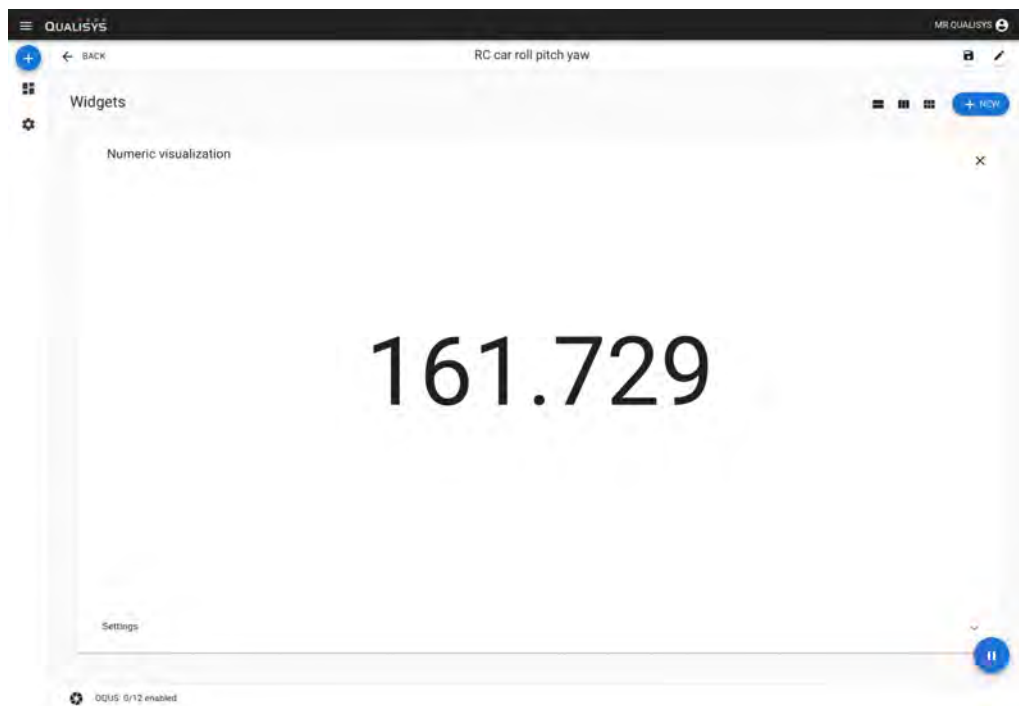


Figure 5.7: Final result - VFlow - Numeric visualization

5.4.2 Customizability

One of the most significant features was that the dashboard was going to be customizable. Why personalization and customization was such an important factor

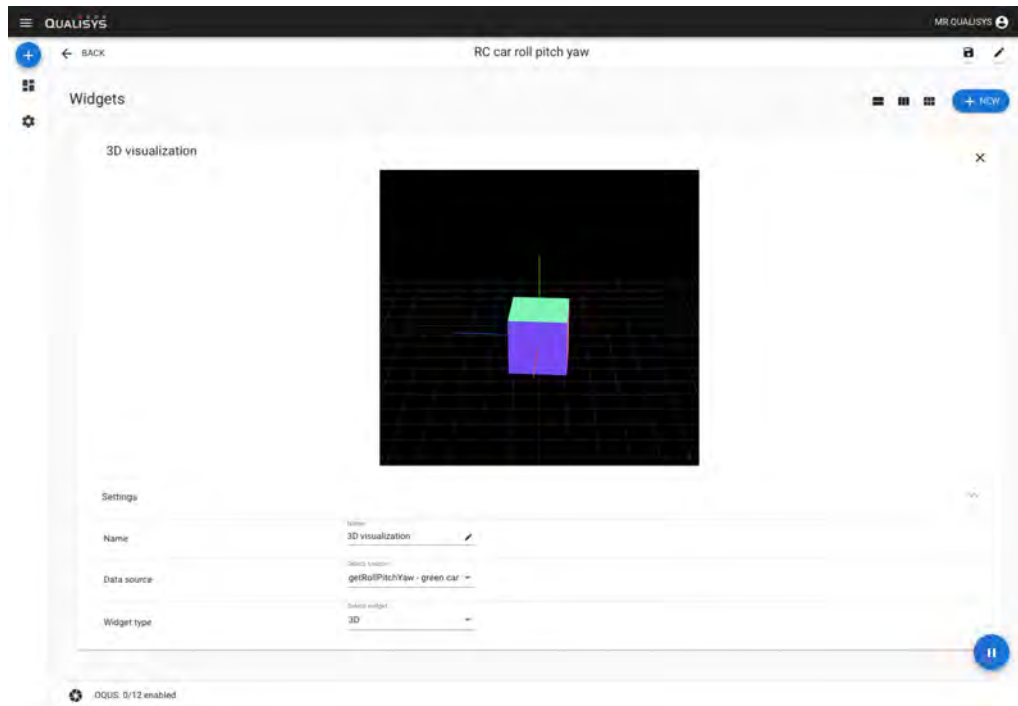


Figure 5.8: Final result - VFlow - Single dashboard 3D visualization

was because the system was going to deal with complex data, the user groups were not going to be singled out to a specific one and because the company had gotten indications that the software QTM was quite difficult to use. The learning curve was too steep.

A newly created dashboard will have the name "Example dashboard" which is generally not the name that the user wants. Because of this the first thing that happens is that name will get highlighted and the input field for changing name will become selected. This can be seen in Figure 5.9.

By clicking either the name of the dashboard or the edit - pen icon in the toolbar the user can change the dashboards name.

