CHALMERS

User centred design for wireless data transfer device

Master of Science Thesis in the Master Degree Programme Industrial Design Engineering

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Gothenburg, Sweden, 2014

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A rendering of the receiver as seen in the Final concept chapter. © Nils Berg 2014.

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Abstract

This Master's thesis is done for the faculty of Industrial Design Engineering and in collaboration with wyberry Technologies. The thesis develops a solution for packaging a technology that enables high quality video streams to be transferred wirelessly over a larger distance. This project also covers the design of the interaction between the product and the user. The final concept is specified to the extent that manufacture of a working prototype is possible.

The project has done research in the areas of temporary (touring) events where video/audio data transfer occurs. Interviews with a wide range of different actors within the research area have been conducted, as well as a study visit to a larger exhibition for the industry. Using relevant theory the data was developed into a requirement specification, which would ensure a successful end result if fully fulfilled.

Sufficient data was successfully acquired through various data collection methods in the set out research areas. The data was processed, using relevant theory, into needs and requirements. The requirements formed the basis on which the concepts were generated. The final deliverables set out were successfully met and the final result, a virtual representation of the final product, was delivered.

Table of contents

Terminology

Tripod dollie: The mount of a tripod which provides the ability to tilt and pan the mounted device.

FoH: Front of House. The area, often a tent or tower construction, in front of the stage at concerts where all the audio mixers sit with their equipment and live sound mixes the concert.

ISP: Internet service provider. A company that hosts fibre networks in a specified region.

KAPA®: Is a foam board material consisting of two layers of rigid paper with a layer of foam between them. This material is very apt for making physical models.

PCB: Abbreviation for printed circuit board, which is a platform that supports and connects electronic components using conductive tracks.

UI: User Interface. The space or surface where interaction between humans and machines occur.

1 Introduction

This project will be executed in accordance with the regulations for a master thesis project in the Industrial Design Engineering programme at Chalmers University of Technology.

1.1 Background

Wyberry Technologies is a start-up company based on a unique patent pending method for high-capacity wireless data transfer developed at Chalmers University of Technology (hereafter referred to as Chalmers). A technology invented by Chalmers-researcher Zhongxia "Simon" He, from the MC2 institution at Chalmers. Wyberry, managed by the former Chalmers students Dzana Damjanovic and Jens Kjellerup, are currently developing a demo product; a high-capacity radio link for wireless video transfer for the event and entertainment industry; with focus on touring events. Wyberry's technology has a market leading capacity that means to replace the current solution for transferring video; fibre cables. Today, there are a lot of work in hooking up these cables at larger events and having them tangled with each other. A wireless solution would both save money and especially time, which is highly valued in the industry of live events.

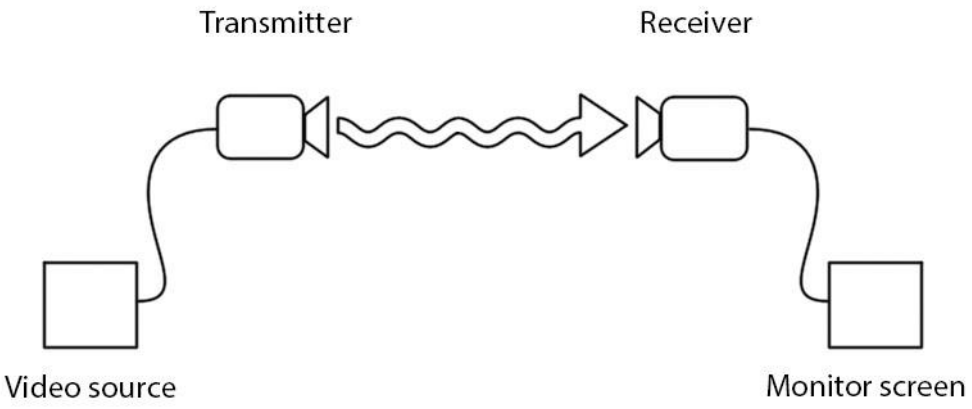

Figure 1 The technology setup

To simplify, the technology is a system consisting of a transmitter and a receiver. The video source sends the digital video signal to the transmitter, which converts it to microwaves and sends it over to the receiver. The receiver in turn converts the microwaves back into a digital video signal which is then sent to a monitor screen.

The product development is currently focusing on optimising the technology. Designing PCBs, antenna and the hardware behind the interface for both the transmitter and receiver. They need a design of the packaging of the components in both the products and a design of how the user interacts with them. No design yet exists of this packaging. It not only needs to house the components, but also enable easy access to them and for some possibilities so upgrade the components. Lastly, there also needs to be an interface design and research done on what connectors and UI that the user wants.

1.2 Goal & Deliverables

The goal of this thesis is to develop a design the "mechanical box" of wyberry Technologies upcoming demo product. This mechanical box is the packaging of the products internal components and the products interface. The final deliverable, a virtual representation of the final product, is intended to be used as a base for the manufacturing of the mechanical box. It is also intended to be used as marketing material and as a communications tool to explain to customer how the product works.

1.3 Scope

- This project will focus on developing a visual representation of the final product. The detail of the final concept will be specified to the extent that manufacturing of a working prototype is possible.
- This project only covers the packaging and interaction with the product, not the technology behind its functions.
- A study of the user and environment will be done in this project.
- Research areas include temporary (touring) events where video/audio data transfers occur.

1.4 Participants

Wyberry representatives for the project:

Dzana Damjanovic
Business Developer

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Jens Kjellerup
Business Developer

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Examiner and advisor for the project:

Lars-Ola Bligård
Researcher at PPU/D&HF

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1.5 Report setup

The project covers large portions of the product development process which this report will describe; starting with research of the user and environment, followed up by an analysis of the gathered data which then will be compiled to requirements and design guidelines. The requirements and guidelines will then be used to create concepts which in turn will be developed into a final concept. This report will also add a discussion of the process and results complemented with thoughts on further development of the projects results.

2 Methods

This chapter describes the theory for the methods used throughout the project. The theory will come in order of appearance in this report.

2.1 Interviews and observation

Interviews are the most basic methods for data collection; it's basically an interviewer that asks questions and an interviewee whose answers are recorded. The goal with an interview is to get a good view of what the interview thinks of a specific subject or understanding of a situation.[1]

Interviews come in many different forms; there are for example personal interviews, telephone interviews, group interviews, and so forth. They are different varieties of the same thing, but when doing the interview you can have two different ways of approach; structured and unstructured. Structured interviews have in advance formulated questions that are asked consecutive. Unstructured are the opposite to structured, the interviewer and interviewee discusses relatively freely around a subject. The interviewer usually follows some form of interview guide. This guide could be a list over which areas that is to be discussed or something similar.[2] Important to note is that there also are steps in between these two main forms, such as half structured or directed unstructured[3]. Mixing these up can be a good way to effectively obtain quality data from an interview.

Observations are another basic method to acquire data. The investigator observes the course of events that are interesting to attain data from. It's a way to study users' behaviours and interaction with products or how they respond to different events. They are made either out in the field or in a controlled environment; such as a lab. The purpose of observations is to get an understanding of what the user does and not only what they say they do.[4]

2.2 User Profile

A user profile describes abilities, characteristics and limitations of the user. It's also used to describe the variations within the user group. Important aspects that affect the interaction between the user and the product are described using information about mental, physical and demographical data from the user group. Other interesting data about the user group is also included; for example education, competences and other facts surrounding the product. A user profile could also be supplemented with descriptions of the relations between different users within the user group, if this should be interesting for the study.

2.3 Persona and scenario[5]

Persona is a description of a fictitious typical user in a way that the persona is perceived as a real person by the reader. This is a tool meant to help the product developer to meet the needs and requirements set by the users.

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[1] Engelbrektsson (2010)
[2] Ibid.
[3] Lantz (2007)
[4] Bligård (2011)
[5] L. Wikström (2010)

A scenario works in the same way as the persona, its function is to make the usage scenario more alive. The story depicts how the product is to be used, the important factors and the emotional response the user gets. The important aspect is to convey the user experience to the developers, the thoughts and feelings that the user has when using the product.[6]

2.4 Function-Action Tree (FAT)

Is a method for combining the user aspects and mental activities with the technical functions of the product. The method is built upon the method HTA, it decompositions the functions of the product to a level of detail that is chosen. The main objective or function that the product is to have is in the top of the tree. That is then broken down into part-functions that both describe the technical function and the user action required. The sought after mental activity by the user is also described, but since the users think differently, this is more of a detail than a requirement for the product to work.

[insert the "figure 5" from the paper by Janhager]

This method though gives a more comprehensive view of the use of the product, since it also considers the interaction with the user. Not only can the FAT be used for detailing out the products functions, but can also be used to analyse the relationship between functions and actions that could lead to new features for the product.[7]

2.5 Expression Association Web

An Expression Association Web is used to describe with words the expression that the product should be imbued with. It has the shape of a mind map whit a main expression placed in the middle with the remaining expressions surrounding it. These expressions are then further defined by a number of supporting words describing them further in detail. This map represents which expressions the product should deliver to the user. It is to be used as a basis for choice of material; colouring and other design aspects, such as creating an Expression board.[8]

2.6 Expression board

Is a collage of pictures depicting the mood, expression etc. for something, in this case a product. The function of the expression board is to document and communicate the thought behind the aesthetic design. The main use of this is to help and guide the development team in the right direction. Though, the expression board could also be used to describe the user or the environment where the product sees use in.

2.7 Requirements Specification

The purpose of a requirement specification is to gather all the needs and requirements that have been identified during user studies or been directly requested by a stakeholder (client, user etc.). It can be of benefit to weigh them against each other in order to identify the most important requirements. The requirements specification is a useful tool for the later stages of the project to be used as a guideline. The second use of the requirements specification is to use it as a quality control test to ensure that it

[6] Bligård (2011)
[7] Janhager (2003)
[8] Bligård (2011)

fulfils the goals of the project. To make it easy to check if the concept fulfils the requirements, it is important that they are expressed in such a way that they are measurable in some way. Otherwise it can be troublesome to ensure that they are fulfilled.[9]

2.8 Sketching, mock-ups and functional models

Sketching is a traditional tool to visualise and communicate ideas in the early phases of a project, it's a fast tool compared to other ones, like CAD (Computer Aided Design). It can be used for designing physical products, interfaces or even buildings. It's often done with paper and pen, but can also be done using computer programs.

Functional models and mock-ups are physical representations made to test different things that sketches and computer models fail to show. This can be to test different aspects like; ergonomics, different sizes and proportions or design features. Mock-ups tend to be more rudimentary than functional models which are in general more advanced prototypes with perhaps some working functions.[10]

2.9 Computer Aided Design (CAD)

Is a tool to make a digital representation of a product design. This tool can be used throughout the different stages of the product development process, but is most often used in the later stages to create a detailed 3D model representation of the final design.

CAD is generally a slower method compared to sketching, for representing a product design proposal. But the strengths of this method is that it is much more accurate in proportions and gives the possibility to view the model from other angels. This model can then be further rendered in other software to create presentation material.[11]

2.10 Pugh's method

Is a method for comparing concepts with each other and ranking them against a set reference. This methods purpose is to reveal which of the concepts that fulfils the requirement specification the best.

Pugh's method starts with the choice of a reference object. This could be the present product design, a competitor design or the concept that is presumed to be the best. All the other concepts are then compared to the reference and receives a value depending on pro's and con's within each area of the requirements specification. Complementary, ranking between the different areas of the requirement specification can also be done to further evaluate the concepts.[12]

[9] Österlin (2003)
[10]Engelbrektsson (2010)
[11] Karlsson 2012
[12] Johannesson et al., (2004)

3 Implementation

3.1 Working Procedure

The thesis is divided into four different phases which handle each a different aspect of the product development process. For each phase there will be a set deliverable and each phase will be iterated until the desired result is attained. The different phases act as a funnel, starting with the research phase holding a large amount on information. This will then be compiled and funnelled down with each consecutive phase until a final result is reached. For a more detailed plan, see Gantt scheme in Appendix 1.

Figure 1 describes the different phases of the project. The whole idea is to gradually define the product step by step. During the research phase all the data was collected that formed the base on which this project stands on. It delivers a perception of how the environment is like in which the product will be used in, who the users are and what they will expect of it. In the product framework phase the designing starts in the form of defining the user and environment and identify requirements that the product must fulfil in order to be a success. The purpose of the product framework phase is to produce a framework of how the product. Features that many different solutions can fit in, like the functions of the product or how it's interacted with. Another example is what expression the product should convey. This framework is then taken into the next phase, where its designed how the product will implement the defined functions. The last phase will take the rough solution resulting from the concept generation phase and develop it to a final concepts.

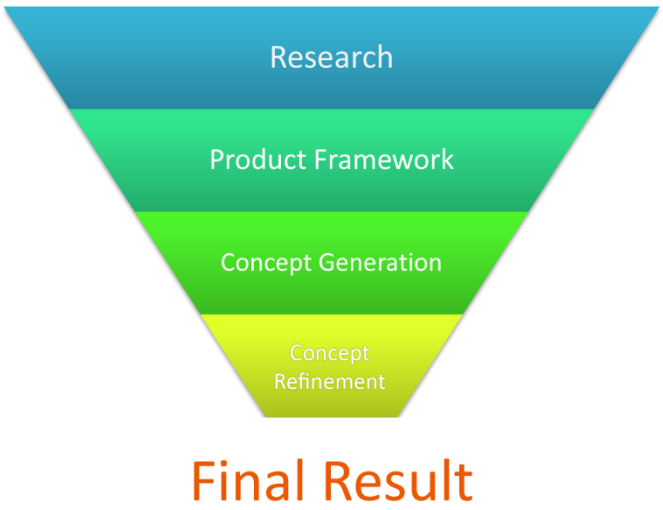

Figure 2 The four different phases of the project

Phase 1; Research

During this phase all the data will be collected. It will include information about the user, the environment around the product, key moments and important design variables. This phase will also identify routines and interaction sequences applied in the business. As a compliment, a deeper study of the delimitations for the technical aspects of the product will be made. This phase will result in a knowledgebase for the project.

Phase 2; Product framework

The collected data will be compiled into a list of needs & requirements. The main design aspects will be identified and prioritised. This will form a framework for the product design and work as a main description of the functions the design needs to have.

Phase 3; Concept generation

This phase will determine how the product will fulfil the functions set out by the product framework. This will be done by using different methods to generate a large cluster of ideas. These will then be sorted, winnowed down and merged to an array of three to five different concepts. The phase will end with a presentation of the result and decisions will be made on which concept(s) to further develop.

Phase 4; Concept refinement

After decisions been made on which ideas that are to be further developed they will be refined. There will be room for more research to fill in possible gaps in the knowledgebase. The concept(s) will then be optimised and developed further. This last phase ends with producing the finale product design i.e. final deliverables.

4 Research

During this phase all the data will be collected. It will include information about the user, the environment around the product, key moments and important design variables. This phase will also identify routines and interaction sequences applied in the business. As a compliment, a deeper study of the delimitations for the technical aspects of the product will be made. This phase will result in a knowledgebase for the project.

4.1 Process

4.1.1 Brand investigation

The investigations goal was to get an understanding of how the company wants to be perceived and what values the company wants to express. This was done by analysing the company's homepage, logo and an interview with the CEOs were be held.

4.1.2 Study of the technology's delimitations

An In-house study will be made to get more detailed information about the delimitations of the technology. Interviews will be held with the technology experts at the company and with the CEO:s to identify which design variables are flexible and which are not. The result of this study will be put into the Needs and requirements list under the category "Demands from wyberry".

4.1.3 Interviews and study visits

Semi-open interviews (hereafter referred to as only interviews) were conducted with different managers and technicians within the event and concert industry. The interviews focused on how the current rigging and procedure is made. The first interviews were conducted at the local resource at Chalmers; LoB ("**L**jud **o**ch **B**ild föreningen"). At a visit to LoB's fraternity room in the student union building's basement, interviews were held with the fraternity's experienced members. There followed four iteration; Interviews and observations during the rigging of "Nollfinalen" at Chalmers (13-14/9). Including first-hand experience with rigging and disassembly of all the equipment used for both concert and dance floor. Made observations and interviewed professionals rigging for a heavy metal concert at Brewhouse (26/9). An interview session was held with technicians at the company Proshop Europe, who sell and rent out modular LED screens holistic solutions for events. Lastly, a telephone interview was held with Rogerl Allstedt at STRIX and a visit was made to one of the exhibition PLASA in London, the largest exhibition for the industry. Complementary to this, interviews with members of the Chalmers fraternity CFFC were held. They have experience in rigging big screen TV: s and video mixing at events like the Chalmers spring ball and "Chalmers Cortègen".

4.1.4 Literature study

The study was conducted in order to get an understanding of how the products on the market look like today. Because of the scarcity of competitors to wyberry, some of the competitors included in this study are from related industries. The different line of businesses included are; telecom, film production and the event and concert industry.

To get a better understanding of the users in the event and concert industry, a study of video and audio mixing was made. These professions play a very central role behind the scenes of a concert or larger event.

4.2 Result

This chapter will present the results found from the In-house study of the technology and branding of wyberry, as well as the result from all the interviews and study visits. The latter will be presented in the order they were conducted and summarised.

4.2.1 In-house

Brand

Figure 3 The wyberry brand

The Wyberry brands core values are:

> **Offer our customer cutting edge products that delivers exceptional quality, robustness and reliability**
>
> **Always exceeding expectations through deliver more and faster than agreed**
>
> **Staying competitive by continuous innovation and creativity driven by customer needs**
>
> **Having a great company culture that attracts and keeps the best people**
>
> **Transform strategic discussions into clear goals and actions, work effective & efficient and win by preparations**

They have chosen to have an orange colour as the brand profile, it delivers the feel of being personal and it stands out on the market.

Technology

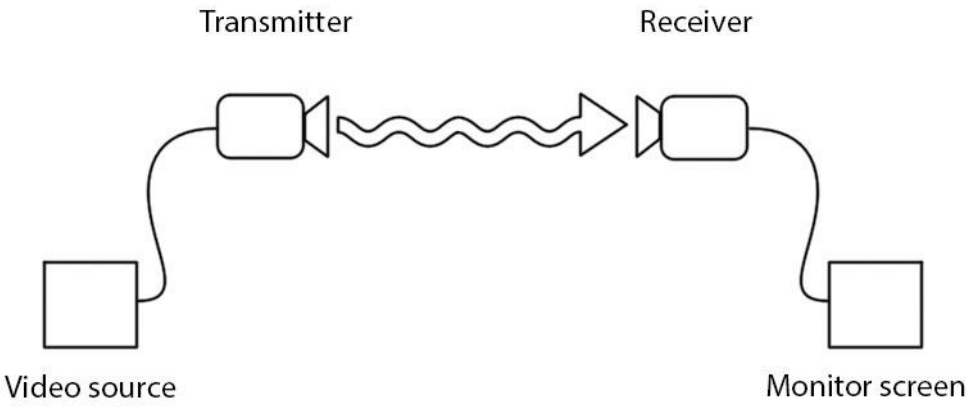

Figure 4 The technology setup

The technology is based on a point to point link that transfers high amounts of data wirelessly with microwaves. This system can only send information one-way and since it's a point to point link; it means that the transmitter and receiver need to be in line of sight and aligned towards each other with a tolerance of circa 10 degrees deviation. The system ranges in theory up to 3 km and the demo-product will be designed for a range of 500 m. The transmitter can send up to three individual video signals at the same time and there can be three different receivers picking up one video signal each.

4.2.2 Interviews and study visits

The user studies were conducted in numerous places with several different users. Starting with a study visit to Chalmers Nollfinalen, moving on to interviews with other professionals in the industry and lastly visiting an exhibition in London.

4.2.3 Nollfinalen (LoB)

Background info

Nollfinalen is a big party situated at the Chalmers Union building. Everything is planned, executed and done by students from Chalmers. The interviews and observations are focused on the sorority called LoB (Ljud och Bild-gruppen), they are in charge of rigging all the equipment, speakers, lights and such, for the concert and multiple dance floors. They are also responsible for the audio and light mixing during the concert.

