CONFIDENTIAL REPORT

Bachelor assignment report

Virtual reality in concept-testing of crew rests

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Industrial Design Engineering, University of Twente

An assignment for Driessen, part of Zodiac Aerospace

December 11, 2012

ZODIAC AEROSPACE

UNIVERSITY OF TWENTE.

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Preface

Mid 2012 I began to orientate on the possibilities for the final assignment of the bachelor Industrial Design Engineering at the University of Twente. After considering several options I asked Roy Damgrave if he knew an assignment about virtual reality - one of my favorite topics to work with. After a while I came in contact with Driessen (part of Zodiac Aerospace) about an assignment for the implementation of virtual reality in their business. A visit to the office in Alkmaar resulted in an attractive assignment. Right now I can look back with satisfaction on the process and the result.

I would like to thank my supervisors of Driessen, Ad Eijkelenboom and Tom Schreuder. Thanks for the pleasant contact, the constructive feedback and the enthusiasm about my work. Also I would like to thank my supervisor of the University of Twente, Roy Damgrave. Thanks for bringing me to this great assignment, sharing your experience with virtual reality and the supervision during the assignment.

I hope you will enjoy reading the report and hopefully the results are useful for Driessen.

Teun Jelle Lassche

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Abstract

Introduction

This bachelor assignment is done as a project at the University of Twente for the company Driessen, Alkmaar (part of Zodiac Aerospace). Driessen develops products for airplanes, for example galleys and trolleys. The company designs mobile modules for flight attendants to rest during long flights, called a 'crew rest'. Caused by the limited space in an aircraft the crew rest is a very claustrophobic place to stay. For this reason, the crew sometimes prefers to rest in a business class seat instead of the special designed crew rest. Driessen wants to improve the experience of the crew rest and to achieve that, they evaluate their current design and developed some redesigns. Before introducing the new systems to the market a test program has to be developed to measure the pleasant experience of the new designed crew rest. Driessen would like to know if and how virtual reality (VR) can be used for this concept-testing. The purpose of this report is to give Driessen an advice for the use of virtual reality in their business.

Requirements

After formulating a clear purpose for the assignment, research was done to the expectations of Driessen for the use of virtual reality in testing the redesigns. The most important thing that had to be tested is the experience of the crew rest, with a focus on the physical size of it. Besides using virtual reality for testing the concepts, Driessen wants to use it for presenting their concepts (on - for example - an exhibition) and for communication about their concepts with people on another location. Driessen does not have much requirements, because they want to leave room for an explorative research on the use of virtual reality for their company.

Current situation

To get a picture of the current situation of Driessen, research was done on how they already use virtual reality and how they currently test their concepts. It became clear that Driessen is already orientating on the use of virtual for some time now, but they have not gone further than the orientation stage. Testing the developed redesigns is only done by showing end users pictures of it and asking for their thoughts about the experience of the redesigns in an interview. So, there is definitely development possible for Driessen in the field of virtual reality and testing their concepts.

Virtual reality and concept-testing

There was done some more research to gain insight into the use of virtual reality outside Driessen and how concepts from other fields are tested with virtual reality. It became clear that virtual reality is mostly used for technical evaluations and that involvement of the end user is little in this process. This research is completed with an overview of many existing VR techniques as a basis for the following design process.

Concepts

A wide brainstorm to the use of virtual reality at Driessen has been done. After this, the brainstorm is summarized to several ideas, which are discussed with Driessen. The ideas differ a lot and after the feedback of Driessen four concepts are created out of all the ideas, which can be seen in figure 1. Concept A consists of a physical setup of the space of the crew rest in which the visualization of the redesigns will be added with virtual reality. The second concept, concept B, is a setup with a big flat screen on which can be navigated through the virtual crew rest. Concept C consists of a screen with the shape of a hemisphere, which immerses the user into the virtual environment. Concept D consists of a table with a top view of the crew rest on which a physical character can be placed and moved. Then the point of view of that character is used as the view of a virtual image on a screen.

Advice

Because the three purposes of Driessen for the use of virtual reality (concept-testing, concept presentation and concept communication) differ too much for advising just one setup, a specific advice is given for each purpose. The advices include a description of the necessary parts and software.