In order to make changes to the different cards a settings expansion panel is expanded. The panel can be seen in Figure 5.10 and provides the user with input fields for changing card name, data source and widget type. The reason for choosing this solution was because the company viewed the different use categories/states as either editing data or viewing data. The expansion panel suits this view.

To further allow the user to customize their dashboard the different cards are flexible. This means that the cards can be resized and moved in order to suit the users need. In Figure 5.11 the moving action can be seen. The system provides the user with modeless feedback when clicking on a card and if the user initiates a click & drag action the cursor will change to a moving icon and a grid will appear indicating available positions. Worth noting is that if the card is dragged past another card, they will change place.

To change size of a card is initiated by holding the cursor on one of the cards corner



Figure 5.9: Final result - VFlow - New dashboard

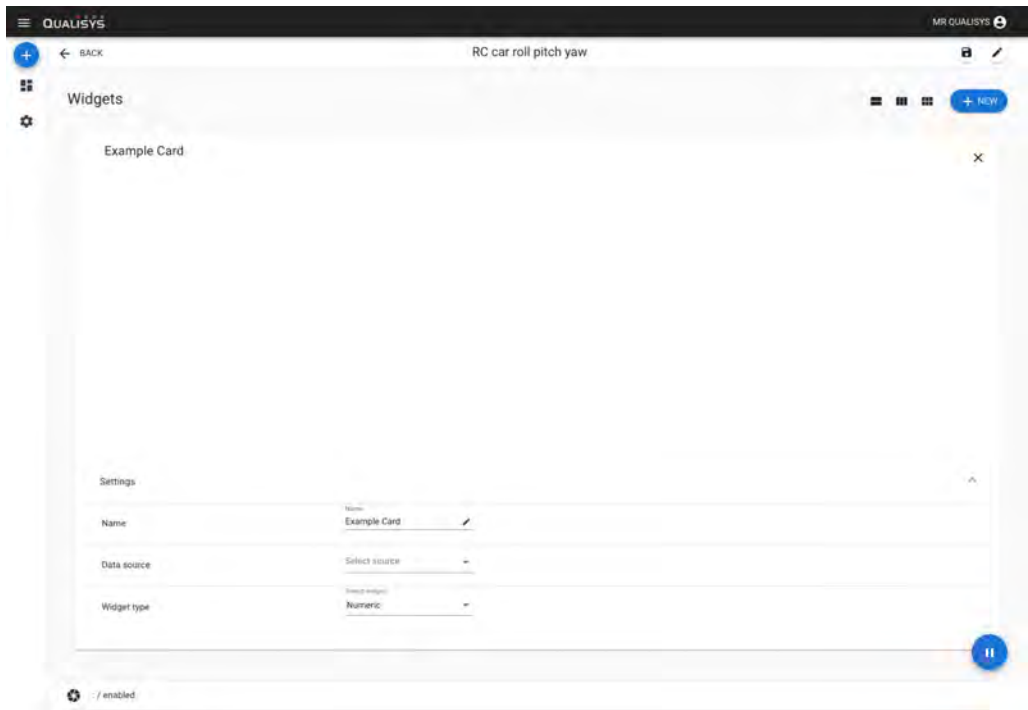


Figure 5.10: Final result - VFlow - Settings card panel

or border. The user will then get an indicated action of resizing by changing the cursor to a resize icon. By click and drag the user then can choose to change the size. This can be seen in Figure 5.12.