Basic concert setup

Stage construction

The stage is built with stage floor and trusses. The stage floor is just enforced wooden square boards standing on legs. These are tethered together creating a platform. Larger events and concerts that take place in parks or sports arenas have first protective flooring laid out under the stage platform. This is to preserve and protect the grass or running track. On the stage a framework of trusses stand, called a truss cage. Four trusses are linked into a square which hold all of the lights and speakers. This is then

raised with a chain pulley system on four legs. The function raising the square truss construction is so the rigging personnel are able to mount all the equipment at chest height.

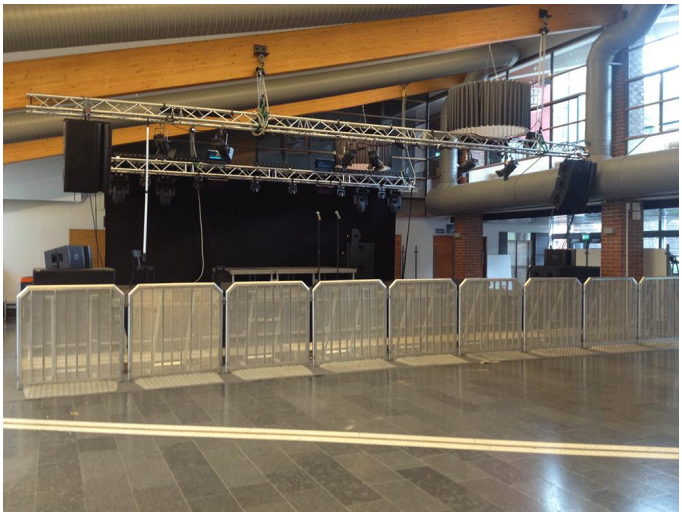

Figure 5 The complete stage assembly

The time it takes to assemble a stage, with equipment and all, is about 2-3 days. For larger events and concerts, this can stretch up to six days. Artists on world tour, due to having gigs every few nights, need to have up to three complete stage sets. These are shipped around in trucks. At medium to small events, the stages are often rented from an equipment provider. A company that already owns and rents out complete stage setups. General for all sizes is that there is always a backup for everything.

General for the touring and concert business is that much is much optimised and routine based. The assembly of the stage is planned so that the disassembly is quick and effective. All cables and connections are during the assembly not tethered to the trusses, so they are easily disconnected and rolled up when disassembly begins. Then the equipment is dismounted from the trusses and packed into its case. Lastly the trusses are disassembled, fitted onto trucks with all the other equipment and cables and hauled away.

Figure 6 Transportation cases for equipment

Personnel

For a larger event or concert there are typically two different kinds of crew. There are the tour crew; employed by the artist. They mix the audio, the lights and such. They are the personnel taking care of everything happening behind the stage during the event. Then there is the house crew (also called local crew); employed by the promoter for the concert or the organisers of the arena. They support the tour crew to assemble the stage and rig the equipment.

There are some important aspects they value in the equipment they use:

- Dependability
- Safety
- Easy assembly and disassembly

Audio setup

The main output loudspeakers are called Front-of-House loudspeakers. They project the acoustical sound picture onto the audience. The FoH speakers are often a setup of three different speaker types, consisting of a base register, midrange register and a set of horns (treble). On stage there are speaker directed towards the artists, this is to enable them to hear their own performance. There are two different types of monitors, the in-ear versions and the loudspeaker versions. Briefly they are either ear pieces or speakers standing on the stage platform.

The audio outputs from the artists are generally picked up by an array of microphones positioned on the stage.

Front of house audio and effects mixing

All of the input from the microphones and instruments on stage goes to the so called the Front of House. It stands in front of the stage at approximately 35-45 meters. There the audio mixer receives all the input signals from the stage and mix them together into a single stereo output that's sent back to the FoH-speakers through an amplifier. The operator of the audio mixer also decides the output in the monitors on stage, which enables the artists on stage to hear them. More advanced mixers also allows for auxiliary outputs for recording and headphones.

Beside the audio mixer sits the lights and effects operator, which commands over the light show and effects on stage live during the show. The equipment used look like the audio mixer, but only sends out signals with pre-programmed commands.

Cables

Connecting the FoH and the stage are cables that go through the audience. These are protected with so called Defenders; Cast hard plastic housings that are linked together forming a protected trench for the cables.

The standard interface for sending audio signals back and forth between the stage and FoH is the 3-pin XLR-connector. It's generally used for most low frequency signals; audio to the amplifier, signals to the lamps etc. Other connectors that are more seldom used are the 6.5mm Jack (used for audio only) and the RCA interface (which is a coaxial cable).

Transportation and storage of equipment

Figure 7 Cases used for equipment in the industry

All equipment used in this business comes with its own casing. An often black wooden box enforced with aluminium profiles, often with mounted cart-wheels. Inside they have a inner lining of foam perfectly cut to snuggly fit the equipment inside, keeping it from sliding around inside the casing. These are sturdy constructions meant to be able to stack on each other for efficient storage. They also come with quick and easy snap locks, or butterfly locks as they are called by the industry. There are mainly three large manufacturers of these cases; Thon, Thomann and Gator.

4.2.4 Interviews with CFFC members

Background info

CFFC are responsible for operating the big LED-wall display at the Chalmers Cortègen. It's a 56 m^2 mobile screen from Mediatec. The screen comes mounted on a truck trailer, folded in half inside it. Electric motors and hydraulics are used to unfold it into position.

Equipment used and how they interact

The cameras are placed in different strategic positions and HDSDI cables connect them to the video mixer. Two of the cameras are mounted on tripods, while the third is handheld. If the cable runs over a road or along a doorsill, the cable needs to either be covered by a defender or taped to the floor. This is either to avoid people tripping on it or prevent vehicles from getting entangled when passing over the cable. PC's are also used to show previously recorded content and still images, they are connected using either DVI or HDMI cables. The video mixer in turn takes all the input from the different video feeds and generates a main output that is shown on the big LED-wall. The mixer is often the bottle neck in the system, due to that the full HD versions are really expensive compared to the SD counterparts. CFFC didn't know how the video mixer and the LED-wall are connected, but probably using some form of digital cable with an intermediate controller box.

Personnel

Mediatec delivers the mobile unit and sets up the screen. CFFC has three cameramen and for the handheld camera, there is an extra person who is in charge of keeping the cable from tangling. The person operating the mixer has direct communications with the cameramen and is also in control of all

the settings for the cameras. Except for composition and focus, those are the cameramen responsible for.

Troubleshooting

They always start at the camera end of the system and work their way towards the mixer. This is because the mixer is the last thing to look over due to it being complicated to troubleshoot.

Views on wireless technology and desired features

Wireless has both pros and cons. Pros being the freedom of mobility and not needing to manually drag a cable for long distances. If there aren't any obstacles between the wireless points, there usually shouldn't be any problems. It would be of great benefit just to be able to connect all the cameras in one click and then you'd be done.

But the cons with today's solutions are that there is no insight in the health of the wireless connection. You don't know if the camera has a low signal or if the quality has become worse with the signal being fainter. And there isn't much trust put into wireless solutions due to the connection not being 100% stable at all times.

In conclusion, a wireless solution should give some feedback on the health of the connection to the users in the system. The cameraman would benefit from seeing the signal strength, then knowing how far away the camera can be from the wireless connection point leading to the control room. For the operator manning the video mixer, it would be of help to see more information on the status of the cameras: Information like battery-status, camera setting; exposure, current focal length and so forth. In general; a lot more insight in the status of the system is needed, updated in real time.

4.2.5 Interview at Proshop Europe with Bror Beckholmen

Background info

Proshop is a company that sells holistic video solutions for exhibitions, permanent installations of LED-walls and temporary LED-wall setups for larger events and concerts. They are a multi-national company with HQ in Denmark. The interview was made with a technician working mainly with rigging and operating LED-walls and projectors at larger company events and concerts.

Equipment used and how they interact

The cameras they use at various events are connected to the video mixer via a CCU (Camera Control Unit), which controls the exposure and focal length settings for the camera. Connecting them is a so called triax cable, it carries the video information from the camera, the control signal for the cameras aperture, audio and a return image of the main monitor screen. The return image has the purpose to show the camera man what is on the screen and when his/her camera is live. When Proshop is out on a concert or larger event, they use an OB (Outside Broadcasting) bus where they house the CCU and video mixer. These OB busses are essentially remote broadcasting television studios.

If the cable runs over a road or along a doorsill, the cable needs to either be covered by a defender or taped to the floor. This is either to avoid people tripping on it or prevent vehicles from getting

entangled when passing over the cable. The video mixer in turn takes all the input from the different video feeds and generates a main output that is shown on the big LED-wall.

Personnel

There are usually four operators manning the FoH at larger events and a cameraman for each of the cameras. In the FoH there are an audio operator who's responsible for the audio mixing and main output for the loudspeakers. There's then an operator controlling the CCU (Camera Control Unit), ensuring that the video feed from the cameras has the same exposure and colour balance. The video mixer is responsible for what the LED walls display, changing from camera video feed to showing a power point presentation or a static image. The recorder's task is to record all the video input from the cameras and the main output the video mixer sends to the main displays. This is to have backup if post editing is needed to be done.

Troubleshooting

There are two different scenarios for troubleshooting video. The first is if only one or some of the displays are malfunctioning. Then they start by checking the displays whilst moving back towards the mixer, checking each step on the way. The other scenario is if all of the displays are malfunctioning, then they start by checking the video mixer and move towards the displays and checking each step on the way.

Views on wireless technology and desired features

There is a lot of distrust in wireless technology. In Bror Beckholmens experience with wireless microphones he says that they tend to "fall out", resulting in audio information being lost. He says he's okay with that happening, but if a wireless video feed falls out, there would be such a great information loss which can't be acceptable. Also, these wireless solutions tend to interfere with each other and other equipment on stage. Solutions they use in the industry today are over dimensioned so that they are sure to work during the event. This also includes working with different kinds of backup systems, which wireless technology solutions of today can't offer.

If he were to use a wireless solution, there are different aspects that he would require in order to trust the equipment. The first thing that is needed is for the wireless solution to deliver the same video quality as with cables. To use wireless solutions today means that you have to sacrifice video quality. Since the distrust wireless technology is so great, the user needs to feel more in control and "in the loop". Bror Beckholmen would like a more transparent system where he can see exactly what's going on. If a problem would appear, he needs to quickly be able to determine where the source is located. "Today the wireless solutions are only two black boxes that don't give you any feedback on their systems status. I need to know if they are working or not."

4.2.6 Interview with Roger Allstedt at STRIX

Background

Roger Allstedt is technical manager for tv productions at STRIX. He has been involved in the productions of the reality tv-shows *Robinson* and *Farmen*. Before working at STRIX, he's worked at 24/7 productions for seven years.

Equipment and how they interact

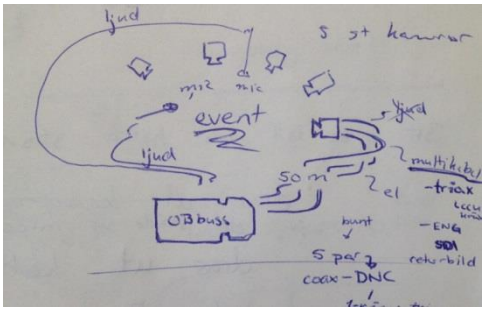

Figure 8 The general TV-production setup

A general technical setup for a TV-production of a reality show is that there are two to four teams going around at the set and recording everything that happens. The team usually consist of a cameraman and an interviewer. For the events and contests that occur throughout the show, the setup looks more like that of a concert or company event.

There is a set of five to six cameras with two separate microphones, all connected to the OB bus. The cameras are connected to the OB bus using mainly triax cables. But it happens that they also use a so called "5 par" cable; five cables that are bundled up together where the different signals going back and forth between the camera and OB bus have each its own cable. For example; the video from the camera goes through a SDI cable (standard cable for digital video) and the intercom goes through a coax cable.

The equipment used by the industry is generally very expensive and each of the different shows they handle varies in a wide range of different equipment. So the most economical solution is to rent the equipment when they are needed. There are a lot of different rental companies on the market, but the absolute largest is Mediatec.

Application scenarios and Desirable features

Larger arenas have a built in outlet system for cameras around the track. But at larger sport events and such, there is a need for overview shots of the event taken with cameras mounted high up in the arena. Today there needs to be fibre cable drawn all the way up to those cameras, a scenario where a wireless solution would be of benefit. If the event is to be broadcasted, the OB bus at the site is linked up to the fibre network of the ISP in the area. But often, these uplink sites are quite far away from the arenas, so a satellite uplink is used instead, sending the video signal to the broadcasting studio.

If he were to use a wireless solution there are some features that he would prefer. Wi-Fi solutions are according to Roger very unreliable, have bad range and a slow latency. Since there is very much signals going through the air today he would like to have some way to check the vicinity for potential interfering signals. If there were to be such signals, he would like to be able to choose another band width to operate on. If there were to be any disturbances during transfer, he would like to be able to have a back-up recorder hooked up with the transmitter. If there were to be any interference, there would always be back-up of the video feed. Also he would like to have some form of insight into the systems health during use. Lastly, if something were to break down it would be of great benefit to be able to call some form of support line in order to get help on site.

4.2.7 PLASA London

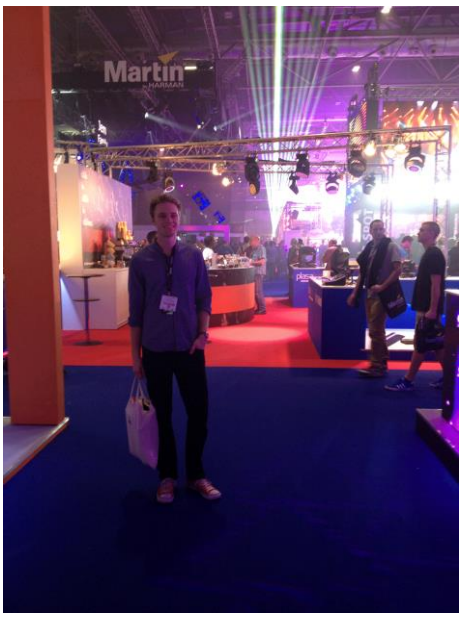

Figure 9 PLASA London

Background

Connecting the international entertainment technology industry has been PLASA London's goal since its beginning. It's the largest exhibition of its kind, a place for all the companies in the industry to present the newest and latest technology to the audio, lighting and stage technology professionals. PLASA London is owned and organized by PLASA, the leading international trade association for entertainment technologies.

The industries expectations of a product

There is a heavy focus on performance, since the products main function is to blend in with the surroundings and put focus on the show at hand. Performance in this case consists of three different aspects:

Technical capacity; how much the product can do compared to competitors and other models, i.e. how much lux does the lamp produce or how much wattage can the amplifier output.

Durability; how the product will fare after hours of use and under rough handling and how dependant it is during use. A low maintenance requirement is highly valued.

Assembly; the assembly should be intuitive, fast and easy, which also applies to disassembly.

It's a conservative market; the stakeholders want to be able to completely rely on the product when using it at an event or concert. Products need to be proven by the industry in order to be used, which means that new technologies have difficulties being adopted. Many of the products used by the industry are highly flexible. For example a video mixer has up to five different types of inputs/outputs; mainly one or two are used, but the user still wants to be able to use the other interfaces if need be. This is because each event and concert needs its own custom equipment setup.

There is a demand for wireless solutions all through the industry since it would streamline the work process; switching connections with a click of the mouse or not needing the storage and transport or cables. But as earlier stated, the solutions needs to be dependant and transparent. Today wireless technology is neither of those two according to sources at the exhibition. Wireless signals tend to interfere with each other if sent on a similar frequency. Also, wireless technology is perceived to be hard to troubleshoot since todays solutions aren't very transparent.

Desirable product features

The suggested application scenario would be when broadcasting a video feed from a stadium event out to a remote modular LED wall offsite within 3 km of range. Because of this range, there is also a need to send the audio embedded with the video signal. Since there is such distrust in wireless solutions, the user wants to be in the loop with what the product is doing. There are a couple of features that should provide the user with insight into the status of the product. The features that were mentioned were to have information about the signal strength and if anything are interfering with the signal.

It was mentioned that it happens that the user isn't educated in using the technology in the FoH, but is under surveillance of an operator. So a transparent and intuitive user interface would be of great help in streamlining the work process behind an event. This should also include an easy setup and disassembly of the product.

Throughout the industry, SDI is used as the main video interface. Fibre is also widely used, but it's converted to SDI before going into equipment. In order to have a line of sight, there's often a need of positioning the product at a roof or similar. This means that it can be hard to get a power supply cable to the position of the product and a battery powering it would be of great benefit. As a side note, there is a wish for that an intercom connection were to be integrated.

To further streamline the workflow, the industry wants to be able to send multiple video streams through one single transmitter and have multiple receivers receiving only one of the signals.

4.2.8 Competitor study

The product is to pioneer a new market which means that there are few direct competitors. Some of the models on the market were analysed; a mobile broadcasting device from Vubiq,Boxx communications mobile device "Cerulean" (used for wireless video transfer) and the "Extend Air r5005" from Exaltcom.

There are though some products on the market today that have similar application that the end result of this project will see. The products out on the market now are very bulky and designed for heavy duty. Many of them are designed to be used outdoors in harsh conditions. The most extreme, for example a telecom unit from Ericsson, is said to be able to withstand hailstorms and winds reaching 25 m/s.

The idiom is very governed by the function of the products. They are more casings for the PCB: s and antenna that make the heart of the product. Many of them resemble CCTV: s and telescopes, something that maybe isn't intended. There is little to no aesthetic design, only pure engineering. There is much to win on making the product both look appealing and to have good usability. Many of

the competitor products are used in the telecom business and therefor are most of the time permanently mounted solutions for building rooftops and similar. The mobile ones, as the Boxx Cerulean, are mounted on supports originally designed for cameras.

4.2.9 Summary of the research result

This is an industry that values three things with the equipment they use: Dependability, Safety and efficient assembly and disassembly. Since this product streams video wirelessly, it's primary going to see use at outdoor concerts and larger sporting events where LED walls are used. At these larger temporary events OB buses are commonly used.

Wireless solutions are often frowned upon, it's caused by the wireless equipment in the industry. They tend to disrupt each other and one of the desired features for the product is just the ability to check signal health. Other desired features is a transparent system that puts the user in the loop, so troubleshooting can be done quickly if something were to go wrong.

The designs of the competitors are clearly functional in the way that the aesthetic aspects to the product aren't even considered. The products are done by engineers, thus very bulky and optimised for various manufacture processes. Also, many of the competitor designs are made for permanent installations, resulting in tougher demands on weather resistance.

5 Product Framework

The collected data from the research phase was compiled through different stages. The product framework phase began with loosely defining the users and the environment using written fiction. This was to first get a feeling for how the users behave and what kind of environment the product will see use in. This later transferred into facts and definitions, identifying core aspects that will make the product successful. Lastly in this phase; a product framework could be set. Giving a basic idea of how the product will come together and a good base for the concept generation phase to stand on.

5.1 Process

5.1.1 Persona, scenario & user profile

The first step to start analyse the collected data was to describe the typical users through a persona. This piece of written fiction helps in making the user a person and not a bunch of facts. The same thing was done with the environment; creating a scenario in which the product will see regular use. To support and map out all the variations and important user aspects a user profile was also used in this phase. This is an important part of the project that helps to make the product successful.

5.1.2 Component profile

Since this design project goes on parallel with its technical counterpart, the components that are to be inside the demo product aren't 100% decided on yet at this point. This required a component profile; which purpose is to describe the significant variations in sizes of the span of possible components. This profile also describes the relationships of the connections between the different components. Describing which of the components that needs to be close together and those who are as good as independent from one another.