Concept-testing

The setup advised for testing the concepts (see figure 2) consist of a physical room in which the user can perceive and experience the crew rest with a head mounted display (HMD). A HMD is a device worn on the head through which a virtual environment can be seen. Through the physical limitation of the space the experience of the redesigns can be tested well with this setup. Outside the crew rest a screen is mounted with the view of the person with the HMD inside the crew rest and also a touch screen is installed on which several setting of the virtual environment can be changed. With a sound connection it is possible to get direct feedback on the concepts.

Concept presentation

The advice for the presentation of the concepts (in particular for on exhibitions) is the use of a hemispherical screen on which the virtual crew rest can be seen, see also figure 3. With a visualization with a scale of 1:1 the user can experience the space of the redesigns. Using a top view of the crew rest on a touch screen the user can navigate through the environment. On the touch screen the user can also do modifications to the virtual crew rest, for example by placing animations of other flight attendants in the room.

Concept communication

By the use of virtual reality for concept communication between different locations, it is mostly about the underlying software system. The advice is focused on the configuration of the VR-tools and the possibilities of the setup. The setup looks a lot like the one described in the advice for concept presentation, but in this case there are several characters in the top view of the crew rest on the touchscreen, as can be seen in figure 4. Every location has

an own character of which they can share the point of view. On this way, they can easily look at the same aspect of a redesign and talk about it.

Conclusions and recommendations

There are many possibilities for using virtual reality in the company of Driessen. Virtual reality makes it a lot easier to experience different redesigns and VR also shows that Driessen is an innovative company. The result of this assignment can also be used for other products and purposes and so it is a basis for Driessen to take concrete steps in the use of virtual reality.