One way of customizing the list of dashboards is by selecting a color that will

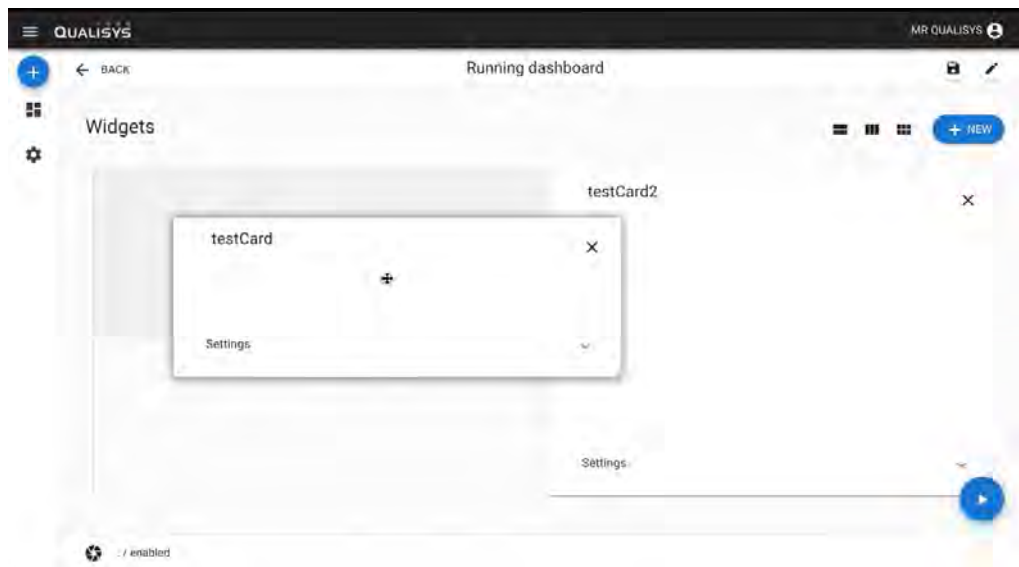


Figure 5.11: Final result - VFlow - Move card

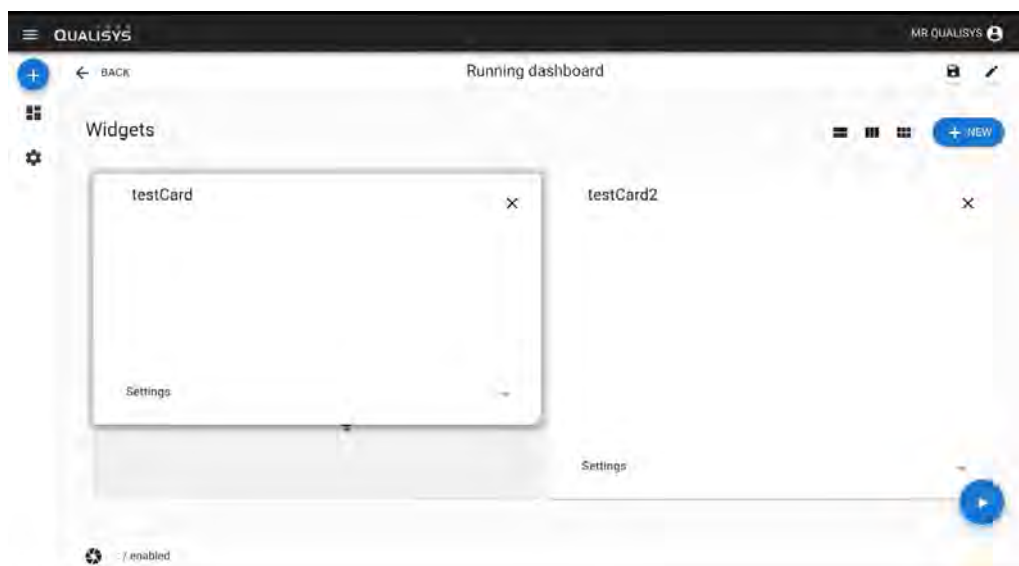


Figure 5.12: Final result - VFlow - Change size

represent the dashboard. This is done in order for the user to more easily be able to find dashboards. The selected/created color is shown in a table row next to the dashboard name. A newly created dashboard will get a random color assigned to it but the user can later select a new color. Selecting a new color is done by a click action on the already selected color. The user then gets prompted with a color picker which can be seen in Figure 5.13.

5.4.3 Data manipulation

The system allows the user to manipulate data in various preferred ways. This section will display the final results which deals with data manipulation such as