5.1.3 Functions and expressions

With the user and environment defined the design of the interaction and specification of the functions could be made. This was done using a FAT (Function/Action Tree) taking the different aspects from the user profile and persona in consideration when designing the interaction and functions.

The branding is a more standalone part in the design process of the product. The aspects that were taken in consideration were not only the company branding, but also how the user perceives the product through its aesthetics. To identify and develop what expression the product should have, the methods EAW (Expression Association Web) and Expression board were used. These are good methods for integrating brand values and user aspects into expressions.

5.2 Result

5.2.1 Personas and scenario

Figure 10 Picture of Henrik[13]

Main user: The technical manager

Meet Henrik, a 39 year old technical manager and is responsible for delivering video at larger events. He has worked in the industry for the past 20 years and has learned the trade by doing. He started as an apprentice in his early 20's and have gained rank over the years. He's divorced since a while back and loves to spend time with his 5 year old daughter when she lives with him every second month. Other to that his big passion is for driving his motorcycle with friends.

Henrik has a very hands-on perspective to his work. He decides what equipment is needed at the event and since every event is different from one another, so is the need of custom equipment setups. When choosing the equipment, he uses products that are proven by both time and by the industry. He values credibility and practicality. In his line of work you have a good amount of margins; to be sure that everything works during the event. Even if something unexpected should occur. He wants also to be in control and on top on how the setup works. In order to be able to respond quickly if something were to stop working. His experience with wireless technology is almost only with Wi-Fi and he's quite reserved with using it. He thinks that it isn't a very dependable solution to rely on.

[13] Gettyimages.com 1

Figure 11 Picture of Martin[14]

Secondary user: The rigger

Martin is 24 years old and works with rigging larger concerts and events as a thing besides his studies. Martin spends his free time mainly outdoors, either out rock climbing or if the weather agrees; windsurfing. During day time, he's currently majoring in mechatronics at the local university.

He usually gets to do the "dirty work", but feels that he's started to move up in the ranks and is getting more and more responsibility. Martin is rather in-experienced in working with high tech equipment. He gets instructions by the senior operators and the technical manager in how to setup equipment. Like Henrik, he has also a hands-on approach to working as of the industry. The different equipment he set up are very fast and easy to mount and disassemble. The equipment may be complex to setup, but hates it when they are hard to disassemble and when it takes a long time. He finds building everything and finding solutions to smaller problems in the rigging process satisfying. Compared to rigging down afterwards, that he thinks is only stressful work that needs to be done.

Scenario

Henrik and Martin have just arrived at the big arena where their company are going to deliver live video using cameras and large LED walls. The event organisers want a large LED wall showing a live video feed from the stadium at a market square about 2 km away, so they use a wireless video link to connect the LED wall with the OB bus. Henrik retrieves the case with the link inside from the truck that has transported all the equipment to the stadium. He opens up the case and confirms that everything is in it and that both the batteries are fully charged. Martin carries the receiver to a car that transports it away to a local market square. Henrik starts to look for a high position at the arena and decides that being the arena roof covering the audience seating area. The transmitter will be operated by battery since it's hard to find an available power socket near the location where it will be mounted. The receiver is carried up in the bell tower of the market square and there Martin finds a power supply beside the spot where he means to position the receiver.

[14] Gettyimages.com 2

When Henrik arrives at the roof of the arena he starts mounting the transmitter on the appropriate support and points it in the general direction of the bell tower. Another rigger had already drawn a fibre cable up to the roof from the OB bus and attached a fibre-SDI converter at the end. Henrik connects the SDI cable to the transmitter and calls to Martin over the intercom. Martin has done the same thing with the receiver at the bell tower and has already aligned it towards Henrik. He calls over the intercom and says that he can see Henrik through the optical enhancement tool. Henrik switches on the transmitter and aims it towards the bell tower. Martin has also turned on the receiver and the products give feedback on how close they are from getting into a perfect alignment. When alignment is done the links give feedback that they are correctly aligned and ensures that a stable link is established. Both Martin and Henrik lock the products in place.

The system is tested with a test video feed and Martin calls from up in the bell tower and confirms that the video is working. But after a short time of testing the screen suddenly goes black. Henrik is at that time down at the OB bus, he starts with checking the signal from the video mixer. The mixer is sending a signal up to the transmitter. The transmitter shows that it's getting the signal and sending it, so he calls Martin over the intercom and asks him to check the receiver. Martin, who is working with rigging some lights, sees that the receiver gives feedback that it is misaligned. He thinks he must have bumped into it while handling the other equipment. Martin quickly aligns the receiver with the transmitter and the video link is up and running again.

The event unfolds as planned with no more interruptions. After the event, Martin takes the car over to the bell tower and starts to disassemble the receiver. The first thing to do is to switch it off and unplug the cables. It is unlocked from its position and dismounted from the support. Martin puts it down into its case and closes it. Henrik does the same thing with the transmitter up at the arena roof. Martin comes back with the receiver to the arena where the transport truck has started to load all the equipment. The cases are laid side by side directly on the floor of the truck, stacked beside other larger casings.

5.2.2 User profile

Main: The technical manager

- Background
    - Type of user: Primary, secondary.
    - Educational level: 1 year education or self-taught, usually very competent on their responsibilities
    - Mental model of how the system as a whole works (Video mixer => LED screen): Have a deep understanding for the system
    - Experience with wireless technology: Negative
- Attitudes
    - Attitude towards new technology: Conservative, products need to be proven and be credible
    - Attitude towards wireless solutions: Attractive features but unreliable
    - Attitude towards work: Very hands-on
    - Buys equipment that are very robust, reliable and of high quality
- Interaction with the product

- Degree: Very high
- Values reliability of the equipment, that they are easy to troubleshoot
- Values the aspects of performance, reliability, quick assembly and transparency in the equipment
- Mounting equipment is usually enabled to be done at chest height

Secondary: The rigger

- Background
  - Type of user: Secondary.
  - Educational level: None
  - Mental model of how the system as a whole works (Video mixer => LED screen): Have a superficial insight on how the system works
  - Experience with wireless technology: Neutral to slightly negative
- Attitudes
  - Attitude towards new technology: Open minded
  - Attitude towards work: Very hands-on
- Interaction with the product
  - Degree: Low
  - Only interacts with the product during set up
  - Values minimum effort to assemble, set up and disassemble equipment
  - Mounting equipment is usually enabled to be done at chest height, but the riggers are usually equipped with kneepads and other protective gear.

Critical aspects

Technical capacity; how much the product can do compared to competitors and other models, i.e. how much lux does the lamp produce or how much wattage can the amplifier output.

Durability; how the product will fare after hours of use and under rough handling and how dependant it is during use. A low maintenance requirement is highly valued. The users are very keen to always have a backup solution if something were to fail.

Assembly; the assembly should be intuitive, fast and easy, which also applies to disassembly.

Insight; the users have a bad attitude against wireless solutions, since they tend to malfunction and get disrupted by other wireless systems. The system needs to let the user understand; what is happening inside the system and of the health status of it.

5.2.3 Component profile

The transmitter and receiver will have a similar component setup. The transmitters components will though be both be slightly larger in size and in number. To aid and simplify the design process and idea generation, the component profile will result in a "component box". The shape of the box and its measurements will make sure that all the components will fit into the design. It will also fulfil the other requirements of being able to upgrade the components and allow easy access to them. Therefore, this box will be used as a place holder in the design. Since the transmitters components will be slightly larger, the box will be used for both the transmitter and the receiver design.

- Components
    - Antenna
    - Front end with power supply
    - Baseband (receiver has one, transmitter has two)
    - FPGA board
    - Power supply (battery and power input)
- Connections between components
    - Antenna and frontend needs to be fixed using 4 M2 (typ) screws
    - The Front end and its power supply are connected using a 15 cm plastic cord that is bendable
    - The Front end is connected to the baseband box using a dual coaxial 30 cm cable (running TX and RX inside this single cable). The cable is able to have power integrated to it.
    - The baseband
    - FPGA has all the interfaces (SDI, DVI, etc.) and is connected to the baseband with a more rigid cable

Important aspects

- Antennas vary within a wide range
    - Small horn antenna and a reflector antenna at circa 100 mm in diameter
    - Reflector antenna at circa 600 mm in diameter
- The other components vary with circa 5 cm in both width and length, compared to the antenna variations, this is a small difference. It could be said that the components box is virtually the same in size. If some margins are set (about 15%), the measurements of the component box can be set.
- The connections between the FE and antenna are rigid and set with screws (FE fixed with the antenna at a set angle)
- The connection between the component box and the FE. 30 cm half rigid cable (quite fix)

Component breakdown

To simplify the component profile and make it easier to apply on the upcoming concept generation phase, it was compressed into three different modules; the antenna module, the component module and the support module:

- The **component module**, it will have:
    - All the components except the FE and the antenna
    - The user interface
    - The alignment tool
- The **antenna module**, it will have
    - The FE with its PSU
    - The antenna

The antenna varies so much in size that there is need pay extra attention to it when designing the product. The support module is more of a secondary module compared to the other two. This will probably consist of a third party solution, if no better and easier solution is to be found.

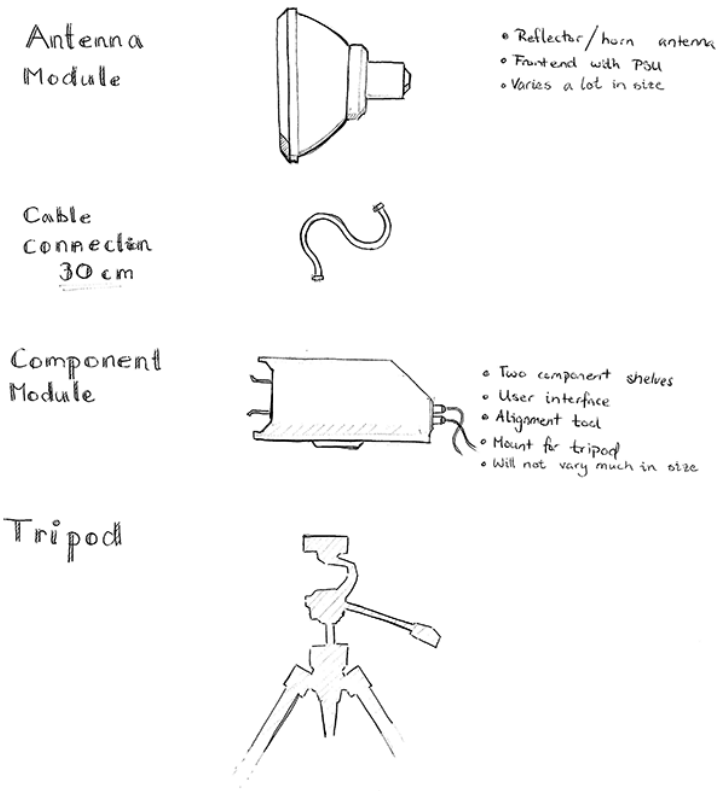

Figure 12 The different modules of the product framework

5.2.4 Function listing

Basic setup of products, there is a FAT (Function/Action Tree) in Appendix 2 that in detail explains the functions of the product. Important to note is that the main function of the product will be to carry the signal from the video source (OB bus) to the monitor screen (LED wall).

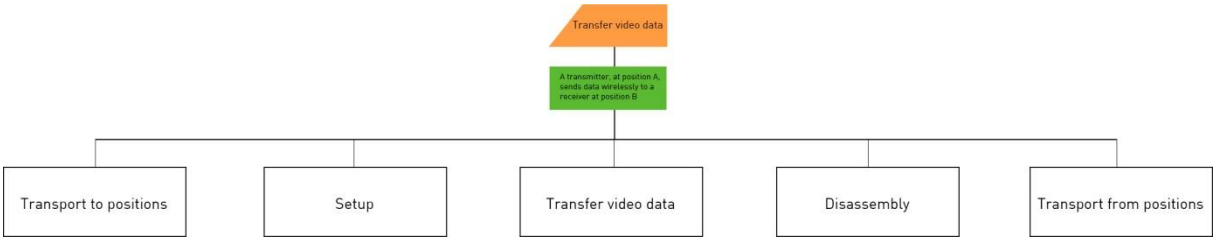

Figure 13 The Function/Action Tree

5.2.5 Expression association web

Figure 14 Expression assosiation web

The five large words centred on the wyberry logo, seen in figure 13, are words that represent the main expression. They are a summary of words from both the brand analysis and the conducted interviews. The smaller words around them are to further emphasise what parts that are the most important for the product. Wyberry is a very innovative company with ground breaking technology and aims to create a new solution on a market that is very conservative in nature. Signal robustness and the low latency are the two factors that the end customers value within performance; capacity is also important but it's more of something that is taken for granted. Trust is something that will be very important for this product solution to imply, because the views on wireless solutions today in the industry are very restricted. It also implies that the product must be reliable and tough to be able to always deliver its designed function. Professional stands mainly for quality, it's really important that the product delivers a quality experience for the user. Precision, efficiency and capability are factors that help create and support the feeling of quality. Lastly the product needs to be user friendly, the solution that this product aims to replace, cables, are in nature very easy to use and understand. This means that the system must be transparent in the means for the user to be "in the loop" and understand how it works. Since this product will be used not only by educated personnel, it needs to be very intuitive in how to setup.

5.2.6 Expression board

Figure 15 Expression board

The largest image in figure 14 with the arrow represents ground breaking innovation and high performance. Moving on to the rugged chain, this stands for robustness and durability, providing the user with the sense of trust. The PCB globe depicts the transparency of the system and to provide the user with a broad insight in how the system works. The iOS interface just below the globe, saying slide to power off, is there to complement the image with having an intuitive and easy way for the user to interact with the product. The two images showing satellite dishes are there because they are the symbol of wireless data transfer. The right one has an aura like halo depicting the feeling of wireless data transfer and the left one shows the precise and intricate structure that keeps the dish together. The image between the two satellite dishes depict the feeling of flow in information transfer and that the product have a high capacity. The blue colour tint that pervades through the whole image is often associated with professionalism and technology. It also often associated with trust and strength, used by many airline companies and hospitals.[15][16]

5.2.7 Summary of the Product Framework result

The raw data from the research phase were compiled into a more manageable description of the user and environment. A main and secondary user was identified and presented using the method of personas. Complimentary to this a user profile was made to cover all the variations within the user group. It describes the abilities, characteristics and delimitations of the user in a way that is hard to do

[15] Colormatters.com
[16] Digitalskratch.com

with a persona. Both these descriptions together give a complete picture of the user, showing what important aspects that needs to be incorporated when designing the concepts in the next phase.

The research done on the technical components resulted in a detailed and complex list. The different components have intricate relations between each other and limitations on how far they could be fitted from each other. To make the information more manageable when taken into the next phase, a component breakdown was created; grouping up all of the technical components into larger and more manageable modules.

Lastly, the expression of the product was developed. The expression was developed by blending the important aspects from the user profile with the branding of wyberry. The aspects and branding was first compiled and used to create an EAW. The final expression of product then became concretized through an Expression board.

6 Concept Generation

This phase will determine how the product will fulfil the functions set out by the product framework. This will be done by using different methods to generate a large cluster of ideas. These will then be sorted, winnowed down and merged to an array of three to five different concepts. The phase will end with a presentation of the result and decisions will be made on which concept(s) to further develop.

6.1 Process

6.1.1 Application of the Product Framework

Following the completion of the product framework, focus shifted to how the different modules could be placed in reference to one another. To get an idea of size of the product and how the different parts could be arranged, physical representations of the different parts in the product framework were created. To represent the components in the component module, a shelf system was designed. The idea was to have a system that could easily be expanded if need be by adding more shelves. In this case there needed to be two shelves. The size of the antenna was still not decided, so a scrapped reflector antenna of the largest size was used as a representative.

To get new input from outside the project, two brainstorming sessions were made. One with other students at Industrial Design Engineering at Chalmers and one with the other employees at wyberry Technologies. These sessions main objective was to freshen up the project with new thoughts and ideas on solutions and ways to fulfil the needs and requirements. During these two sessions, sketching was the main tool used to convey ideas and solutions. Complementing this, functional models gave an even better insight into the project than a short presentation and the product framework gave. There were some specified areas to generate ideas around; their main purpose was to act as guides and to stimulate the creativity for the people involved.

6.1.2 Sketching

During the brainstorming session with employees at wyberry, three main areas to generate ideas around were defined:

- The antenna position
- The handle and support design
- Feedback to the user and UI design

Narrowing down and defining limits makes idea generation much more easy and effective. The sketching process was iterated by cycling through the three different areas. The sketching included exploring different shapes, functions and different ways to communicate the expressions set by the product framework. But also taking in some of the most important needs and requirements in consideration.

6.1.3 Analysis and concept generation

The sketching generated a lot of different part solutions within each of the three areas. To create concepts out of these part solutions, the best solution within each of the four areas were chosen. The

best solutions were screened out using Pugh matrixes. Which were then combined onto different concepts, resulting in three main concepts focusing each on one main aspect.

6.2 Result

Based on the same framework, the different shapes and variations generated during the brainstorming sessions were combined into three specific concepts.

6.2.1 Brainstorming

The antenna position

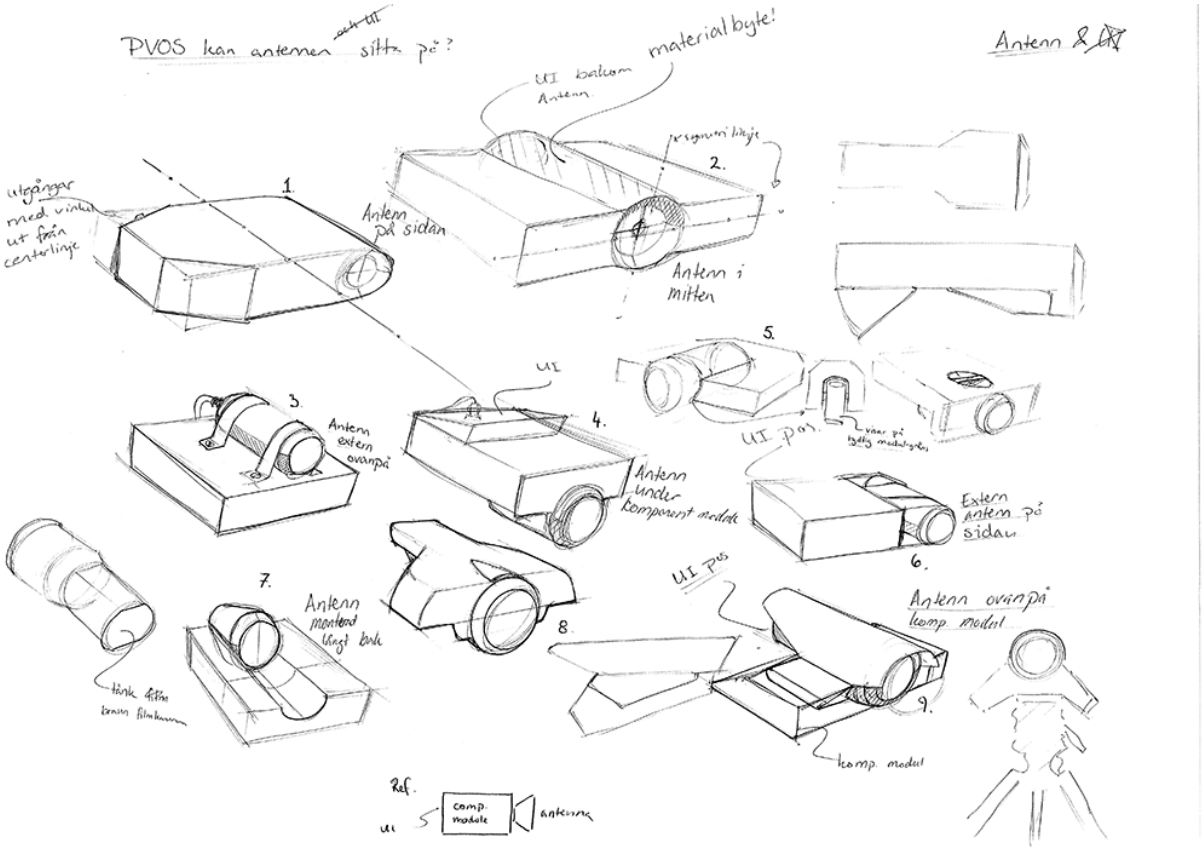

Figure 16 Ideas on the position of the antenna

Varied how the antenna and component modules could be positioned in relation to each other. The best feel was achieved when the all over shape had some kind of symmetry. Emphasis was put on expressing three of the words in the EAW; Robust, Professional and Performance. Since the overall shape and feel of the product would be the most efficient to communicate those expressions.