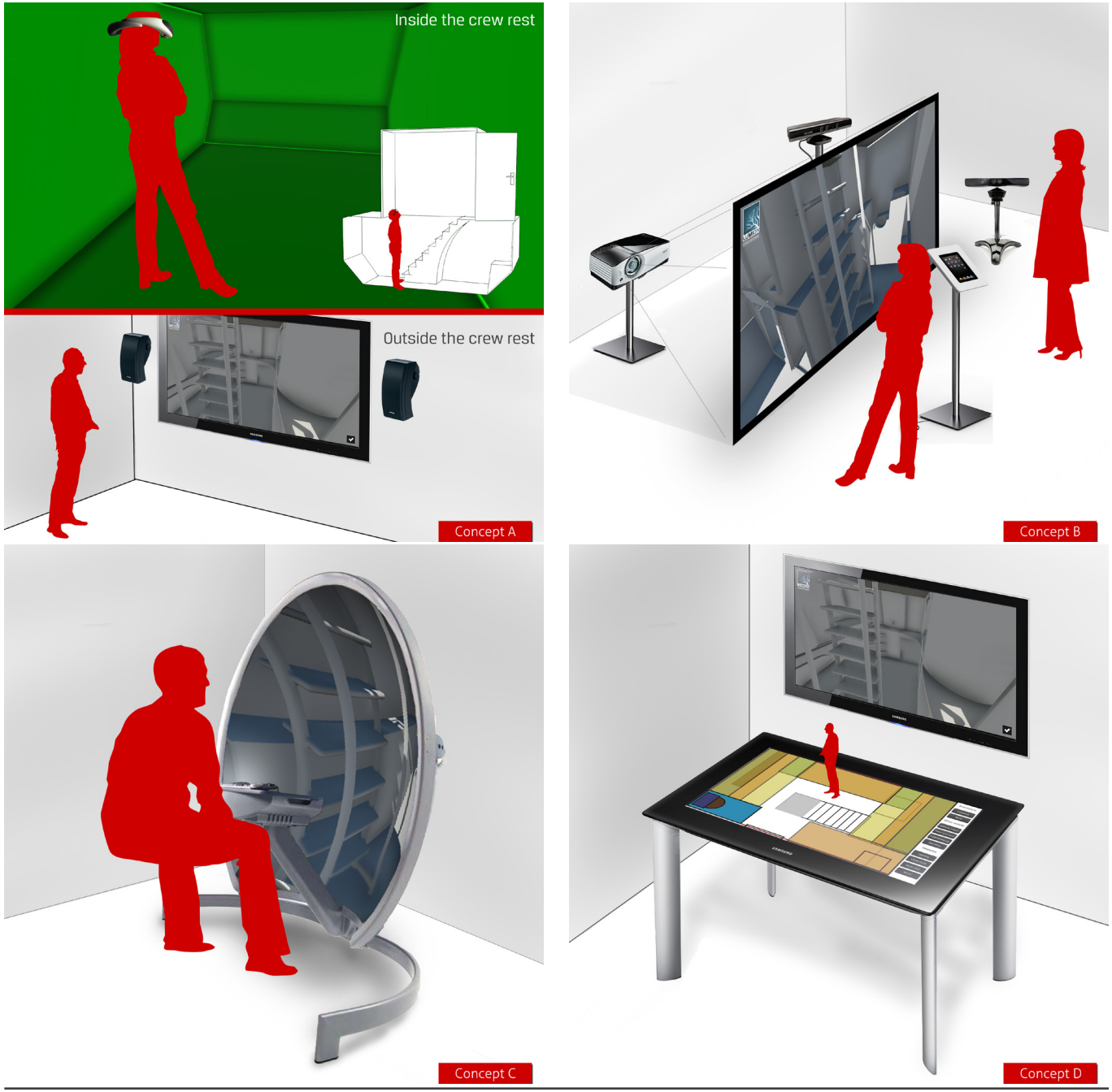


figure 1. Concepts

Samenvatting (Dutch)

Introductie

De bacheloropdracht beschreven in dit verslag is uitgevoerd namens Universiteit Twente voor het bedrijf Driessen (onderdeel van Zodiac Aerospace). Driessen ontwikkelt producten voor vliegtuigen, bijvoorbeeld keukens en trolleys. Het bedrijf ontwerpt ook een mobiele module waarin de bemanning van een vliegtuig kan rusten, ook wel crew rest genoemd. Dit is vanwege de beperkte ruimte van een vliegtuig een erg claustrofobische omgeving om in te verblijven. Om deze reden rust de bemanning soms liever uit in een vliegtuigstoel dan in de speciaal ontworpen crew rest. Driessen heeft daarom zijn huidige ontwerp geëvalueerd en enkele herontwerpen ontwikkeld. Met deze herontwerpen wil Driessen de ervaring van de crew rest verbeteren. Om te weten of de ervaringen van de herontwerpen inderdaad beter zijn dan van het huidige ontwerp is het nodig de herontwerpen te testen. Driessen wil graag weten of en hoe virtual reality (VR) gebruikt kan worden bij dit zogenaamde concept-testing. Het doel van dit verslag is een gedegen advies geven aan Driessen voor het gebruik van virtual reality.

Eisen

Na het doel van de opdracht duidelijk te hebben is nader onderzocht wat Driessen precies verwacht van het gebruik van virtual reality bij het testen van de herontwerpen. Het overbrengen van de ervaring van de crew rest is belangrijkst, met daarbij de focus op de fysieke grootte van de ruimte. Naast virtual reality alleen te gebruiken bij het testen van de concepten, wil Driessen het ook gebruiken om concepten te kunnen presenteren (op beurzen) en om over concepten te kunnen overleggen met mensen op een andere locatie. Driessen laat de opdracht verder redelijk vrij van eisen, om zo de vrijheid te geven voor een verkennend onderzoek naar het gebruik van virtual reality bij het bedrijf.

Huidige situatie

Om een beeld te krijgen van de huidige situatie van Driessen, is onderzocht hoe nu al gebruik gemaakt wordt van virtual reality en hoe op dit moment concepten getest worden. Driessen blijkt zich al enige tijd georiënteerd te hebben op het gebruik van virtual reality, maar het is daarbij vooral in de oriëntatiefase blijven hangen. Het testen van de ontwikkelde herontwerpen is enkel gedaan door aan de eindgebruiker plaatjes ervan te tonen en een interview af te nemen. Er is dus zeker nog ontwikkeling mogelijk op het gebied van virtual reality en het testen van de concepten.