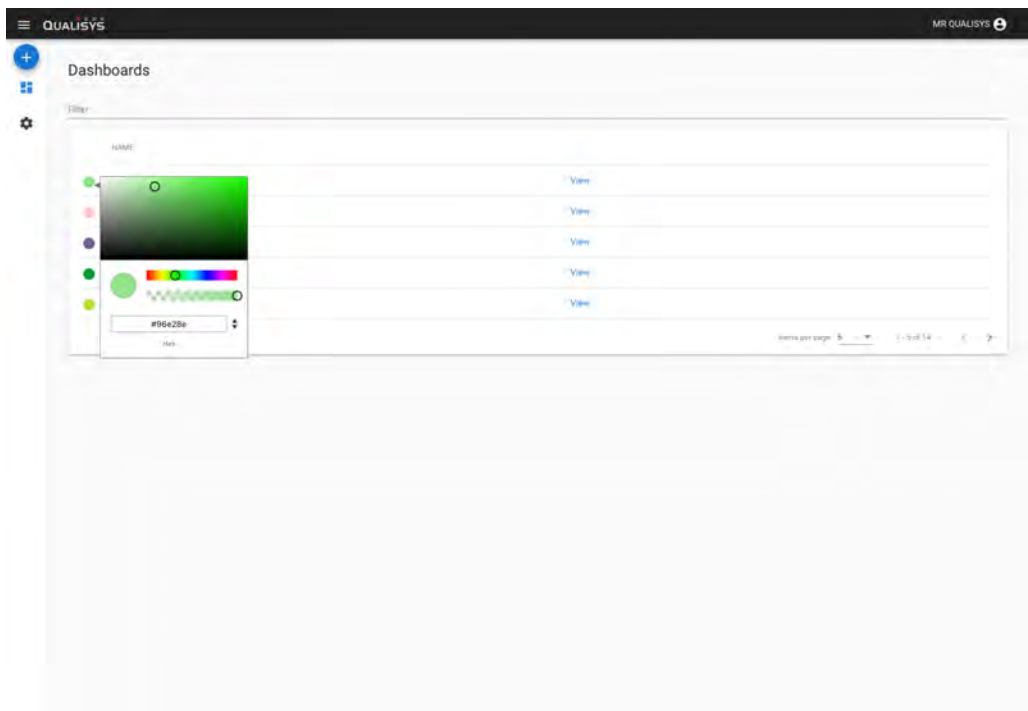


Figure 5.13: Final result - VFlow - Color picker

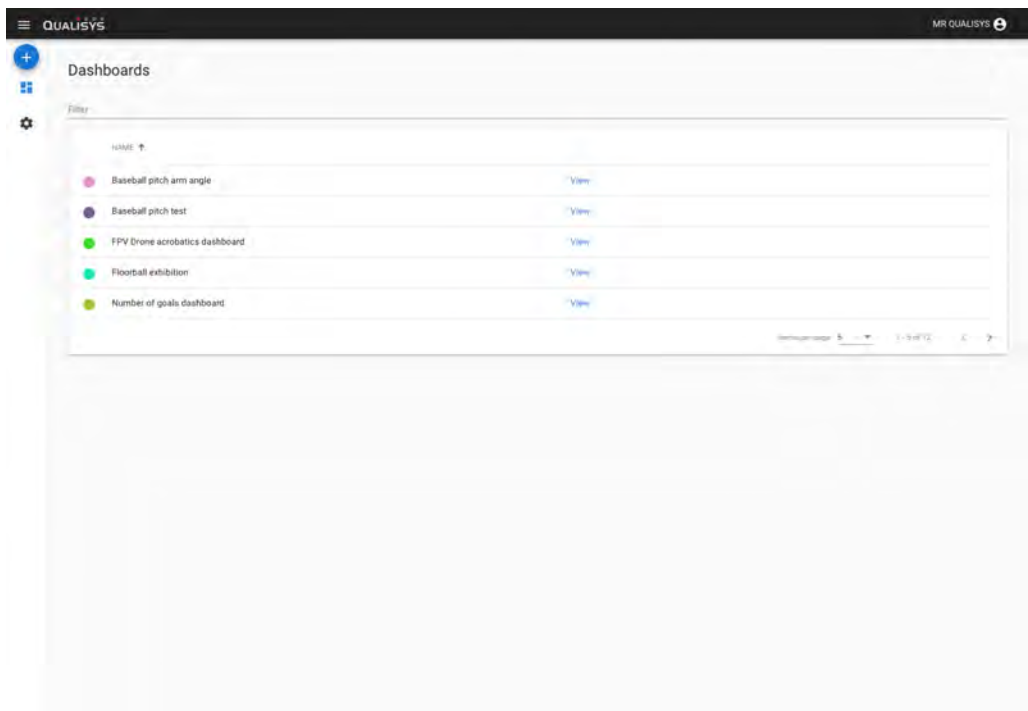


Figure 5.14: Final result - VFlow - Sorted dashboard list

filtering and sorting. In order for the user to complete the task of finding a specific dashboard from the list of dashboards the user can choose to sort the data either on name or by color code. A sorted list can be seen in Figure 5.14. Sorting a dashboard list is done by a click action on the header of the corresponding

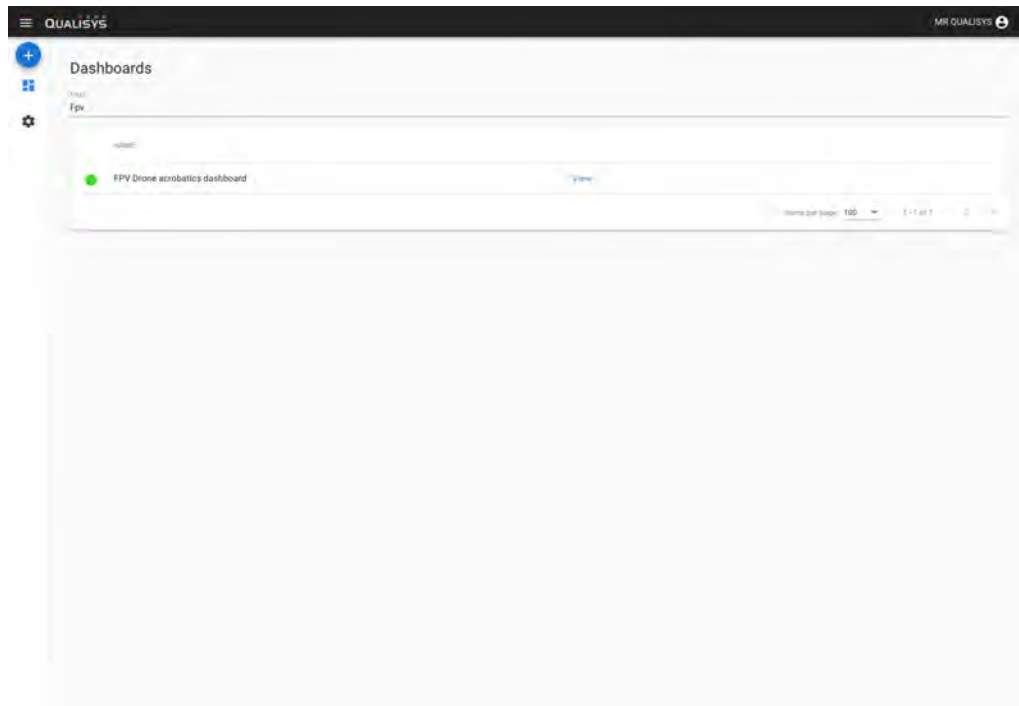


Figure 5.15: Final result - VFlow - Dashboard search list

table row. The user gets visual modal feedback that the action is possible through hovering on the name, this is done by highlighting the row and displaying an arrow indicating whether or not the sorting will be ascending or descending.

Another way the user can complete the task of finding a specific dashboard is by filtering, e.g search. Above the dashboard list an input field is displayed with a "Filter" hint label. After input from the user the result is updated and displayed in real time. A filtered list can be seen in Figure 5.15.

5.4.4 Navigation

In order for the users to navigate through the web application a hamburger menu on the left is used. A regular menu of this type has two states where one is completely hidden. We concluded that this solution was going to affect the user experience negatively and prohibit efficient navigation. One of the user requirements was that the menu should be small so the solution that the final result contains is a hamburger menu with two states, one fully expanded which can be seen in Figure 5.16 and the other state being much smaller with clickable icons.

5.5 Evaluation

To evaluate the final prototype a Usability test was conducted. To prepare that test a set of tasks that tested the functionalities of the webpage was decided upon. Those tasks can be found in the figure labeled 'Usability tasks' on the next page.