The handle and support design

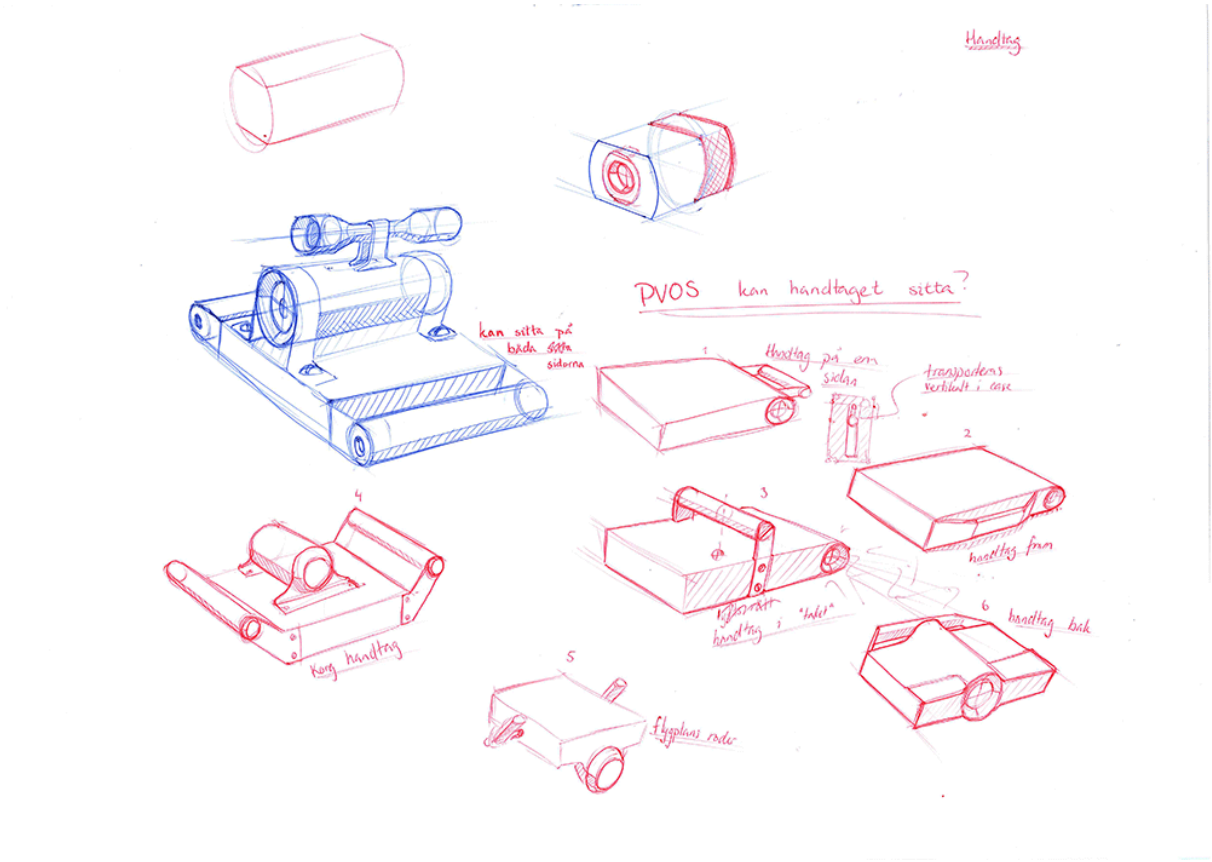

Figure 17 Ideas on handle postitions

The FAT specified that the products needs to be aligned and directed in some way. It was decided in the product framework that the product were to be mounted on a tripod. The product needed a tool for the user to direct the product and it was decided that a handle would be a good solution. Well during the session, it was quickly concluded that there aren't many ways to vary the handle design, since the design is to be as simple as possible.

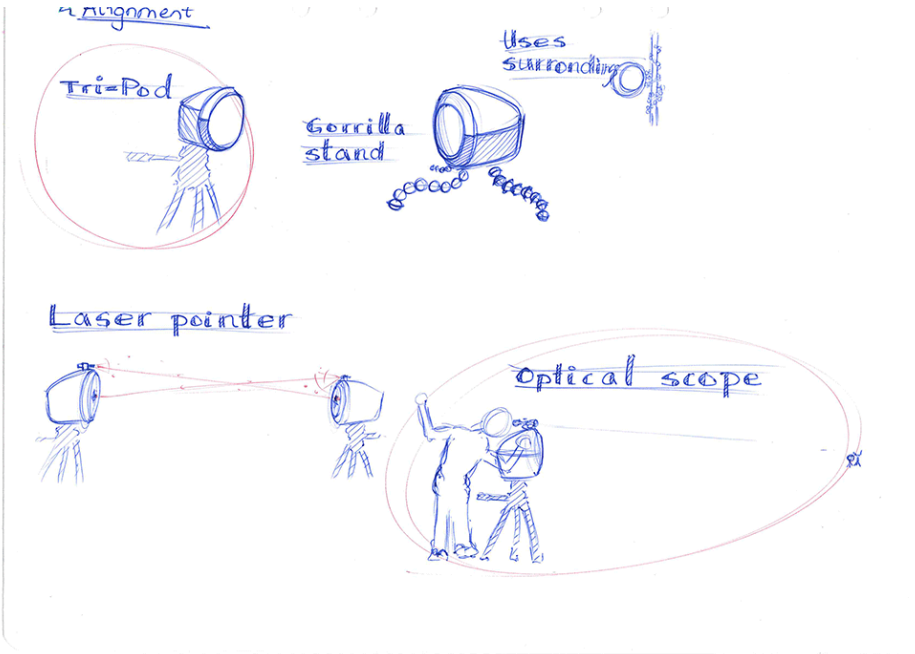

Figure 18 Different solutions for support

The support must enable the transmitter and receiver to tilt and pan in order to properly align them against each other. It must also be stable when mounted on uneven or rough terrain. As with the handles, it was concluded that there aren't many solutions that are viable. The most cost efficient and easy solution would be to buy a third party tripod that is already on the market to use as a support.

Feedback to the user and UI design

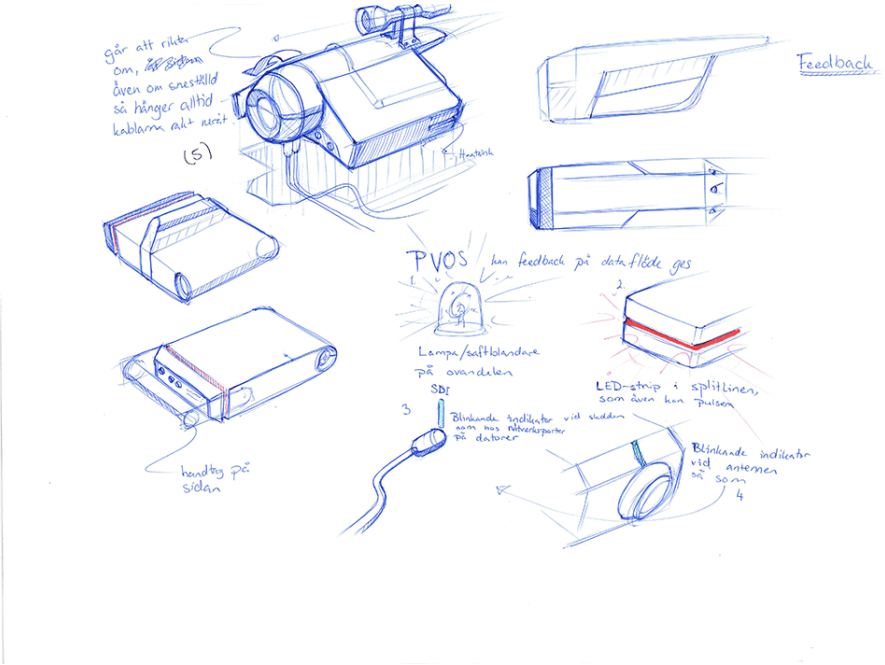

Figure 19 Ideas on feedback solutions

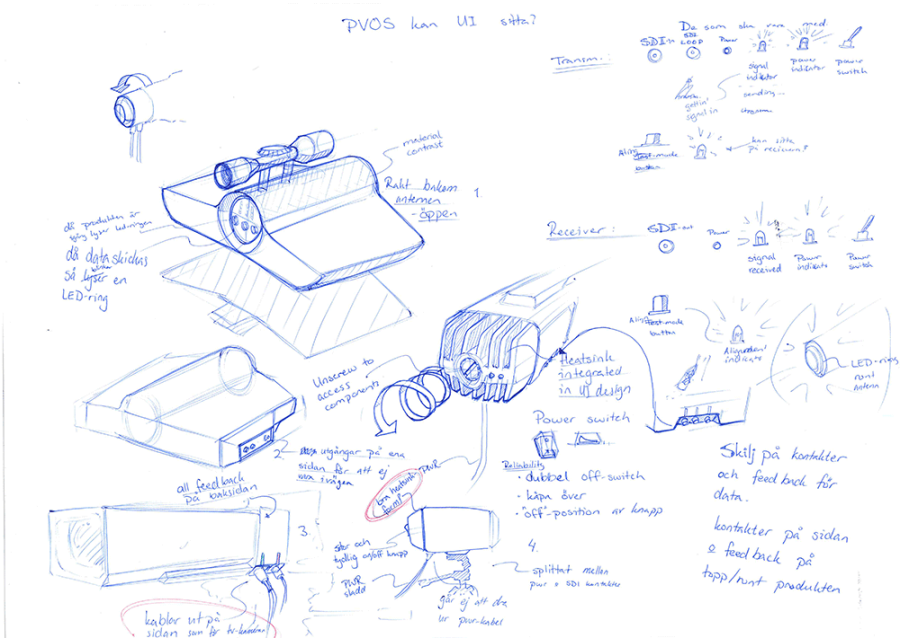

Figure 20 Ideas on where position of the UI

Following the handle and support design was the ideation for what feedback the product should give the user. The feedback that was concluded most important was; Signal strength, signal input and if the transmitter and receiver is aligned or not. The UI also need to have three inputs on the transmitter and two on the receiver. On the transmitter there needs to be a SDI signal in, a power input and a so called SDI loop. The SDI loop is a connection that mirrors the input signal from the SDI input (to enable a recorder or other equipment to be connected to the system). On the transmitter there is only need for the power input and the SDI out signal that is received from the transmitter.

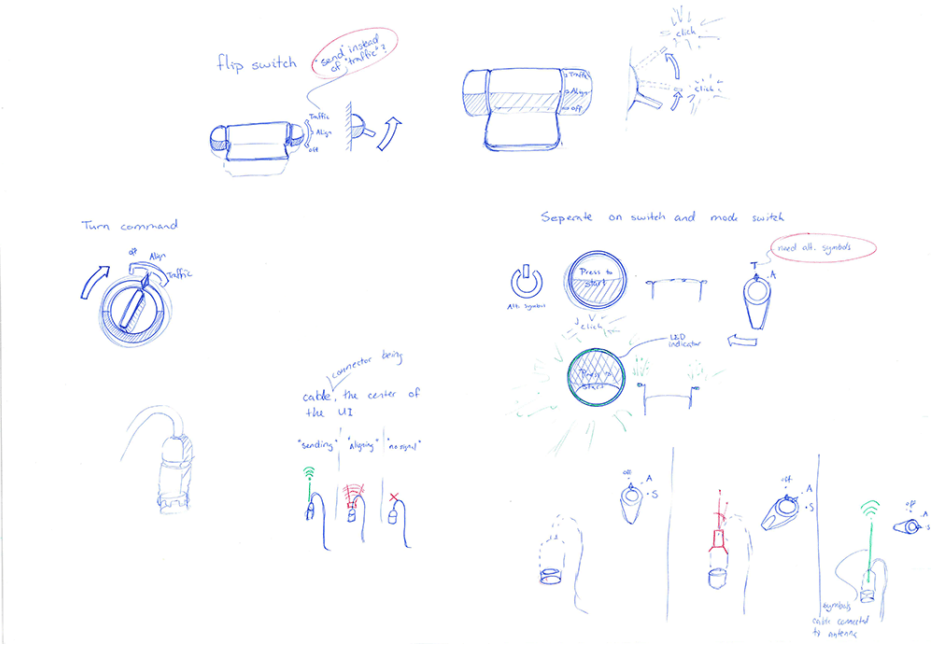

Figure 21 Ideas on UI design

To show if the transmitter and receiver are aligned, a mode-based system was developed. The system had three modes; OFF, Align and Traffic. The first indicating that the product is turned off, the second mode was to be used as the transmitter and receiver was aligned and the last mode is turned on when the video were to be streamed. Since the demo product will have a range up to 600 meters, the user will need some kind of aid when aligning the transmitter and receiver. It was decided that the cheapest and most effective way to align the them is to use a common rifle scope. It's used by most of the competitors and the third party market is very accessible. It was also decided that this mode based UI was to be applied on all the concepts that were to be generated.

6.2.2 Concepts

The three main concepts were more like guidelines than actual finished concepts. They are all based on the product framework and therefor are quite similar to each other. They all have the same UI and support as previously stated.

Concept 1 “Moving head”

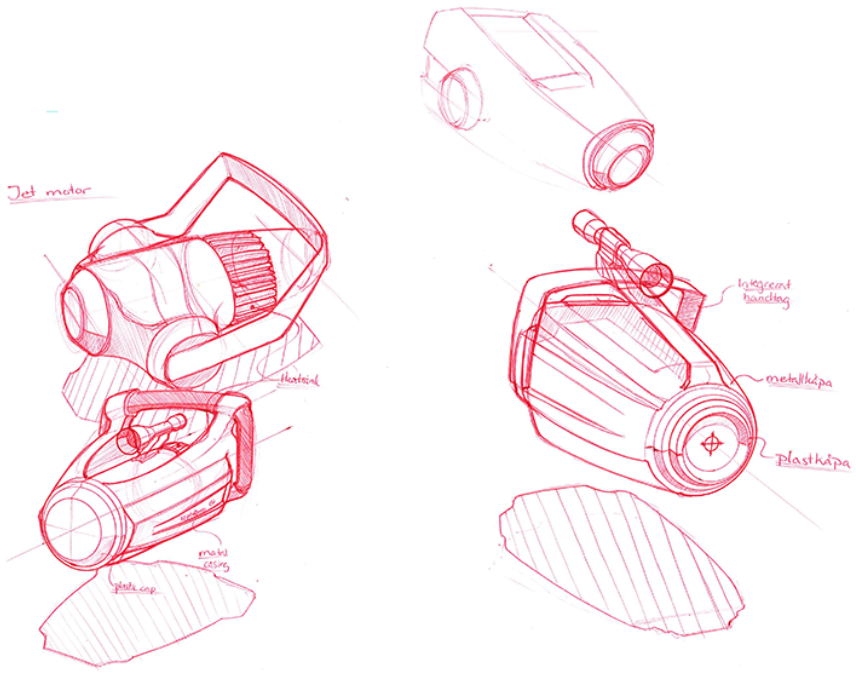

Figure 22 Concept 1 "Moving head"

This concept is inspired by equipment in the industry. The components are housed in a line with the antenna in the front. It has an integrated handle on top for use when carrying and aligning. The shape has a great sense of direction and expresses high tech and performance due to its streamlining and details. It’s a construction of a cast metal casing with a plastic cap in front covering the antenna. Also the handles would be plastic or metal covered with a rubber or leather sleeve.

Concept 2 “The box”

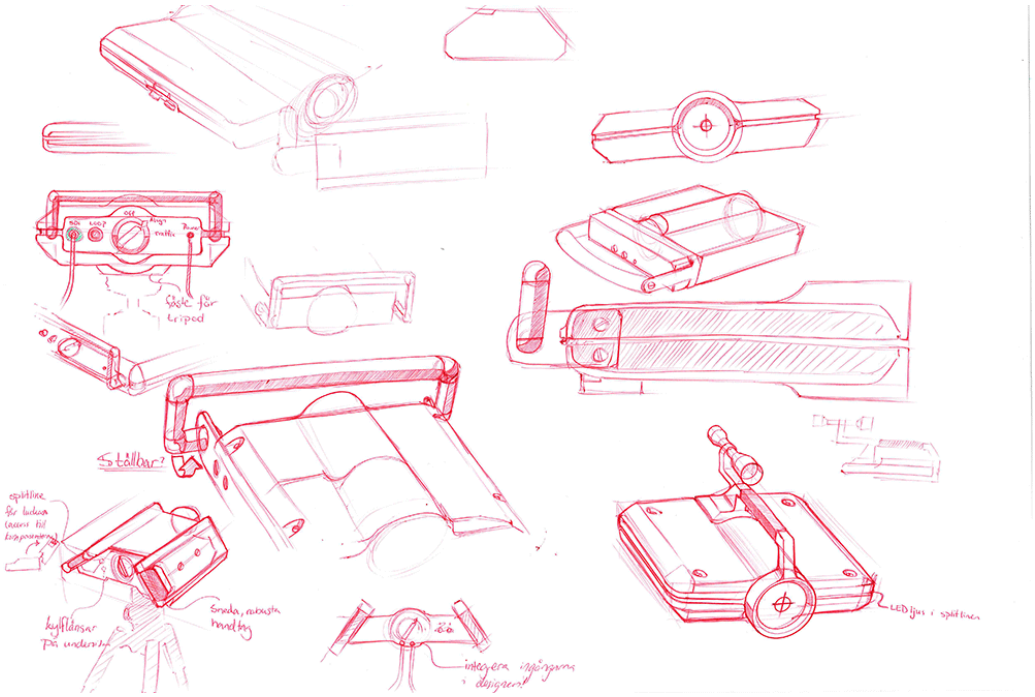

Figure 23 Concept 2 "The box"

This concept took inspiration from current solutions done by some of the competitors to wyberry. The competitors’ models are in general a metal box with a hole on one side for the different input connectors. This concept took that and made it more interesting and aesthetically appealing. The components are housed inside the box beside the antenna and Front end. The latter forming the cylindrical shape that runs through the middle of the shape. As with the moving head concept, this has a handle on top for carrying and a rear handle for aligning. This concept puts emphasis on expressing robustness and stability.

Concept 3 “External”

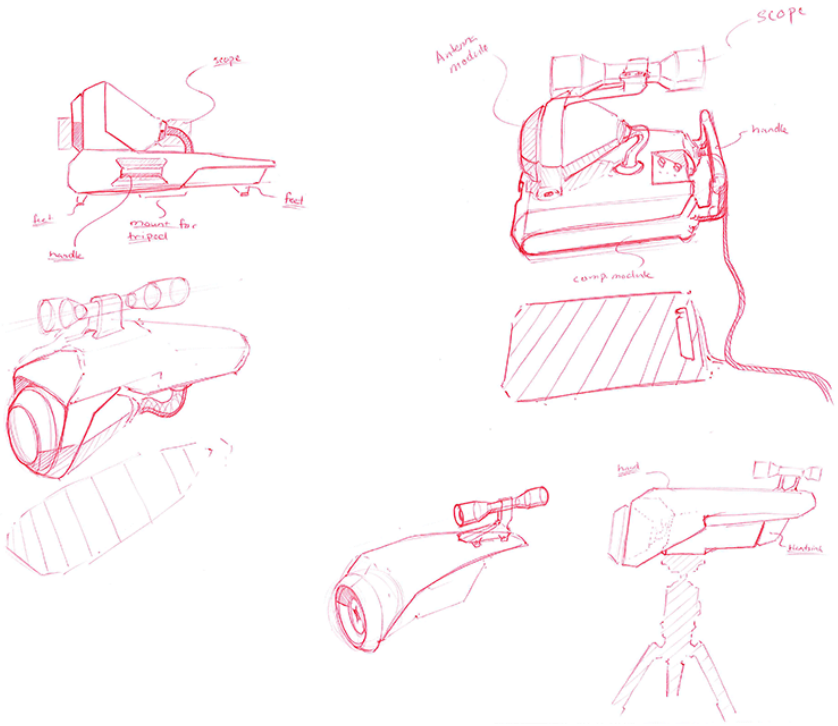

Figure 24 Concept 3 "External"

Focus lies on modularity and transparency of the product. The idea is to expose the antenna and clearly separate it from the component box. The antenna module is connected to the component module with a cord

This concept is more of a variation of the box concept with the difference that it can house different sizes of antennas. Especially the larger ones in the size range for the antenna.