Virtual reality en het testen van concepten

Om zicht te krijgen op hoe er buiten Driessen al gebruikgemaakt wordt van virtual reality en hoe hiermee concepten getest kunnen worden, is daar onderzoek naar gedaan. Het blijkt dat virtual reality vooral voor technische evaluatie gebruikt wordt en dat de eindgebruiker nog weinig in het proces wordt betrokken. Het onderzoek is afgerond met een overzicht van veel bestaande VR-technieken die als basis dient voor het vervolg van het ontwerpproces.

Concepten

Vervolgens is breed gebrainstormd naar het gebruik van VR bij Driessen. Deze brainstorm is vervolgens samengevat tot enkele ideeën die besproken zijn met Driessen. De ideeën verschillen veel van elkaar en na commentaar van Driessen is toegewerkt naar vier concepten, ook te zien in figuur 1. Concept A bestaat uit een fysieke opstelling van de ruimte van de crew rest waarin de visualisatie van de herontwerpen met virtual reality wordt aangevuld. Het tweede concept, concept B, is een opstelling met een groot vlak scherm waarop door de virtuele crew rest genavigeerd kan worden. Concept C bestaat uit een scherm met de vorm van een halve bol, waarin de gebruiker de virtuele omgeving ingetrokken wordt. Concept D bestaat uit een tafel met een bovenaanzicht van de crew rest waarop een fysiek karakter gezet kan worden. Vervolgens wordt zijn beeld van de virtuele omgeving geprojecteerd op een ander scherm.

Advies

Omdat de drie doelen van Driessen voor het gebruik van VR (concept-testing, conceptpresentatie en conceptcommunicatie) te veel uit elkaar liggen om één opstelling voor te stellen, is een advies geschreven voor alle drie de doelen. De adviezen bestaan uit een beschrijving van de benodigde onderdelen en software.

Concept-testing

De opstelling die geadviseerd wordt voor het testen van de concepten bestaat uit een opzet van een fysieke ruimte waarin de gebruiker met een HMD de crew rest waarneemt, zie ook figuur 2. Een HMD is een bril waarmee in een virtuele omgeving gekeken kan worden. Door de fysieke beperking van de ruimte kan hiermee goed de ervaring van de herontwerpen getest worden. Buiten de crew rest is een scherm gemonteerd met het beeld wat de persoon in opstelling waarneemt. Ook kan buiten de crew rest met behulp van een touch screen enkele instellingen aan de omgeving gewijzigd worden. Met een geluidverbinding is het ook mogelijk om direct feedback op de concepten te krijgen.

Conceptpresentatie

Het advies voor de conceptpresentatie (voor in het bijzonder op een beurs) is het gebruik van halfbol scherm waarin de virtuele crew rest waargenomen kan worden, zie ook figuur 3. Met een één op één weergave van de crew rest kan de gebruiker de ruimte ervaren. Met behulp van een bovenaanzicht van de crew rest op een touchscreen kan er door de omgeving genavigeerd worden. Op het touchscreen kunnen eveneens aanpassingen aan de virtuele crew rest gedaan worden, zo kunnen er bijvoorbeeld animaties van andere bemanningsleden in de ruimte geplaatst worden.

Conceptcommunicatie

Bij het gebruik van virtual reality voor conceptcommunicatie tussen verschillende locatie draait het vooral om het onderliggende systeem. In het advies is vooral ingegaan op de opzet en de mogelijkheden van het geheel, zie ook figuur 4. De opstelling lijkt veel op die voor de conceptpresentatie, maar in dit geval zijn er meerdere karakters op

het touchscreen te zien in het bovenaanzicht van de crew rest, waarvan het beeld in de crew rest gedeeld kan worden tussen de locaties. Zo kan gezamenlijk over de concepten gesproken worden.

Conclusies en aanbevelingen

Er is veel mogelijk met het gebruik van virtual reality bij Driessen. Virtual reality maakt het eenvoudiger om de ervaring van verschillende concepten over te brengen en laat zien dat Driessen innovatief bezig is. Het resultaat van deze opdracht kan ook gebruikt worden voor andere producten en doelen en vormt zo een basis voor Driessen om concrete stappen te zetten in het gebruik van VR.