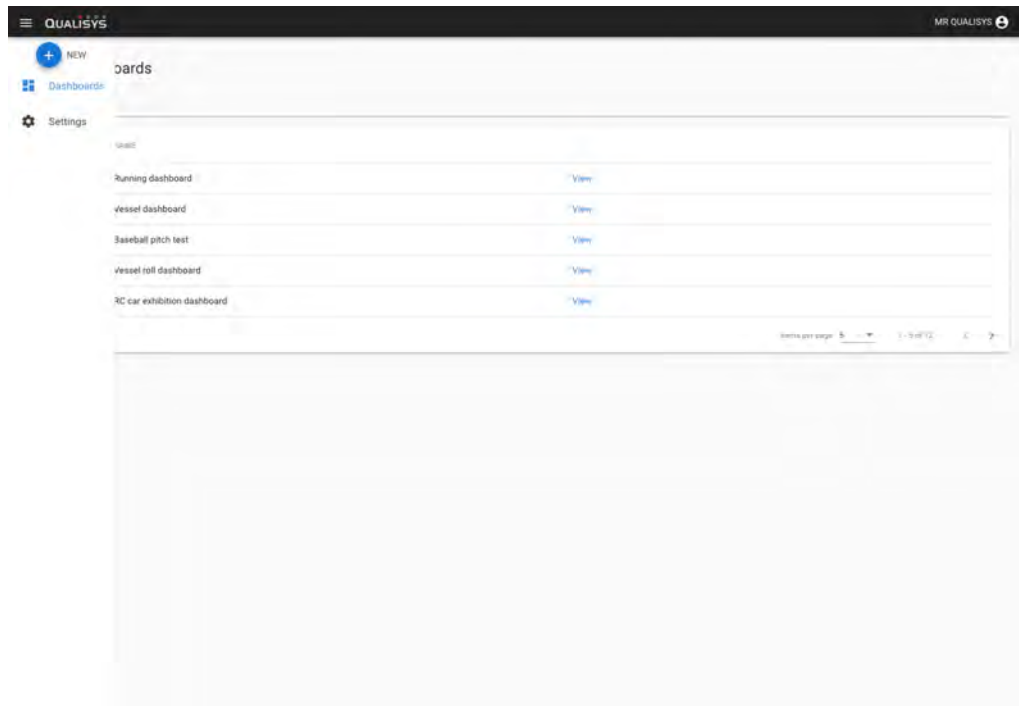


Figure 5.16: Final result - VFlow - Sidebar navigation expanded

When conducting the test there was one test administrator and one that took notes about what happened during the test. There were three participants in the testing, all working at Qualisys but not in all in the same department.

The testing showed that one crucial task was hard to complete for all participants and that was re-sizing the cards to reflect an already prepared layout, on a new dashboard. The testing also showed some other, less severe problems:

- Difficult to spot buttons
- Inconsistent styling for input fields.
- Status bar is not shown clearly enough.
- The chosen number of columns for the dashboard is not clearly shown.

The Usability report based on this Usability test can be found in the Appendix A.3.

Usability tasks

- Task 1: Change the host setting for the webpage.
- Task 2: Create a new Dashboard, name it 'Bil Dashboard' and save it.
- Task 3: Check out the layout of the Dashboard 'Running Dashbboard' and then recreate it on 'Bil Dashboard'. Save it.
- Task 4: Note how many cameras are 'enabled'.
- Task 5: Change the names of the newly created cards to 'Grön Bil' (Green Car) and 'Röd Bil' (Red Car).
- Task 6: On the card named 'Grön Bil', make sure that the widget type shows numbers and then show the X-position for a marker on the green car.
- Task 7: On the card named 'Röd Bil', change to the 3D-widget and then select so that it shows the Roll, Pitch and Yaw for the red car.
- Task 8: Limit the amount of card columns to 1.
- Task 9: On the card named 'Grön Bil', look at the Roll for the green car.
- Task 10: Remove all cards.

6

Discussion

6.1 Methods & Execution

Initiating our thesis work with investigating some of the different domains and applications that our users could come from produced some valuable insights for us. Seeing how the users interacted with QTM, and also using it ourselves, helped us gain an understanding of why a more intuitive interface could prove helpful and what one would want to be able to retrieve from QTM. A key insight was that to be able to use QTM, the user already had to know how to configure QTM. Configuring QTM requires the user to have some familiarity with it since the user interface is not intuitive. That application also came with its own terminology. To minimize the amount of confusion and user-errors we made sure that our applications terminology did not conflict with QTMs terminology.

The reason for the low number of iterations is that we did not follow the design process as rigorously as needed. This way of working allowed us to make changes to our designs and implement them without waiting for a completely new iteration. A positive consequence of that was a sometimes faster and less extensive design loop. The way our work progressed resulted in some iterations being diffuse and it was a bit difficult knowing where exactly one iteration ended and the next one began. To improve on this aspect we could have had a clearer separation between phases when working.

One thing that should have been improved upon is the planning for evaluation of the results from the different iterations. At the beginning of the thesis we performed thorough tests of our lo-fi prototype but the amount of testing and evaluation slowly decreased for each subsequent iteration. Although the evaluation of the final result was even more thorough than the one in the beginning and revealed some problems, those might have been discovered at an earlier stage if we had performed more usability testing during those iterations. The heuristic evaluations that were performed revealed some of the problems with the designs, but since all of those participating in those evaluations had some familiarity with the system being tested there were problems that went undetected.

6.2 Result

6.2.1 Prototypes

We did not experiment with different kinds of prototypes. We assumed that the prototyping concepts that we chose was the most suitable but what might have been more valuable to the company and to research is to experiment with different kinds of prototyping methods. The methods we chose were the ones we were used to before and also most comfortable with. This in itself possibly provides efficiency. Another idea would be to have different prototypes for the different iterations. Comparing the result from different iterations would be harder but as stated before, this might have provided more valuable to stakeholders.

Another important part that could be improved is the amount of design alternatives. As stated before the first iteration only consisted of two major different alternatives. We could have invested more time (especially in the beginning) in generating a several different design solutions for the problem at hand.