6.2.3 Choice of concept

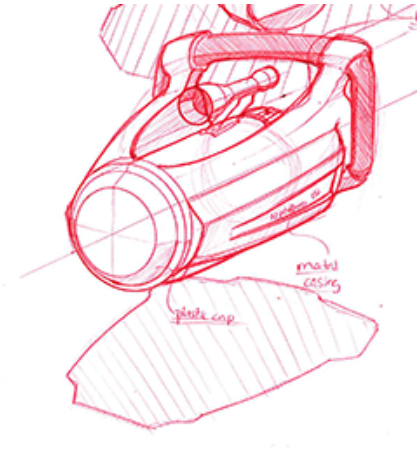

Figure 25 Concept 1 "Moving head"

The concept that was selected to continue to develop was the "Moving head" concept. The high tech look of the concept was the most desirable and it has the best solution in accessing the components and housing them. To further increase the sense of robustness, the circular profile was discarded for a more triangular profile which would give a more steady impression. This concept compared to the others had also the best feel to it when mounted on a tripod support and it would fit better with other equipment in the industry. When discussing placement of the battery, it was concluded that the demo product wouldn't need one. One of the reasons was that if there is a video cable drawn to the product, a power cable could be drawn at the same time. Lastly, it was decided that the demo product should use a smaller sized antenna with a diameter of 100 mm.

6.2.4 Summary of the Concept Generation result

Three concepts were created out of all the part solutions generated during the brainstorming and sketching sessions. Part solutions which were based on the user profile and product framework defined in the phase before this.

The three concepts were tweaked towards one specific aspect each from the aspects identified in the product framework. The first concept aimed towards a high tech look and feel. The second was developed to be robust and stable. The thirds and last concept focused on transparency.

The chosen concept was the moving head. The reason it was chosen was because that the high tech look works the best of the concepts with the wyberry brand. It was chosen though with the condition that the circular profile was changed into a more stable triangular one.

7 Concept Refinement

This phase will take the chosen concept from last phase and further develop and refine it. Some more research will be made to fill in possible gaps in the knowledgebase. The concept will then be optimised and developed further. This last phase ends with producing the final concept design i.e. final deliverables.

7.1 Process

7.1.1 New iteration

Using sketching as the main tool, new shape and function variations of the chosen concept were made. The main objective in this phase was to integrate the triangular profile to the concept and get a more robust and stable feel to the product. New inspiration was taken from the video game industry, since the triangle design reminded a lot of weapons in games. The main reason is that the designs often have both the high-tech look and feel of direction that the concept is to imply.

7.1.2 Design for manufacture and development of functions

Since the result of this project is to make a good base for development of wyberry Technologies demo product, manufacture needed to be taken into consideration. Also, there were some other functionality requirements connected to the manufacture that needed attention.

Focus was also on designing the feedback to the user when setting up the product and demounting it when it's done sending a video stream. This included designing the handles on the product and the support which it stands on.

7.1.3 Modelling, setting measurements and UI design

To get a good perception of the size that the product needed in order to house all the components, a 1:1 scale model was built using Kapa® (Foam board). To make sure that the components would fit in the design, physical representations of the components were made out of wood.

During this the UI and handles could be decided since they needed a full scale model to get the right feel for the handles and to get a good view angle on the user interface. Until now, the UI design has been an on-going development. Ideas and inputs have been documented and iterated. So the final design of the UI was to combine all of the different ideas and create a whole UI solution for the product with consultation of the technical department at wyberry. Following the completion of the full scale model, it was translated into CAD.

It was decided that no advanced ergonomic analysis was required, due to that the user will mount the tripod in a comfortable height. The same as they would with a camera. Also, the product won't cause any extreme ergonomic positions.

7.1.4 Detail work and development

A new iteration was made on how the product was to be manufactured. To get new ideas on manufacture, the project consulted Prototyplabbet at Chalmers University of Technology. They have a lot of experience and they helped make the product easier and cheaper to produce and also much more water resistant.

This meant though needing to redo the whole CAD model since the new manufacture process differed so much from the first. This time the CAD model was finalized and transferred to a rendering program. The renderings are the final deliverables presenting the product design and describing the functions and how it's supposed to be used.

7.2 Result

7.2.1 New iteration

The main objective in this phase was to integrate the triangular profile to the concept and get a more robust and stable feel to the product.

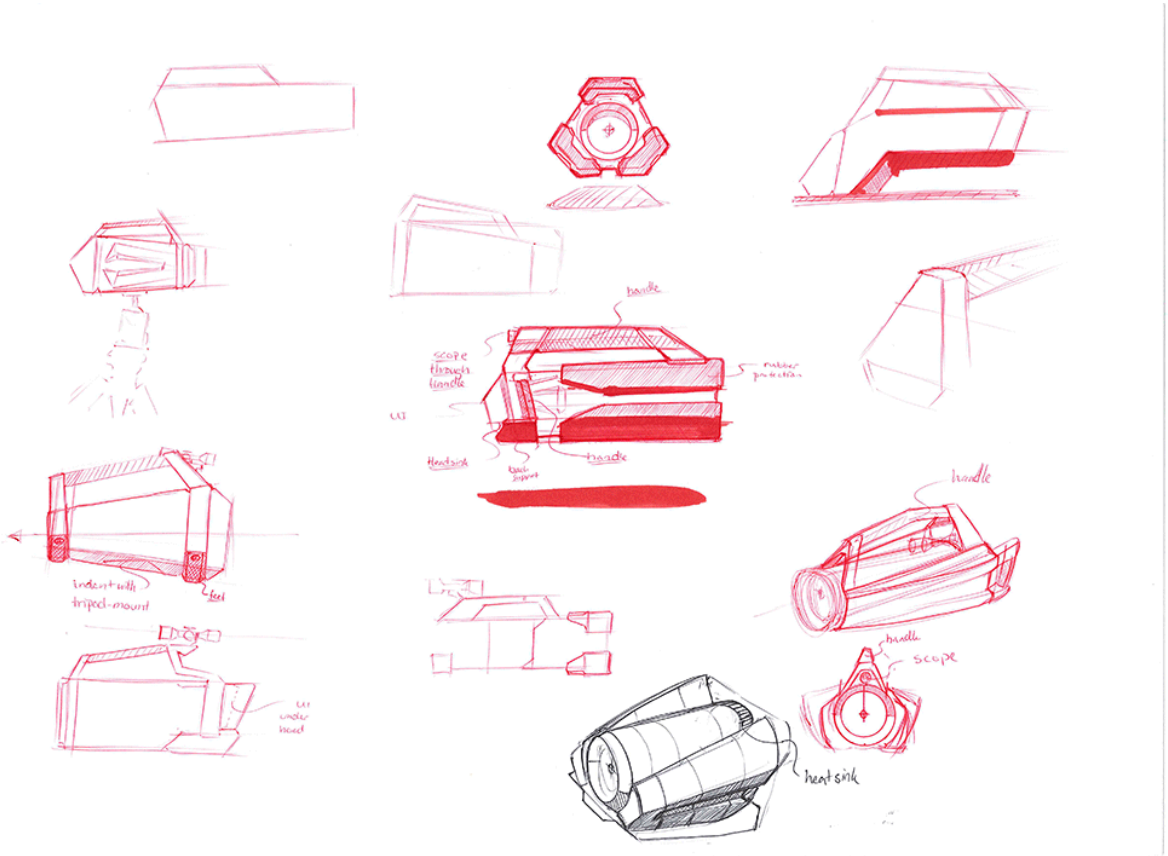

Figure 26 Integrating the triangular profile into the concept

The triangular profile was a very similar to some weapons in computer games. Since they are designed to express high tech and direction, they worked well as inspiration.

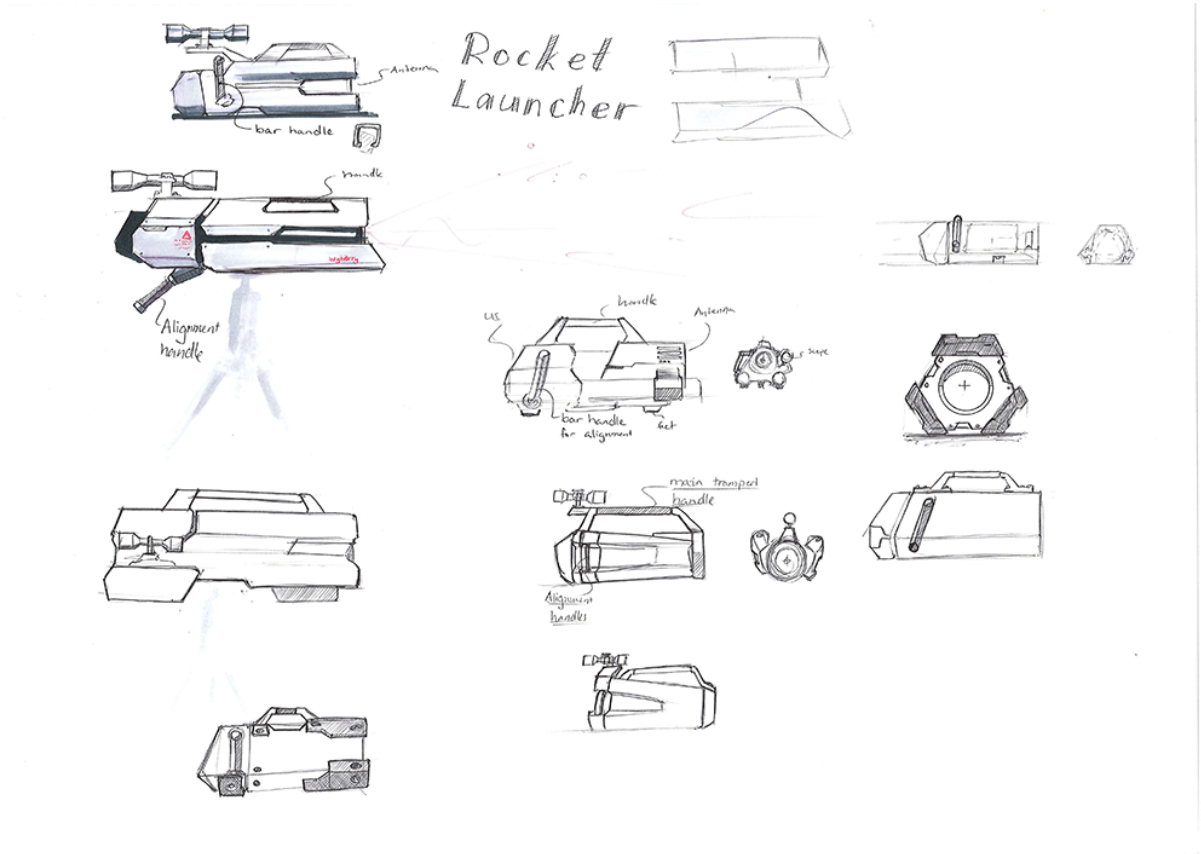

Figure 27 Idea generation with inspiration from video games

7.2.2 Design for manufacture and development of functions

The first iteration on how the product was to be manufactured resulted in having three milled profiles that were to be screwed together. To seal the components inside and keep them from coming into contact with rain, two plastic caps were to be mounted on each side. Silicon was to be used to seal the split lines between the profiles and the plastic caps.

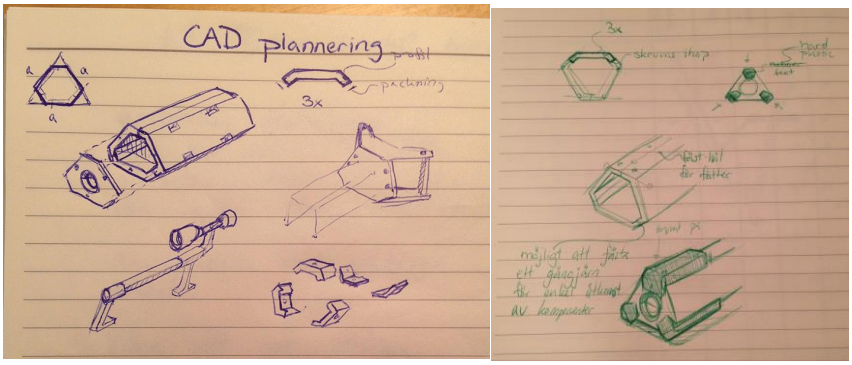

Figure 28 First design of the manufacture process with the three profiles

Since the manufacture of double curved surfaces is hard to do in prototyping, the design went for a more edgy look using flat surfaces. This design was also influenced by the triangular profile being more suitable for this general prism type of look. Though, losing the double curved surfaces which

were found in the "moving head" concept also meant losing a lot of detail that contributed to the high tech expression.

Except from having to be easy to produce in a prototype lab, the solution also had to enable easy access to the components and also enable expansion of component module in some way.

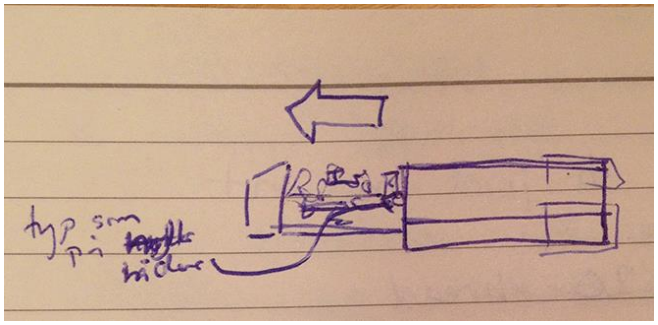

Figure 29 Rough sketch of the sled solution

The demo product now had housing for the components, so work focused designing the handles and support for the product. Another sketching session resulted in having two separated sets of handles; one handle on top for carrying the product and two handles at the rear for use when aligning the products.

A last look was made on different support than using a tripod, but it showed that the tripod will be the best solution since it fulfils the requirements very well. A short study visit was needed in order to make a well-founded decision on which tripod support to use. The decision fell, after consulting experts at *Scandinavian Photo*, on using a tripod made for professional filming using an advanced camera tripod dollie (the mount for the device).

The tripod used for professional filming is much more stable than camera tripods. Movie camera dollies can't be locked in the horizontal direction, since they are designed to take good panoramic views. So a tripod dollie for professional photography will be a much better solution since it can be locked in place tightening only one screw.

7.2.3 Modelling, setting measurements and UI design

Up till now, the product has only been represented using sketches. Sketching is good when working with proportions, but not so when it comes to setting final measurements. To ensure that all the components were to fit, physical representations of the components were created and used as reference when building the body of the demo product. When fitting the components inside the housing, it needed to be about twice the length of the one on the sketch.

Figure 30 The 1:1 scale model with component representations

Also, setting the size and shape of the handles was done by experimenting with different angels and diameters of the grip. A common tripod was also used as reference when trying out the different handle variations.

The UI was created combining various ideas from throughout the project and through consultation with the technical department at wyberry.

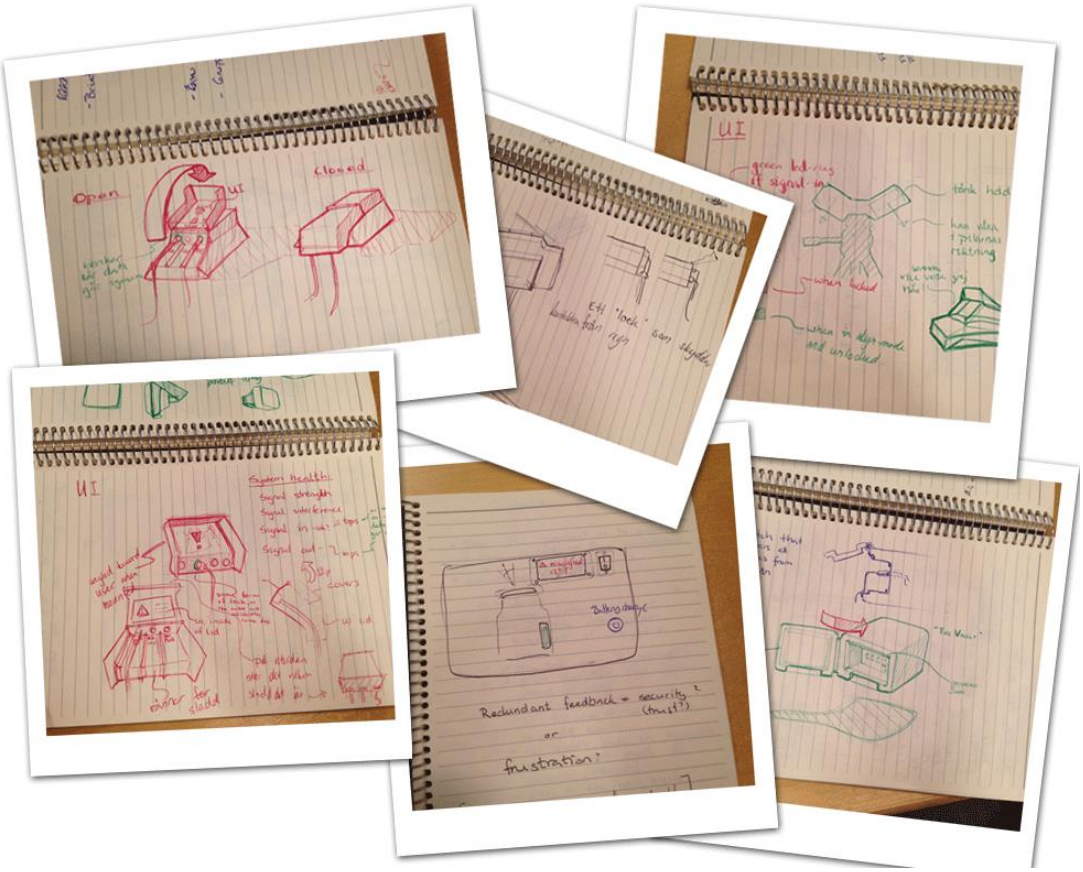

Figure 31 Ideas on the UI design from the projects earlier stages

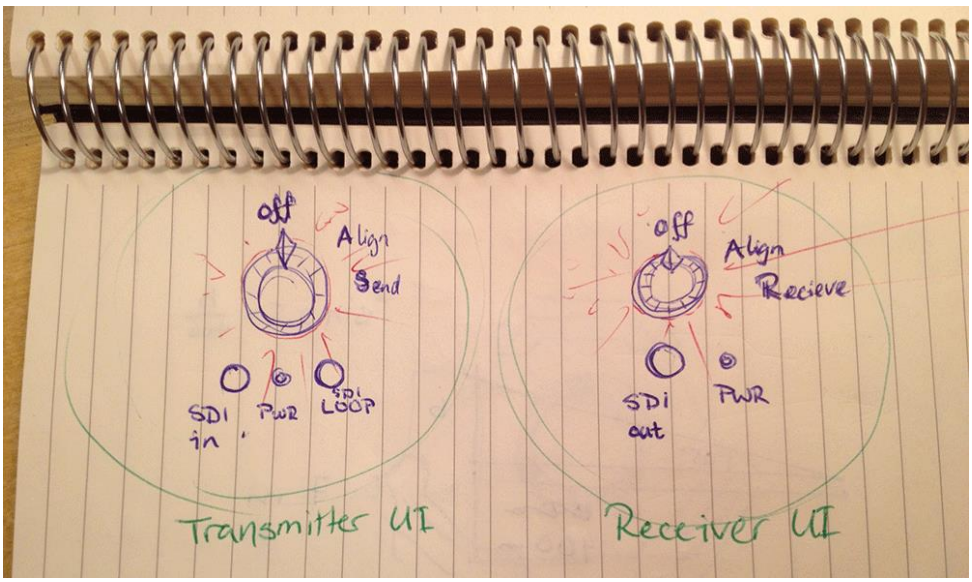

Figure 32 The mode based UI design

The transmitter and receiver have slightly different UIs. There are three different modes; OFF, Align and Send/Receive. The product is powered off in the OFF-mode. If the product is connected to a power source, a LED-ring behind the mode knob is shining red, indicating that it is off but has power. When it's turned to Align-mode, the LED-ring shines yellow instead of red, to indicate that it needs calibration before starting to be able to send a video signal. Here the transmitter and receiver needs to

be aligned and in line of sight. When that is done, the knob can finally be turned to Send-mode on the transmitter and Receive-mode on the receiver and video can be sent between them.