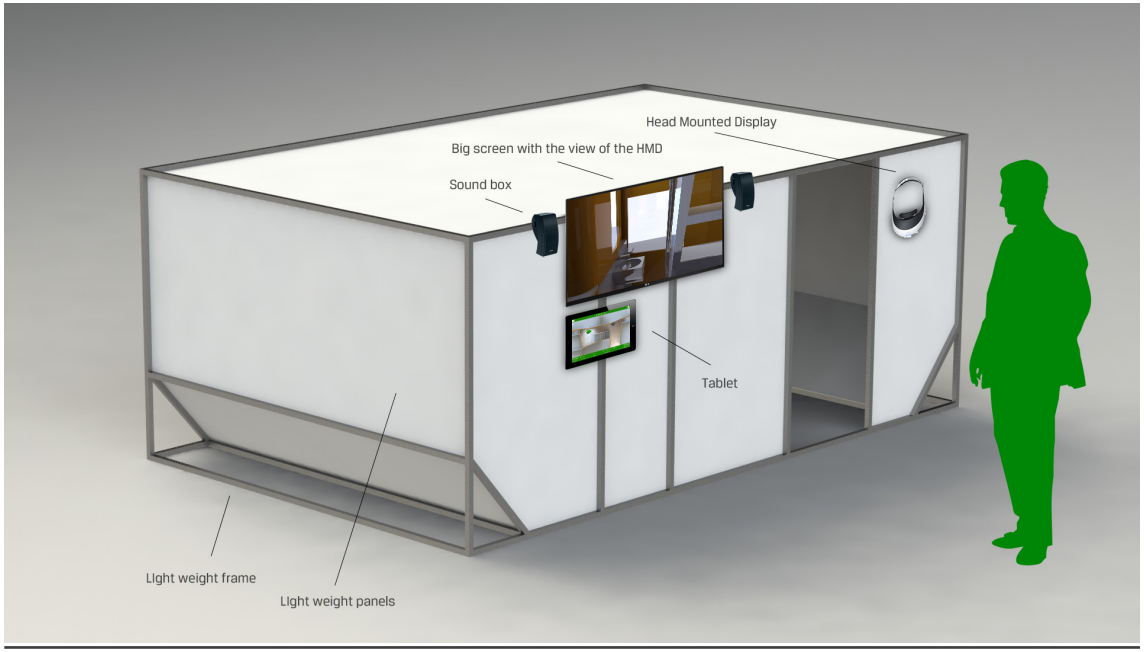


figure 2. Advice for concept-testing

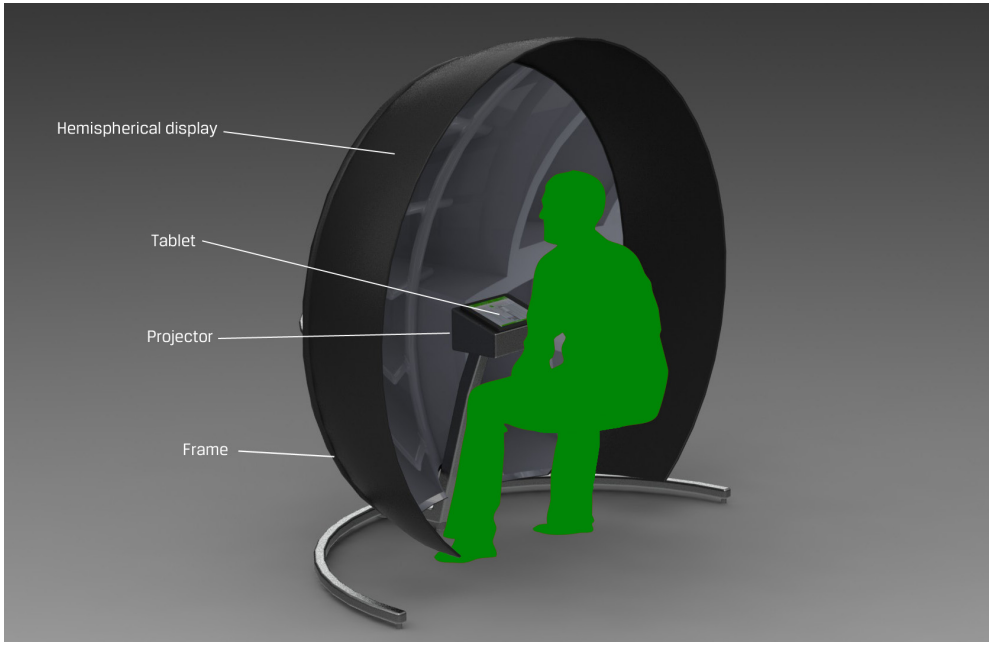


figure 3. Advice for concept presentation

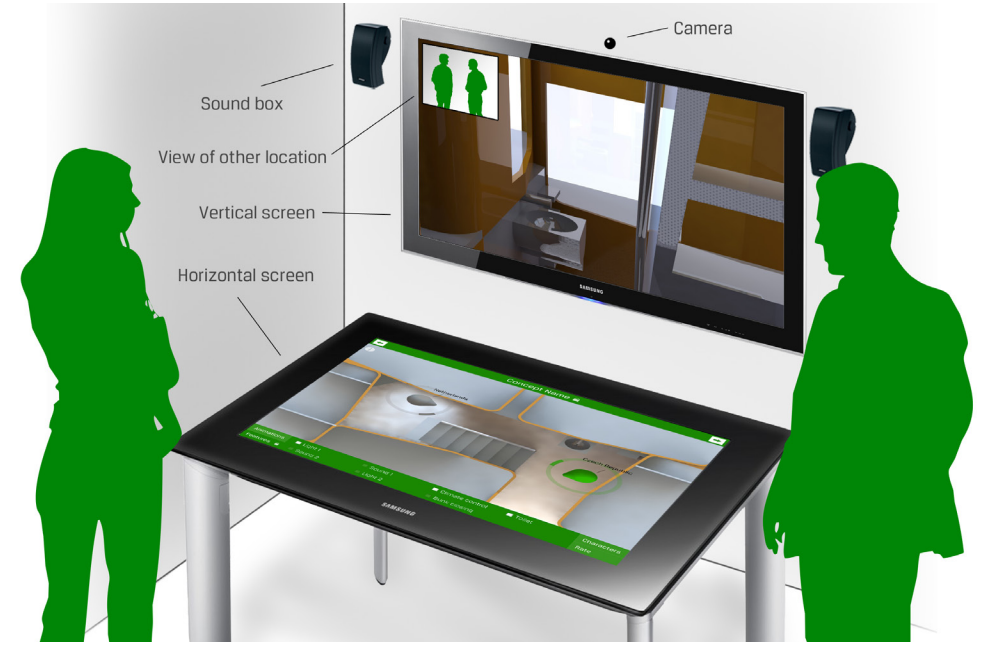


figure 4. Advice for concept communication

1. Introduction

1.1. Driessen

Driessen Aerospace Group NV (Driessen) is specialized in designing, manufacturing, and marketing high quality galleys, galley equipment and cargo equipment. Driessen serves virtually all the world's airlines and airframe manufacturers. It has realized world market leadership by providing its customers products and services of the highest quality. Driessen consists of four sectors: 'Galleys USA', 'Galleys Europe', 'Galley Equipment' and 'Cargo Equipment'. Driessen is part of Zodiac Aerospace, a stock listed company in the aviation industry. Zodiac Aerospace offers a variety of products and services for Cabin Interiors, Aircraft Systems, Aerosafety & Technology, and is the world's market leader in all its activities. Zodiac Aerospace has more than 20.000 dedicated employees around the globe. Driessen has around 2.200 employees. The factories of Driessen are located in Thailand, California, USA, the Czech Republic and the UK.[1]

1.2. Crew rest

One of the sectors of Driessen is focused on the development of galleys and other equipment for Airbus aircraft. A part of this is the development of places to sleep for the crew members of airplanes. For flights longer than eight hours it is obligated that the crew of the airplane can rest horizontally. Airlines usually choose to offer a business class seat to their crew. These seats then can no longer be sold to passengers. Another option is to offer a place in an Onboard Crew Rest (OCR). This is a place in the airplane specially designed for the crew to rest undisturbed. An OCR is available in two versions, namely a built-in and a mobile type. The last type is only build by Driessen and is called a Lower Deck Mobile Crew Rests (LDMCR).