6.2.2 Visualization

During the thesis we discovered that there is a need for a various amount of visualizations and flexibility in those. The 3D visualization is highly limited. Basically the only visualization that is able in 3D right now is roll, pitch and/or yaw. The software QTM already provides a highly sophisticated, thorough and developed 3D visualization. We had the option to integrate there visualization tool into our interactive prototype which would allow e.g marker position in real time, a skeleton viewer and more. In other words this would increase the flexibility of use of the interactive prototype and thus the 3D widget.

6.2.3 Limitations

One of the key limitations that the result provide is that the interactive prototype still suffers from QTM software dependency. What this means is that the user still has to use the software in order to get a working interactive prototype. As the companies goal is to have a fully functioning separate module this dependency would have to be taken care of before providing actual value to their customers. The current state of the interactive prototype only provides three kinds of visualization. The reason a limited set of visualizations is provided in the final result might be because we focused on only two use-cases but the company has many more. Another factor that also played part in the limited amount is the amount of time it took for us to get the interactive prototype up and running.

A common aspect in information visualization is showing data over time. Visualizing data over time can provide further insight rather than just getting a real-time snapshot of the data being visualized. This area wasn't properly explored because our design work was done based on the data we knew we had and were able to work

with. We discussed and planned for future visualizations based on data over time but we did not manage to implement a way to handle data in that way. Since we had no way to implement this functionality, no designs were made and the area was left unexplored for this thesis.

6.3 Customizability

Creating an application that can be used by people from various domains and with different technical backgrounds can be done in many ways. We chose to provide the user with a high degree of customizability. This was done so that the end-user has control over their own workflow for finding and using their dashboards. The user has control over how they navigate to the dashboard they are looking for. Depending on how they have organized their dashboards they can sort and then click through the pages and look for the name of the dashboard, they can use the color coding or they might use the filter. Since the user themselves enter names for dashboards and also the widgets on those dashboards there should not be clashes in terminology that cause any problems for the user.

The high degree of freedom for the application was chosen partly because of the possibility of having users from an expanding amount of domains which results in different layouts and settings that the application will be used in. More domains also means more terminology that could be in conflict with what different widgets and dashboards are called if those would be preset.

6.4 Design vs Implementation

During the project it became evident that there existed some friction between what was going to be designed and implemented and what was best practice to follow. This section will go into detail about our insight of the subject.

6.4.1 Insights of design work flow integrated with code driven development

The existing work flow at Qualisys was heavily code driven. The development work was Agile and divided into sprints that followed a lot of other software development work methods. As designers our work structure tends to be a bit different. The part that code driven development often lack or is not prioritizing is testing functionality before implementation and getting a clear picture of the aesthetics of the final product. These are areas where the design work flow can offer some support. The part that we found quite hard was to assure a substantial value of the design process for the company supervisors. This might have been because we did not communicate the value clearly or because the company was not used to working in such a way and therefore had trouble visualizing value or any other reason. As interaction designers we know that the design process model that we chose was going to provide a valuable information foundation for the decisions to come regarding VFlow but

because of the reasons previously mentioned the design work did not get as much company prioritization as the focus we wanted.

6.4.2 Customer satisfaction versus literature recommendations

One of the more surprising takeaways that we obtained from the thesis work was the fact that what the literature says is best practice is not always what the customer wants. This was proven with the work for the exhibition at the Advanced engineering fair. The solution that we had implemented before working on the exhibition version was sufficient enough for the requested features and also more closely followed what the literature suggests is best practice. The solution that the stakeholders wanted spoke directly against how to visualize data for users in order for them to more easily grasp it. This insight might not be something entirely new but we had no prior practical experience of this issue.

6.4.3 Time spent on Design compared to implementation

Another topic to highlight is the time spent on designing the system compared to how long we spent on implementing the design. Iteration 1 can be seen as an equal workload between the two areas. But the interesting and also expected part here is that the implemented interactive prototype of VFlow barely resembles the designed high fidelity prototype. There exist a lot of different reasons as to why this happened and most likely highlights one of the bigger limitations that we as designer have. Is the effort to code the prototype a reasonable match to the value it provides? All of this comes down to how the team is structured, what the end goal of the design is, the coding experience of the designers and much more but it is an important factor to consider. Worth noting is the fact that the interactive prototype in our case provides the company with insights that a high fidelity interactive prototype could not. Also worth noting is that the first iterations design compared to implementation was the one that looked the most different most likely because the structure of the application had to be implemented from scratch as well as the connection between our application and the server providing data from QTM. In the following iterations it was much more easy for us as a team to match the interactive prototype with the designs that was made.

6.4.4 Coding compared to designing interactive prototypes

As briefly mentioned before there lies an important distinction between whether or not it is of value for the stakeholder to have a prototype implemented in code or an interactive high fidelity prototype. One can never know if our solution provided the most value to the company but the stakeholders saw it as an important part of the proof-of-concept to show that the data from QTM can be visualized in a meaningful manner. An interesting work model in our case might have been to prove with a number widget, implemented in code, that the data could be streamed and visualized and then replacing the code prototype stage with a high fidelity one.

This would both have proven that the solution that we are designing for works in a meaningful way and taken the design much further which would open up possibilities to provide us with solutions that might not have been so obvious. This distinction is always hard to make but two things that are certain is that a) we did not think of it in the start of the process at all, and b) our advice would be to not be afraid of exploring and mixing different methods early on.

6.5 Considerations

The most common problems with motion capture technology is often practical and economical. A functioning system that generates value is expensive and consist of many components. They require skilled operators to use and the whole system is rather complicated. Because of this one of the main issues that the group faced was how to design a system that is rather complicated for an user group that might not fully understand the originating system. The most important aspect of designing the system was management of misinformation or misuse of information e.g displaying information in an overly simple manner which would result in the user feeling overconfident. The situations where the system is mostly used is often clinical or engineering, overconfident users in these situations might lead to severe consequences.