The same idea, as that with the mode knob, is that the SDI signal input (on the transmitter) and output (on the receiver) has a LED-ring that shines with a green light if there is a cable connected and receiving or transmitting a video feed. Lastly, the 1:1 scale model was then transferred into CAD to flesh out the details on the manufacture method based on the three milled profiles screwed together.

7.2.4 Detail work and development

The new iteration with the manufacture design resulted in a very different solution than the one before. The construction centres on an air cylinder; standard component which can be found in common hydraulic arms form robots. The components will be housed inside this Aluminium profile extrusion. It is sealed with two caps, one screwed on at each end.

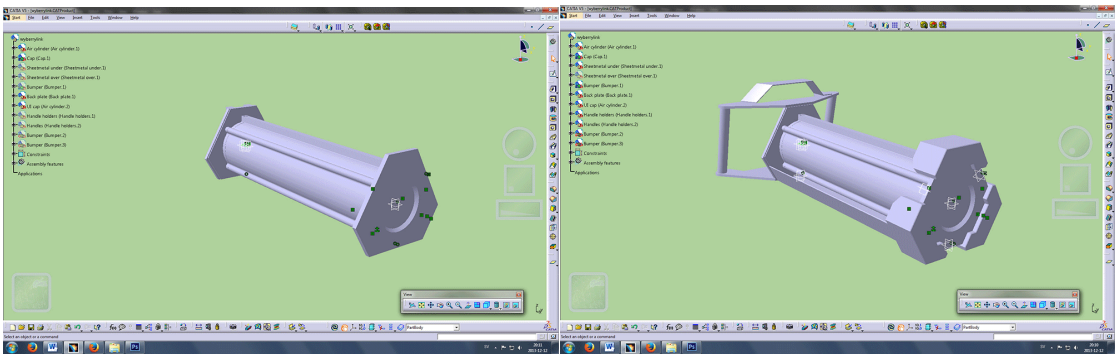

Figure 33 The new manufacture design

The air cylinder is covered by two pieces of bent sheet metal that is welded together to create the triangular profile sought after. The air cylinder with the caps will be water tight, so the metal casing will have a drain if water would gleet in. This requires the SDI interface connectors in the UI at the rear cap to be waterproof.

The components are mounted on a sled inside the air cylinder. The sled is mounted on the UI cap that is mounted between the air cylinder and the rear end cap. By dismounting the rear cap, the UI cap comes loose and the component sled can pulled out.

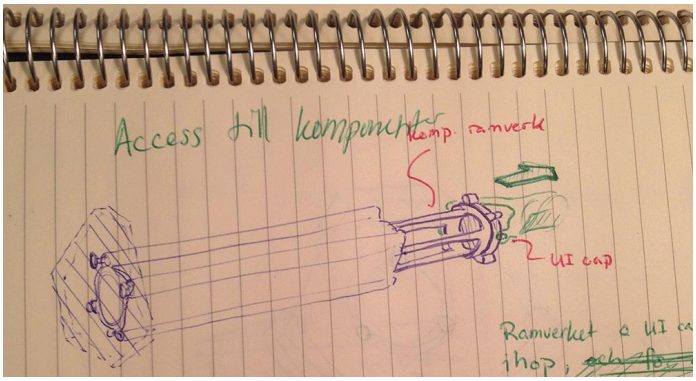

Figure 34 The sled design

The scope is mounted on the rear handles which in turn are mounted on the rear cap. This makes it possible to align the scope with the air cylinder, which in turn is aligned with the component sled housing the antenna.

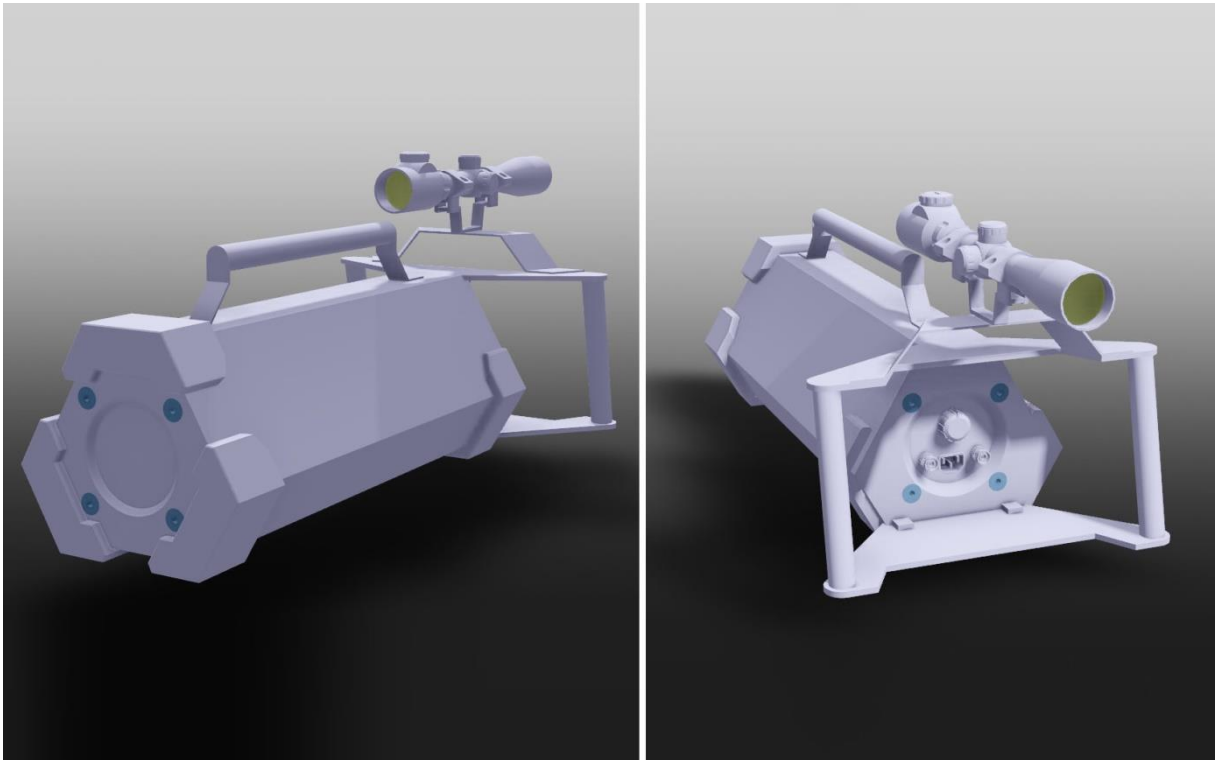

Figure 35 The complete design created in CAD

7.2.5 Summary of the Concept Refinement result

To start of this phase the triangular profile was integrated to the design. The design reminded a lot of rocket launchers in video games, so the next iteration took inspiration from the gaming industry. Following setting the overall design of the product was to develop how it was to be manufactured. The manufacture process was set, then put into iteration and was optimised after consulting professionals in prototyping.

A 1:1 scale model was built in order to get the right proportions and ensure that all the components would fit. Using the model, the design was translated into CAD where the last design details were decided.

8 Final concept

This chapter will present the final concept for the mechanical box of wyberry's demo product. The concept was modelled in the CAD program Catia V5 and rendered in Autodesk Showcase 2014. The tripod design and scope was imported from a CAD-model sharing community called GrabCAD.com.

The final concept consists of a transmitter and a receiver. These can send a high quality video stream wirelessly with a maximal range of 500 meters. An SDI video cable is plugged into the transmitter, which sends the signal over to the receiver that outputs the signal to a SDI cable. For this to work properly, the transmitter and receiver has to be in line of sight. The purpose for this demo product is to showcase the technology and be a proof of concept to show potential customers.

Transmitter

This is the final concept of the transmitter. The video signal is connected into this device and sent using microwaves. It's a robust design made to be durable and has a UI that focuses on making the system feel more transparent and open to the user.

Figure 36 The final concept of the transmitter

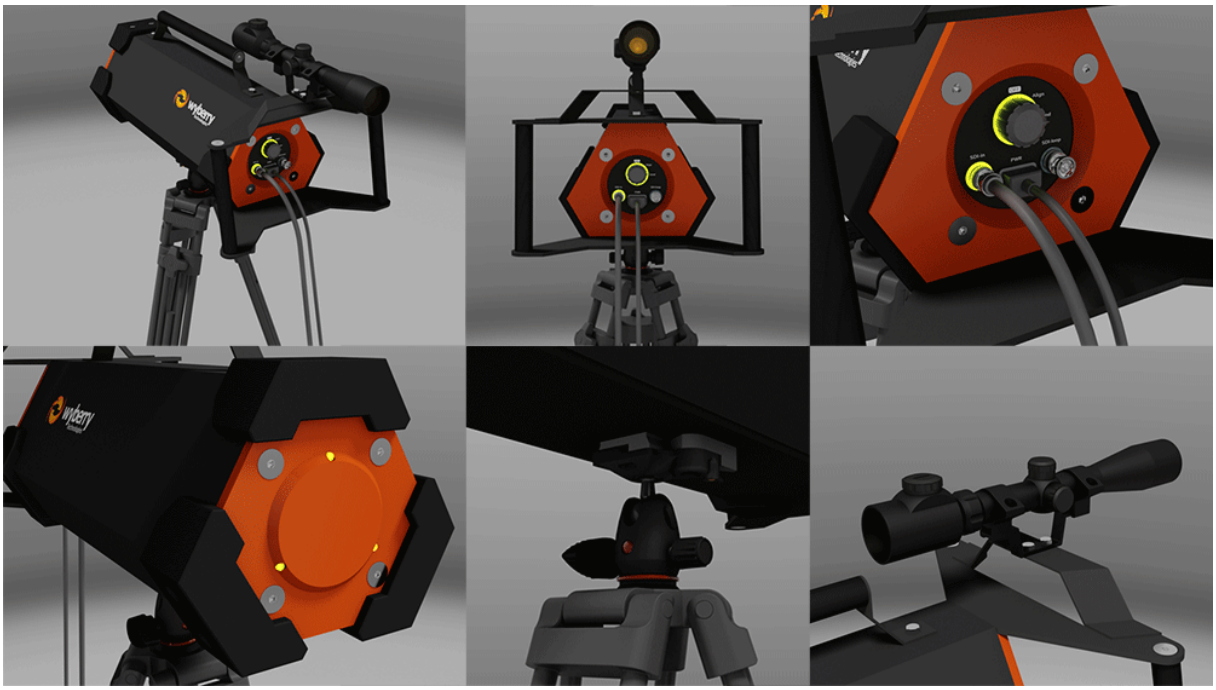

Figure 37 Collage of renderings of the transmitter

Receiver

This is the final concept of the receiver. The video signal sent from the transmitter is received by this device and it outputs the signal to a SDI connector. It has a few differences in its setup compared to the transmitter since its tweaked for receiving.

Figure 38 The final concept of the receiver

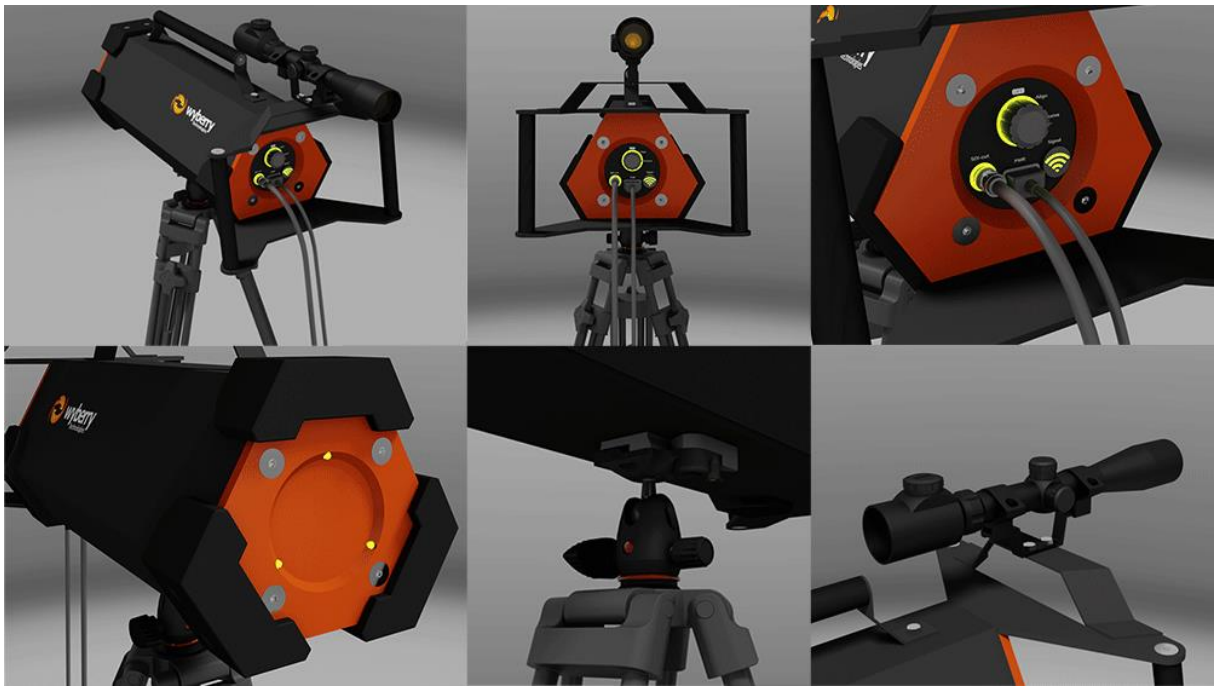

Figure 39 Collage of renderings of the receiver

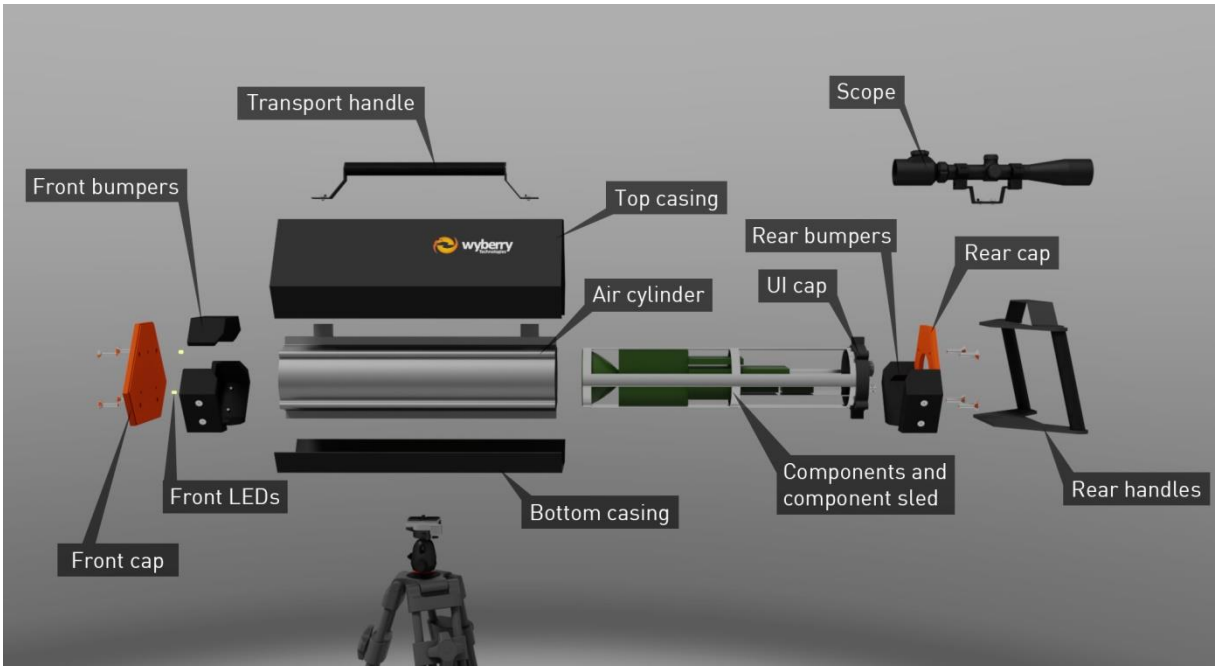

Figure 40 Exploded view of the construction

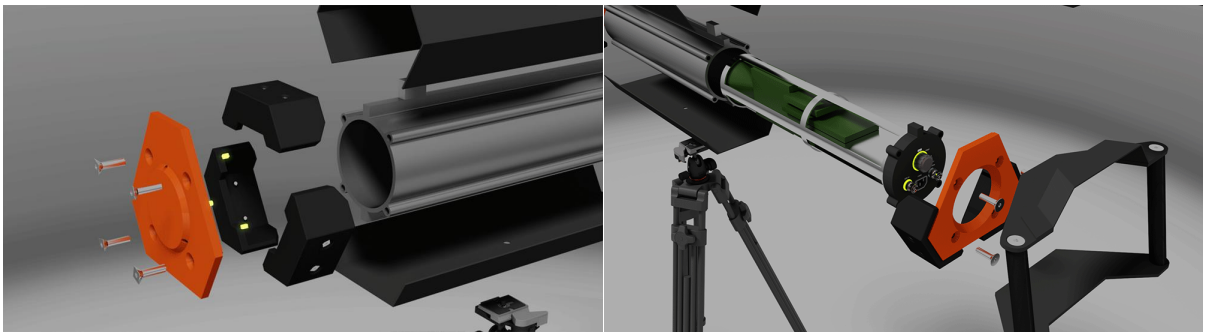

Figure 41 Detail renderings of the construction

8.2 Expression

The triangular profile gives the concept its distinguished look. It suggests stability and durability. The bumpers add to the robust expression whilst protecting the metal casing from getting scratches. To further give the feel that the chassis protects the components, there has been a lot of work in implementing indents to the design. This can be seen on the orange end caps and the bumpers also contribute to this expression. The front cap is different on the transmitter and the receiver. Since the receiver receives signals, it has an indent. The transmitter does the opposite; why it has a bump. The visible screws contribute to the overall expression by giving the product a solid impression and the feel of a sound design.

The colour is inspired by the wyberry logo, which main colours are dark grey and orange. It's mainly dark grey since the product will see most of its use outdoors and in different weather conditions and a dark colour doesn't show dirt as well as a bright surface. The expression board advocates for a blue colour, but the choice fell on the orange colour of the wyberry logo because it links the demo product with the company and that blue is too commonly used by the tech industry.

8.3 Functions

This chapter presents the features of the product and how it's used. The layout of the UI will be explained and also how it's supposed to be used. One of the core design features with the UI is that it's designed to be as transparent and open as possible for the user. The user can follow the video stream through the whole system and therefor quickly identify a problem if the video stream should stop working. Also, if the problem is before or after the wireless transfer, the system can quickly be cleared so the search can move on in the chain.

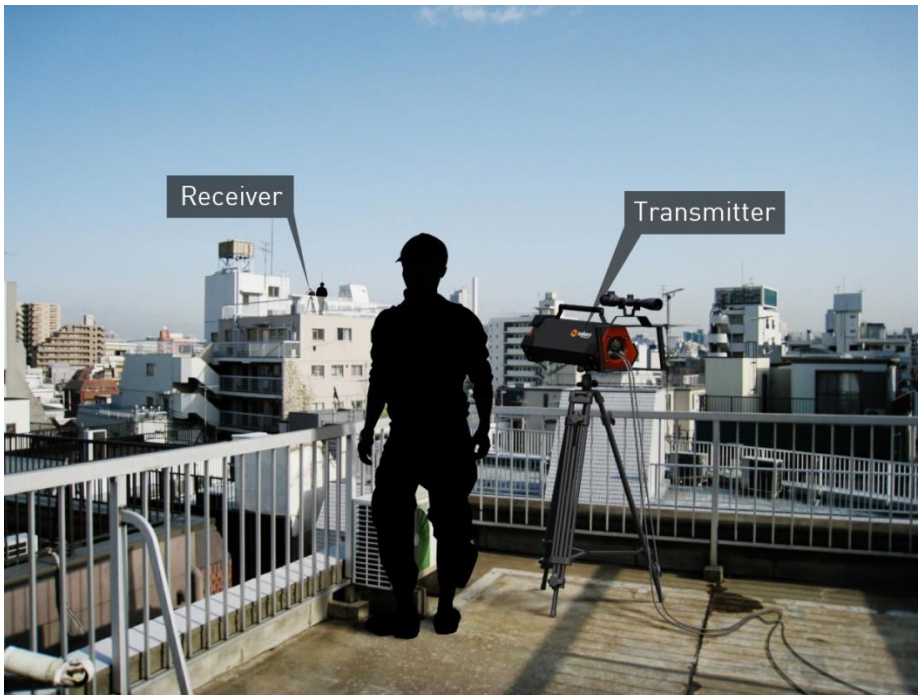

Figure 42 The final concept in use, streaming video between two roof tops

Transmitters UI

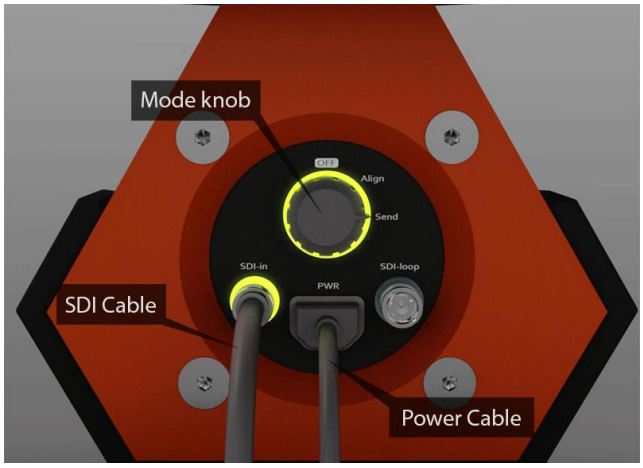

Figure 43 The transmitter UI

- **Mode knob**: Changes the modes of the transmitter. There are three different modes; OFF, Align and Send. The colour of the LED indicator behind the knob changes depending on selected mode.
- **SDI-in**: A SDI connector that receives the video signal from the video source. It has an LED indicator that turns green if a video signal is detected.
- **PWR**: The power input.
- **SDI-loop**: Mirrors the signal that comes in through the SDI-in connector and outputs it.

Receivers UI

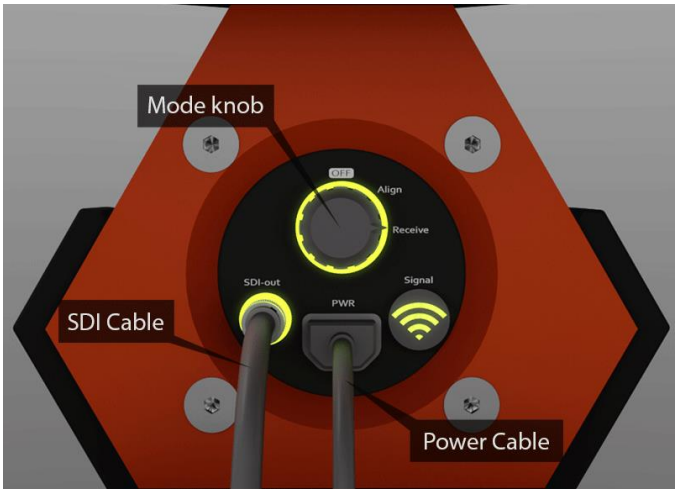

Figure 44 The receiver UI

- **Mode knob**: Changes the modes of the transmitter. There are three different modes; OFF, Align and Receive. The colour of the LED indicator behind the knob changes depending on selected mode.
- **SDI-out**: Outputs the received video signal from the transmitter. It also has a LED indicator that turns green if a signal is received and outputted.
- **PWR**: The power input.
- **Signal**: Displays the power level of the signal received. When the signal is good to ok, the indicator is green. If the signal is insufficient, the indicator turns red.

Setup scenario

The transmitter and receiver are transported to the respective sites were the link is desired. They come in transport cases typical for equipment in the concert industry. The tripods are setup on each side and the transmitter and receiver are snapped onto the tripod dollies snap lock. Lastly the SDI and power cables are connected.

The transmitter and receiver have slightly different UIs. The big difference between them is that the transmitter has a SDI-loop connector, which mirrors the SDI-in connection to enable the user to hook up a recorder with the product if desired. The receiver has in the place of the SDI-loop a signal strength indicator; it shows if there is enough power received to get a good signal out.

Figure 45 Unpowered on the left and powered on the right

The product is powered off in the OFF-mode. If the product is connected to a power source, a LED-ring behind the mode knob is shining red, indicating that it is off but has power.

Figure 46 Align mode

When it's turned to Align-mode, the LED-ring shines yellow instead of red, to indicate that it needs calibration before starting to be able to send a video signal.

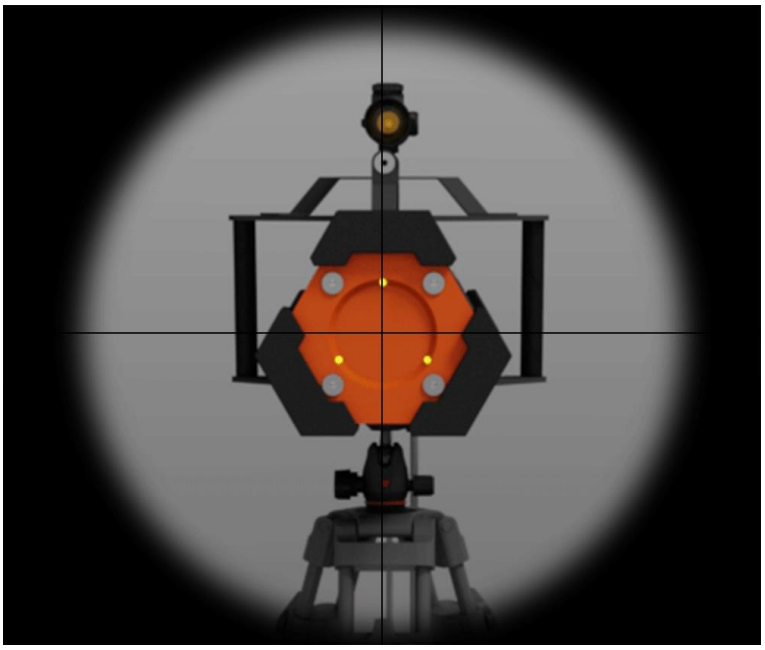

Figure 47 View of the receiver through the scope sights

Here the transmitter and receiver needs to be aligned and in line of sight. As seen on the Receiver in the scope, the front is equipped with three LEDs that mimic the mode knob, showing in which mode the receiver currently is set.

Figure 48 Send mode

When that is done and the transmitter and receiver has tuned in with one another, the transmitter can be put in Send mode and the receiver in Receive mode. This enables video to be sent wirelessly between them.

Figure 49 No SDI signal to the left and received SDI signal in to the right

The same idea, as that with the mode knob, is that the SDI signal input (on the transmitter, output on the receiver) has a LED-ring that shines with a green light if there is a cable connected and receiving or transmitting a video feed. If the SDI cable is just connected without giving any signal, the LED ring stays turned off.

If something were to go wrong, the user can quickly scan through the system. If there is anything wrong, an indicator will flash red, specifying what part of the system that isn't working properly

When the video has been streamed and the products are to be disassembled they are simply turned off, dismounted from the tripod and have all the cables disconnected. After that, either packed away into a travel case (used for most equipment in the industry) or just carried off in the top handle.

Usage scenario

There are a lot of different applications for this technology; it's still open in which scenarios this product will see main use in. But one of the most interesting applications is for the broadcasting of an arena event.

When a broadcasting company wants to cover for example a sports event at a large arena, they want to hook up their OB bus to the local fibre network in order to send the video stream to the broadcasting studio. Uplink points for this fibre network are usually positioned right beside the arenas. But sometimes at newer arenas, this uplink point can be up to 2 km away. It is close to impossible to draw a fibre cable over streets all the way to the uplink point in this scenario. Instead, the wyLink could be set up on the roof of the arena and wirelessly send the video stream over to the uplink point. Important to note is that the longer ranges of up to 2km will be a application scenario for the product that will come after the demo product.

8.4 Construction

The construction centres on an air cylinder; standard component which can be found in common hydraulic arms form robots. The components will be housed inside this Aluminium profile extrusion. It is sealed with two caps, one screwed on at each end.

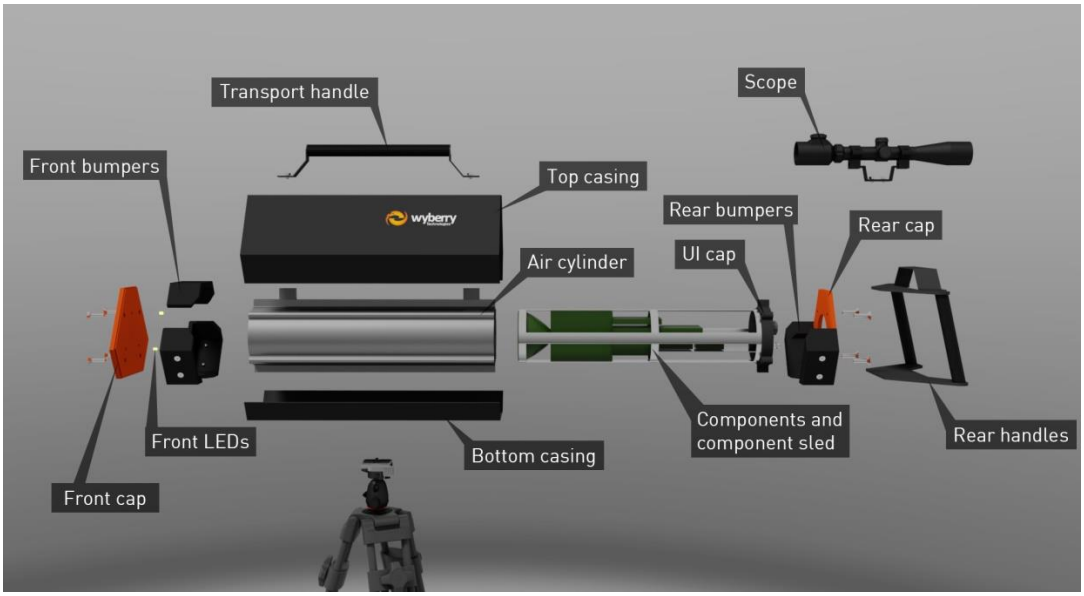

Figure 50 Exploded view

The air cylinder is covered by two pieces of bent sheet metal that is welded together to create the triangular profile sought after. The air cylinder with the caps will be water tight, so the metal casing will have a drain if water would gleet in. This requires the SDI interface connectors on the UI cap to be waterproof.

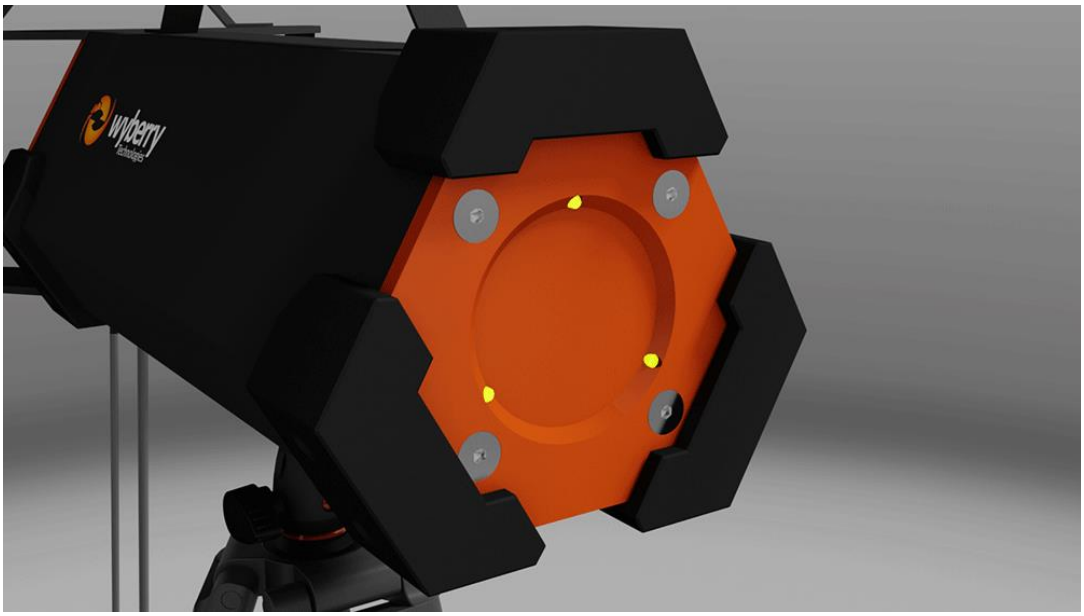

Figure 51 The Front bumpers and LEDs

The purpose of the bumpers is to shield the product from scratches and give the product a sturdy and robust look. They are made of hard rubber and mounted on the chassis with metal screws.

The handles are metal tubes that are wrapped in a rubber material. The top handle is for carrying the chassis and when mounting it on the tripod, the rear is used for aligning the transmitter and receiver. They have both the same mounting on the chassis using two pieces of bent sheet metal. It's mounted on the chassis with two bent metal holders, screwed on using the same screws used for the front and rear cap. The rear handles constructed in the same way as the top handle. The difference between them is that the rear handles are welded on the rear cap. The reason is to increase stability of the construction and to give a solid feel when using the product.

The product is mounted on a third party tripod as support. This enables aligning the transmitter and receiver and then locking them in place. The choice fell on the Manfrotto 546B Aluminum tripod made for professional film production. These are more stable than the common tripod on the market. They are a bit heavier though, but it is a small sacrifice. The chosen tripod ball head dollie 468MGQ6 hydrostatic magnesium is also from Manfrotto and designed for professional photography with the feature of a very strong lock mechanism. It is equipped with a snap lock mount, so the mounting of the transmitter and receiver is very easy.

Figure 52 Scope

Since the range of the demo product won't exceed 400 meters, a common rifle scope will suffice when aligning the transmitter and receiver. There needs to be further outdoor testing of different scopes to identify most optimal one. For reference; a common hunting rifle scope with a magnification of 12 are focused to give a clear vision of an object 200 meters away. This means that any object you view through the scope will appear twelve times larger than if you looked at it without the use of the scope.[17]

The knobs, connectors and LEDs in the UI are standard components available at various retailers. In order to withstand rain and other harsher weather conditions, these components need to be waterproof. The chassis is mainly fitted together with ISO standard screws. The rear handle holders and the metal casing are the only parts that are welded.

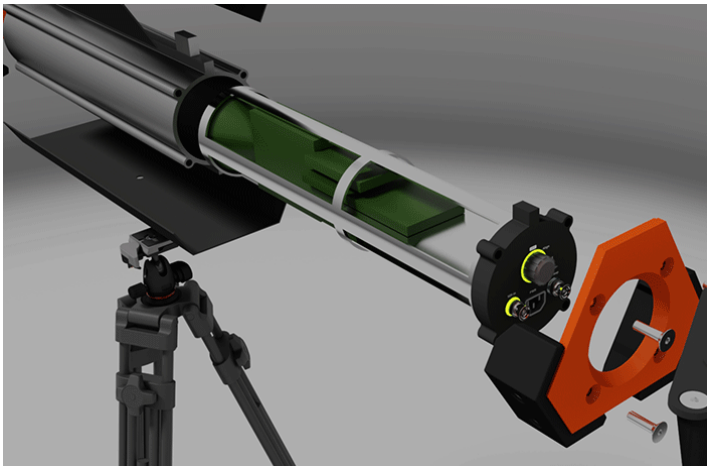

Figure 53 The sled solution

The components are mounted on a sled inside the air cylinder. The sled is mounted on the UI cap that is mounted between the air cylinder and the rear end cap. By dismounting the rear cap, the UI cap comes lose and the component sled can pulled out.

[17] howstuffworks.com

8.4.1 Requirements fulfilment

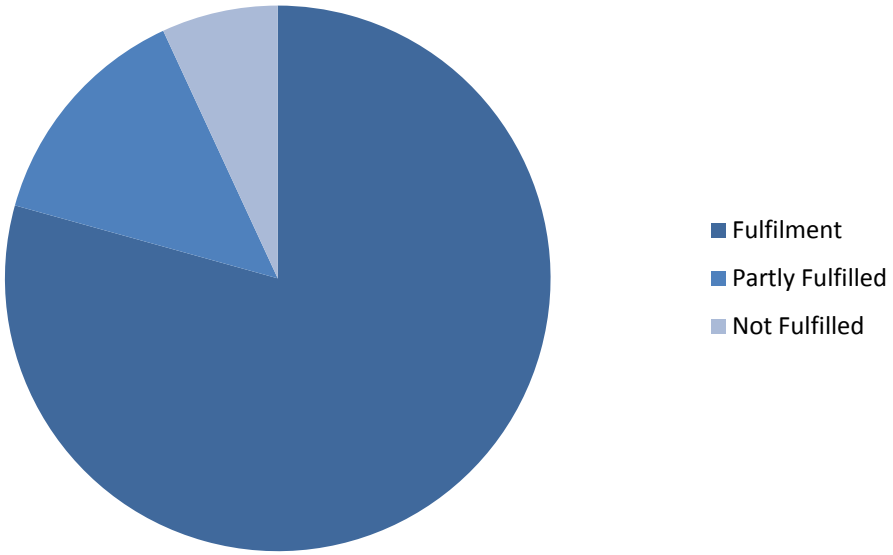

Figure 54; Fulfilment degree of requirements and design guidelines

As seen in Figure 50, about 80% of the requirements and design guidelines were fulfilled. There is one partly fulfilled requirements, three partly fulfilled design guidelines and two non-fulfilled requirements. Important to note is that the non-fulfilled requirements regard the battery function of the product. It was decided when choosing the moving head concept that a battery feature were not to be applied on the demo product, hence the final result doesn't have that feature. The partly fulfilled requirement and design guidelines need some further technology development in order to fully fulfil them.

9 Future work

The goal with this project is to design a concept of the "mechanical box" for wyberry's upcoming demo product. This means that the end result of this project is a concept; there is still more development needed to be done before prototypes can be made. This chapter will cover what areas that needs further work.

There are mainly two areas where further inquiry is required. These are; Construction & manufacture and User interface & interaction. The construction area is primarily dominated by detail manufacturing aspects, but also further investigation is needed in exploring and hunting down all of the standard components (knobs, scope, connectors etc.). For the UI area, there needs to be empiric studies made using a functional prototype of the final concept with real users in the environment where it will see use. This is important for the interaction and usability aspects of the product and couldn't be done within the time frame of this project.