6.6 Future work

As stated in the limitations of the result discussion, the need of interacting with the software QTM still is present. Because of this our recommendation would be to focus the future work at removing this software dependency or at least minimize the amount of time spent in QTM for the user. A possible improvement would be expanding on the 3D-visualization implemented and adding a ‘marker-view’ where you try to reflect what is shown in QTM thus eliminating the need to open QTM. Being able to label data that is sent from QTM would eliminate a lot of the need for QTM as well.

The different usability tests that were conducted resulted in a set of features that would be optimal to improve. The final evaluation also indicates that some components could be redesigned to be more prominent. These components include all buttons as well as the status bar at the bottom of the page.

7

Conclusion

The purpose of this thesis was to investigate if it is possible to design a user interface for different user groups in a uniform way. The project was carried out with the focus of investigating the possibility in the field of motion capture sensor systems. The research question that we wanted to investigate was aimed towards this field and state:

"What guidelines should be considered when designing an information visualization interface for kinematic data streamed in real time to enable personalization?"

The investigation and answering of the question was carried out through the creation of a Dashboard webpage. When designing and constructing this page a set of heuristics were chosen based on the occurrence of them in a several "famous" sets of heuristics as well as how they met the requirements we established after our initial investigations.

The main focus during the project was on the domains 'Running training' and 'Vessel tracking'. Having two domains that are so different from each other helped when and also deciding on the different visualizations that were needed for an application that is usable by professionals from both domains. It was also helpful for avoiding the creation of visualizations that are overly specialized only usable by professionals in a certain field.

We encountered what seemed to be a disconnect between what the literature says is optimal and what the end-user wants to be able to do with the interface. A recurring request for the design was the option to show many pieces of data at the same time, in a space not large enough to accommodate that data. From an information visualization perspective that means that the interface is worsened, but it also enables the end user to do more with the application. More advanced layouts, or simply more data shown on one screen. It is harder to absorb the appropriate data if you do not know what you are looking for, but these users feel that they will know where to look, partly since they set up the interface. They have the possibility to group different pieces of data together based when they need to look at it, or if it is dependent on those other pieces of data.

We would not argue that the result of this thesis is sufficient enough to answer the research question because too few user groups were involved in evaluation of the design. With that said the result of this thesis can serve as a guideline for future work in the field. The recommendation that we would like to bring forth in order for the research question to be validated or not is to involve a larger set of users. Use of motion capture is vast and the company is active in a large set of fields. The

7. Conclusion

recommendation is to take advantage of this.

The interactive prototype has some flaws but serve as a viable proof-of-concept. We do not anticipate further research but believe strongly in future development of the concept and hope that our thesis will serve as a solid foundation.

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A

Appendix 1

A.1 User stories

A.1.1 Runner

- As a runner I want to get feedback from my coach or system in real time so that I can get a more secure feedback.
- As a runner I want to measure in a larger span than a few seconds so that I can get a more secure feedback.
- As a runner I want to view real-time data compared to “goaldata” so that I can more easily work on my form.
- As a runner I want to see step frequency so that I can increase my running performance.
- As a runner I want to see if my arms is close to my body so that I can adjust them.
- As a runner I want to see my upper body angle so that I can adjust my posture.
- As a runner I want to be able to add efficiency measure equipment so that I can use it with real time feedback dashboard.
- As a runner I want to be able to choose what data the system should focus on so that I can get feedback on specific areas (e.g lower body-dashboard)
- As a runner I want to have FEW data areas to focus on so that I can focus on one thing at a time.
- As a runner I want to see an average data over a certain time of period so that I can adjust my running style.

A.1.2 User

- As a user I would like to see live data such as position, rotation, etc. about my vessel so that I can minimize testing time.
- As a user I want to visualize distance between to bodies so that I can demo it.
- As a user I want to be able to quickly change the content of my dashboard so that I don't miss relevant data or measurements.
- As a user I want to choose data and then how it should be displayed so that I can view the data in a fashionable manner (graphs, dial, number).
- As a user I want to be able to choose a widget that I connect to a certain data source from a list so that I can get visualization of data in my preferred way.
- As a user I want to be able to choose how many widget + data options I want to see so that I can focus on only the relevant things.

- As a user I want to have red/green indicators which indicate if the data is in a “safe” range so that I know if I have to take action.
- As a user I want to connect to the live-stream through an ID regardless of network so that I easily can watch the live feedback.
- As a user I want to have a delay between 0-200ms so that I can acquire QTM data feedback in “real-time”.
- As a user I want to show that QTM is running, on a separate device, using a “RECORDING” sign so that I can record in uninterrupted.
- As a user I want the dashboard to visualize if it’s currently recording so that I know if a session is active or not.
- As a user I want to be able to use the web-portal without having deep knowledge about QTM so that I don’t have to spend time learning unrequired information.
- As a user I want to see where the tracking object is located so that I easily can pinpoint it.
- As a user I want to see system/camera status so that I can see if any device is not working properly. (e.g all cameras connected)
- As a user I want to see how long the system has been active so that I know the system status.
- As a user I want to see if the system is currently being calibrated so that I know about the system status.
- As a user I want to see what markers that’s actually labeled so that I easily can pinpoint the different markers.
- As a user I want to see what bodies are identified so that I know if the system is recording properly. (e.g 6DOF body 1 - green identified, red not identified).
- As a user I want to see how much of the data that’s actually identified and tracked correctly so that I know if the recording is valid.
- As a user I want to share data from a dashboard to other users so that I can contribute to my team.
- As a user I want to be able to start measurements easily so that I don’t have to become an advanced user.
- As a user I want to see metrics (numbers, no 3D vis) so that I easily can see data.
- As a user I want to see 2D data (integers, x y) so that I will use the application.
- As a user I want to see 3D coordinates (xyz floats) so that I will use the application.
- As a user I want to see 6DOF data so that I can extract xyz from 6DOF.
- As a user I want to be able to reset the data so that I can fix unwanted data in measurements.
- As a user I want to get a template over measurements in a dashboard so that I don’t have to save own dashboard.
- As a user I want to be able to save different dashboards so that my work will become more efficient.
- As a user I want to be able to copy a purchased dashboard-template so that I can modify it to match my own needs.