A detailed list of all the future work can be seen below.

9.1 User interface & interaction

Further empirical studies need to be made with real users to define:

- Exactly how the front LED light should behave during the different modes (Off, Align, Send/Receive)
- How the mode knob LED light should behave during the different modes (Off, Align, Send/Receive)
- Which alternative supports that are of interest, like mounting the product on trusses for example. There needs to be an investigation if there is a need for an alternative mounting solution other than a tripod. This would be for application on the consumer version of this product, and is deemed low priority for the demo product, thus this project.

9.2 Construction & manufacture

- The sheet metal for the casing is to be bent in a bending machine, there needs to be further investigation for where the bends and overlaps should be placed.
- It needs to be consulted with professionals how the bumpers best be mounted on the chassis.
- It's of utter importance that the scope and antenna is robustly aligned. The current solution of how the scope is mounted needs to be optimized with consultants with appropriate competence.
- There needs to be further inquiry on which air cylinder profile to use for this concept. There is a overabundance of different designs available and further investigations are required in order to make a good decision on which one to use.
- The details on how the rear handles are connected with the chassis needs further development. Preferably in consultancy with a professional.
- As with the air cylinder, the UI cap and rear cap will need further development with that the profile of the air cylinder is chosen. This also concerns the mounting of the rear handles, which also will have to be taken into consideration.

- The standard components for the UI need to be chosen, they all can be found at any of the larger retailers. Since the product is to be used outdoors and in rough weather conditions, it is crucial that they are waterproof.
- There is a need to consult manufacturers of transport casings in order to choose an appropriate design to buy for the demo product. In it, the receiver and transmitter should be able to fit. As well as accessories like tripods and power cables.

10 Discussion

This chapter will discuss the project in its entirety, covering from the most challenging aspects of the project, the result, methods used to end with what I've learnt. The goal with this project was to design a mechanical box (i.e. chassis) for the technical components that were developed in a parallel project. This was done and the deliverables, a virtual representation of the final product, were met. The final concept covers how the components are housed and how the user interacts with the product in a way that fulfils the important requirements identified in the research phase of this project. Research was also successfully made on temporary (touring) events and also on related areas such as company events and permanent monitor screen installations.

To develop the process of manufacture for the chosen concept proved to be the most challenging part of the project. This is because of the great limitations to choice of manufacture process, since wyberry only will manufacture a set of the product (a transmitter and a receiver). This means that all the mass production processes are excluded. And since my own knowledge of prototyping manufacture processes is limited, it posed a great challenge to design a product that could be manufactured in a simple and cheap way. This had a great impact on the expression of the final concept. In this case, the manufacturing process radically altered the design. But usually there can be found solutions that are optimised for manufacture that are a lot closer to the concept design. Examples of this can be enlarged edge radiuses or draft angles incorporated to the design.

The usual process I've used for earlier projects have not been the one I used for this project. I used a slightly modified version of it: First, research and collect all the data needed for a successful product and define the outer limits of the space of possible design solutions. Then slowly and step by step, narrow down that space until you end up with a final concept. The big difference with the usual process is that with this process, you start with defining the framework in which the product is to fit in. You end up with all the product functions defined and what the expression the product should have before you've even touched the sketching pen. In the usual process you start sketching on the physical aspects of the product simultaneously as defining its functions. I found it much easier to have a framework done before the start of the idea generation. I felt as I had much better idea of what solution I was looking for than I've had when starting with idea generation in earlier projects.

No sustainability analysis was made mainly due to that this product won't see mass production. It felt unnecessary to put time in an analysis that won't make a big difference. Though, sustainability is an important subject and I've had the sustainability thinking in the back of my mind when designing. The product is very easy to disassemble. All the PCBs and other technical components are placed together and the rest of the design can be screwed apart and sorted.

Another challenge was that the size of the components weren't set until in the late stages. Especially the large range of the possible antennas caused serious complications. It ranged from a small horn antenna that enabled a large design freedom to a big reflector antenna that would rule the whole shape of the product. It wasn't until the start of the concept generation phase that the size of the antenna was determined and the choice had fallen on a small reflector antenna. It is very hard to make a design that works great for everything. I would almost go as far and say that it's close to impossible

since you'd have to make compromises somewhere along the way. So when narrowing down the range to one antenna, it made it possible to make a good and well thought-out design.

Finally, a last thought of this project is that I did it all by myself. In earlier projects have been group projects, where I've had three or more co-workers. This has been both challenging and liberating at the same time. Challenging in a way that I easily got stuck in a mind-set and liberating with having the project and report done exactly my way. I've realised, that I will never do a large project by myself again. It was a great learning experience, but it is so much more efficient to come up with something qualitative when you are able to bounce ideas of one another. In several occasions I got stuck in a mind-set or a particular solution. A good example of this is the first iteration of the manufacture process for the final concept. I came up with the aluminium profiles that were screwed together, and since I couldn't come up with a better idea I went with it. It was not until a classmate came with a good idea that my mind started working on a new solution. I took this idea to Prototyplabbet and a new and better solution was born. But I've also actively tried during the project to broaden my mind using brainstorming sessions with both wyberry employees as well as classmates. Another aspect of this project is that I've been the design competence at wyberry. I've had no mentor and have had to take full responsibility of the whole project myself. But during the whole project I've been working closely with wyberry. It's been a learning experience and I've learnt a lot about the product development process and have an alternative way to look at it compared to the process I've used in projects prior to this.

11 Conclusions

The new version of the product development process used for this project worked excellent. It had a much more straight forward concept generation phase compared to the traditional process taught at the faculty of Industrial Design Engineering at Chalmers. This was because when the idea generation phase started, there were a much better base to stand on, guiding the idea generation in the right direction.

Work was carried out with close collaboration with wyberry Technologies, although I've done larger parts of this project completely by my own. It has been a good learning experience and it has opened my eyes to alternative tweaks of the usual product development process taught at the faculty of Industrial design engineering.

One final concept has been developed, consisting of a separate design for the transmitter and the receiver. This result is considered to be able to act as a base for the manufacturing of a prototype. Evaluation of the requirement fulfilment and the response from wyberry Technologies show that the goals set out for the project have been successfully met.

As one last reflection is that for me the greatest achievement of this project is that I accomplished it all by myself. I've gotten a lot of needed support during the project by both the faculty and the company, but all the hard work put into this project has mainly been done by me. I'll be grateful of the lessons I've learnt when I take the step from the academic world and into employment.

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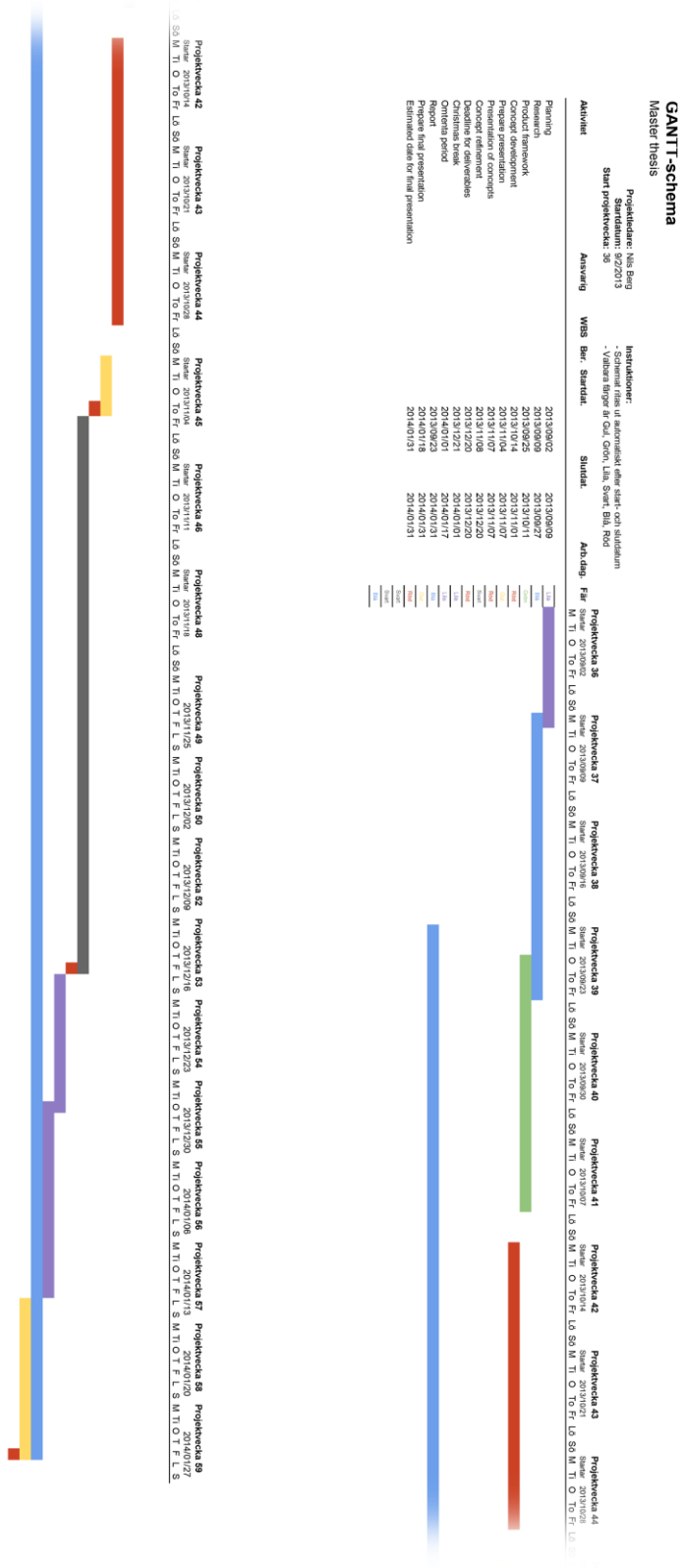
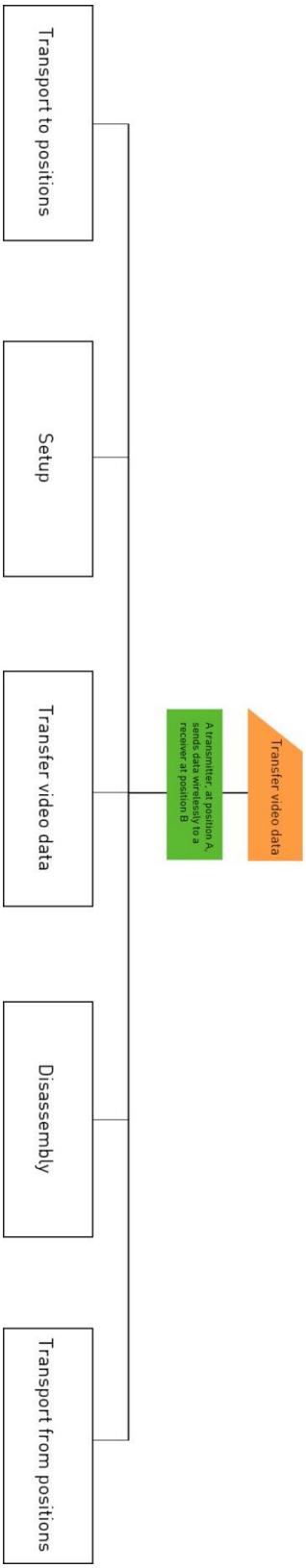
13 Appendix

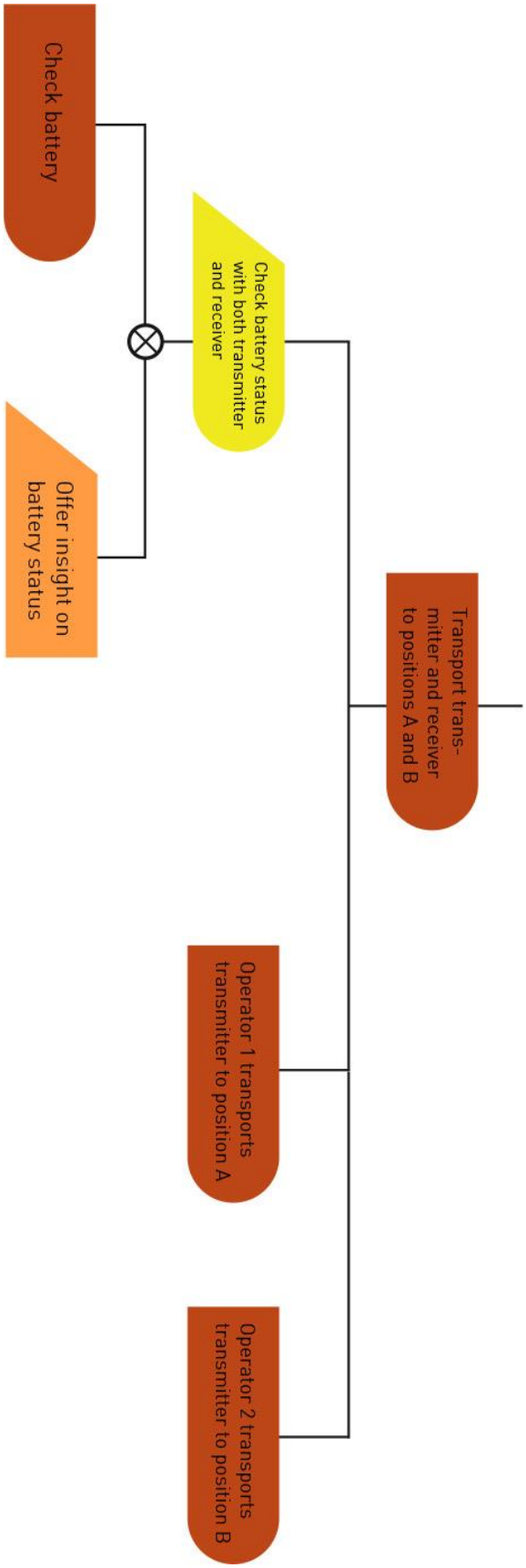
13.1 Appendix 1



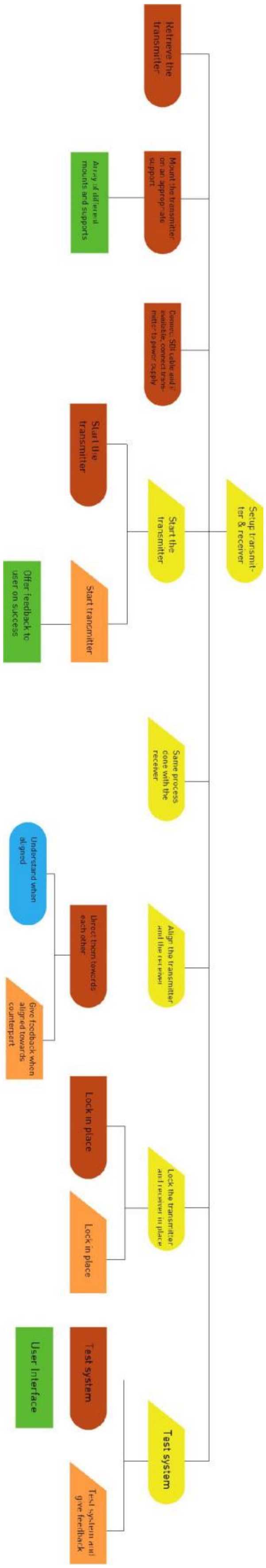
13.2 Appendix 2



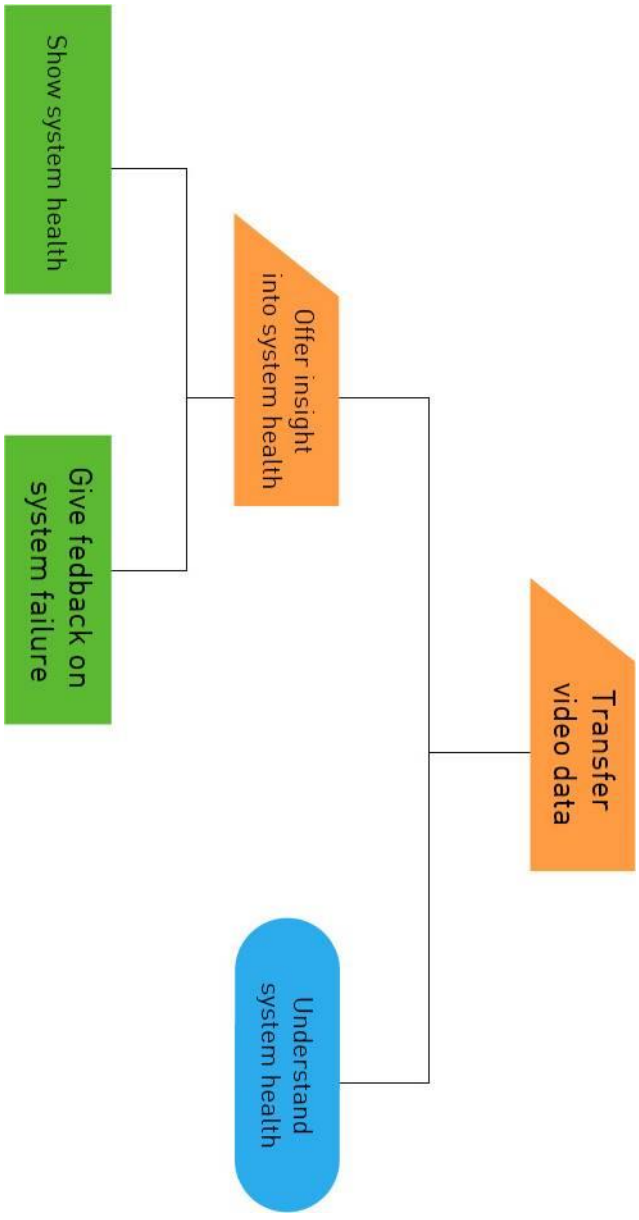
Transport positions



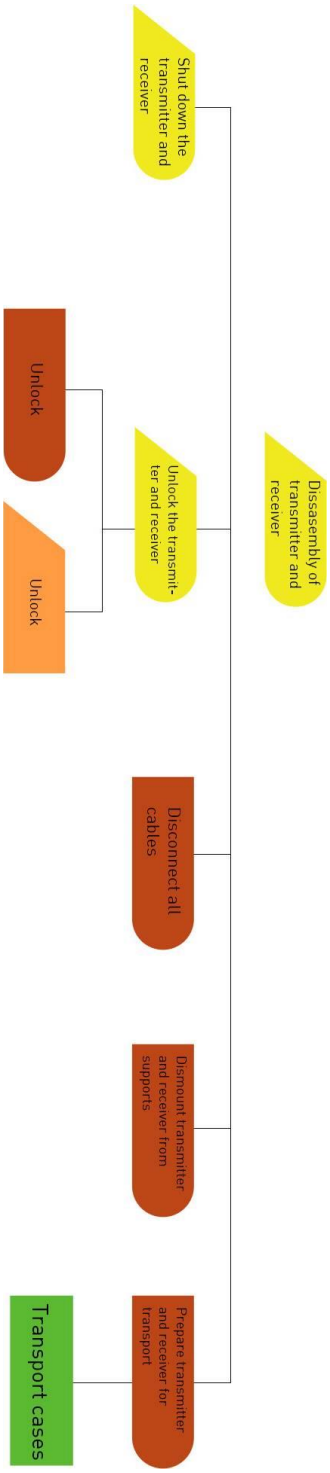
Setup


Retrieve the transmitter
Mount the transmitter on an appropriate support
Array of different mounts and supports
Setup transmitter & receiver
Start the transmitter
Start the transmitter
Start transmitter
Offer feedback to user on success
Same process done with the receiver
Align the transmitter and the receiver
Direct them towards each other
Understand when aligned
Give feedback when aligned towards counterpart
Lock the transmitter and receiver in place
Lock in place
Lock in place
Test system
Test system
User interface
Test system and give feedback

Transfer video data



Disassembly



Transport from positions