- As a user I want to be able to share dashboard templates through email or public link so that I can let other users use them.
-

A.1.3 Salesman

As a salesman at Qualisys I want a product that can be used by end users within many different applications so that I can make profit.

A.1.4 Developer

As a developer I want access to QTM status data on the webportal so that I can get an overview of a capture process.

IV A.2 Heuristic table

Heuristic	Nielsen	Gerhardt-Powals	Weinschenk Barker	Schneiderman	Sum
System status feedback	X	X	X	X	4
System and real world match	X		X	X	3
User Control	X		X	X	3
Consistency and Standards	X	X	X	X	4
Error Prevention	X	X	X		3
Recognition rather than recall	X	X		X	3
Flexibility and ease of use	X		X	X	3
Aesthetic and minimalist design	X		X		2
Recognize, diagnose, recover from errors	X			X	2
Help and documentation	X		X	X	3
Automate unwanted workload		X			1
Present data, clear and obviously		X			1
Simple and relevant data-level		X			1
Meaningful groupings of data		X			1
Modal integrity			X		1
Cultural match			X		1
Offer precision that user needs				X	1
Accommodation			X		1
Provide closure				X	1

A.3 Usability Report

A.3.1 Introduction

The Dynamic Dashboard on the RT-feedback page provides access to data from Qualisys Track Manager (QTM), without the need of having QTM open. The dashboard can then be used to show chosen data so that the user can get real-time access to data that is relevant for their current measurement and planned improvement.

The thesis writers conducted an onsite usability test with an implementation of the RT-feedback webpage running on the test administrators computer. One of the thesis writers acted as a data logger, taking notes about how the users navigated the webpage and whether they were successful when attempting the different tasks.

A.3.2 Executive Summary

The usability tests were conducted at the Qualisys offices in Gothenburg during May 14th 2019. The purpose of the testing was to evaluate the usability of the webpage design and implementation for different user groups.

Three Qualisys employees participated in the usability test.

Generally the webpage was found to be easy to use, with one severe problem present on the design that was tested. Less severe problems were also found. The problems found were: Resizing the first card on a dashboard to half its size. Difficult to spot buttons Inconsistent styling for input fields. Status bar is not shown clearly enough. The nr of columns for the dashboard is not clearly shown.

This usability report contains task completion rates, feedback from the participants, problems found and recommendations for possible solutions and improvements.

A.3.3 Methodology

The thesis writers recruited test participants at the Qualisys offices. The participants were contacted via e-mail, Slack or in-person and then informed of how the test was going to be performed. If the possible participant accepted a time and place for the test was agreed upon.

A test session generally lasted about half an hour. During a test session, it was explained what was going to be done and what was expected of the participant. The different tasks were presented one-by-one by the test administrator as the participant completed tasks.

A.3.4 Participants

There were three participants for the testing done on May 15th 2019. All of the participants managed to complete all tasks. One participant was from the Sales department, and two were from the software development team of Qualisys.

A.3.5 Evaluation Tasks

- Task 1: Change the host setting for the webpage.
- Task 2: Create a new Dashboard, name it ‘Bil Dashboard’ and save it.
- Task 3: Check out the layout of the Dashboard ‘Running Dashboard’ and then recreate it on ‘Bil Dashboard’. Save it.
- Task 4: Note how many cameras are ‘enabled’.
- Task 5: Change the names of the newly created cards to ‘Grön Bil’ (Green Car) and ‘Röd Bil’ (Red Car).
- Task 6: On the card named ‘Grön Bil’, make sure that the widget type shows numbers and then show the X-position for a marker on the green car.
- Task 7: On the card named ‘Röd Bil’, change to the 3D-widget and then select so that it shows the Roll, Pitch and Yaw for the red car.
- Task 8: Limit the amount of card columns to 1.
- Task 9: On the card named ‘Grön Bil’, look at the Roll for the green car.
- Task 10: Remove all cards.

A.3.6 Results

The data logger determined whether a task was completed successfully and the participants were informed of their success rate after the testing was completed. All but one of the tasks were completed successfully by all participants without any assistance provided by the thesis writers. All testers had problems completing **task 3**. More specifically, it was **the resizing of the cards** that proved difficult to complete.

After the testing was completed the participants provided feedback about the interface, both about existing features and features they felt were missing.

A.3.7 Recommendations

Change	Reason	Severity
Enable halving the height and width of a card from start.	Unintuitive resizing of cards	High
Style the buttons to more clearly show what is a button.	It is not very clear what is a button and what is not.	Medium
Choose the style from one of the input fields and apply that to both name inputs.	Inconsistent visual cues for editable name fields for Dashboards and Cards.	Medium
Darker color for status bar with white text on it.	The status bar is not clearly visible and does not grab the users attention.	Low
Show nr of columns for dashboard on relevant button	The amount of columns in a dashboard is unclear if it is not filled with cards.	Low

A.3.8 Conclusion

Generally the participants found the webpage easy to use and without major flaws. The access to QTM data in real-time in a web-browser was appreciated and seen as a way to simplify the workflow with QTM for the users with less technical experience.