Driessen produces crew rests that can be placed in the cargo compartment of the Airbus A330 and A340, see also figure 5. To reach the crew rest a gap in floor of the passenger deck is made. The crew can go down stairs behind a door in a box placed over the gap. Because the crew rest must fit in the cargo compartment the dimensions are limited. The crew rest is 1.6 meters high, 4 meters wide and 2.6 meters deep. See figure 6 for an impression of the dimensions.

The LDMCR is produced with six, seven or eight beds. Also the stairs take much space in the crew rest. The selling price is about 500,000 Euros and Airbus calculated about 700,000 Euros to install the crew rest and adjust the airplane. The total price of the LDMCR is therefore about 1.2 million Euros.

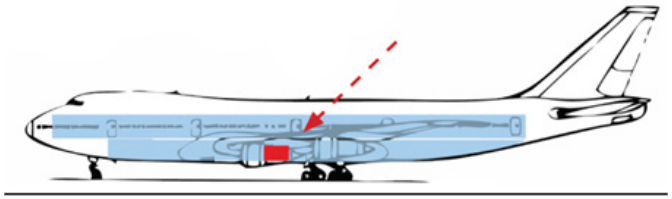


figure 5. Location LDMCR in cargo compartment

figure 6. Crew rest in cargo compartment of an Airbus A330

1.3. Reason of the assignment

Driessen is the only company that develops and produces the LDMCR for the Airbus A330 and A340. At this moment about one in fifteen of these airplanes has a LDMCR onboard. Driessen has investigated how they can increase this number. There appear to be three reasons why they do not sell more crew rests: it is too expensive, it takes too much space in the cargo compartment and the crew prefers not to use it. Research shows that the crew prefers a business class seat over a resting place in a narrow LDMCR.

Driessen expects that there is little to be gained in the first two reasons. That is why Driessen started to redesign the crew rest, with a focus on a pleasant experience for the crew members. Some redesigns are already made, but they are still not tested very well. The existing design of the LDMCR has not been tested at all. Driessen is now looking for a good way to test their concepts and they are thinking about using virtual reality in this process. Building a physical model is very expensive and creating more than one model is therefore not an option. Maybe with virtual reality it is possible to test and see different concepts easy and fast. It would save time and money and it can also be used earlier in the design process.

1.4. Assignment

1.4.1. Objective

The objective of this project is to create a plan with the best way for Driessen to use virtual reality in the concept-testing and redesigning of the crew rest. For this purpose it will be investigated what of the redesigns exactly needs to be tested and how virtual reality is used for concept-testing in other fields. Besides looking just at the techniques already used for concept testing, there will be also looked at other VR techniques. It is important that the virtual reproduction of the redesigns gives a good impression of the narrow space of the crew rest. There will be contact with Driessen about their wishes and the current way of

communicating their concepts and there will be searched for the possibilities with virtual reality. This will be done, among others, in the VR-lab of University of Twente.

1.4.2. Research questions

To achieve the objective, a number of questions is written. With these questions there is given direction to the project and the design process.

1. What are the requirements for the concept-testing?
2. How does Driessen already use virtual reality?
3. What are the possibilities of VR in concept-testing?
4. Which concepts have been designed to use VR for concept-testing?
5. Which concepts are most applicable for Driessen?
6. How can Driessen use this for the presentation of their redesigns?

1.5. Background

Here is an overview of the created redesigns for the crew rest and an introduction about virtual reality and virtual prototyping. Both are useful as background information for the rest of the report.

1.5.1. Redesigns for the crew rest

There are two students (Frens Pries, Industrial Design Engineering student at Delft University of Technology and Pieter Hövels, Mechanical Engineering student at Hogeschool Utrecht) who graduated at Driessen with working on redesigning the crew rest. Also, six groups of students in a minor project of Hogeschool Utrecht and University of Limerick have been busy with generating ideas for improving the experience of the crew rest.

In his graduation report Pieter Hövels mentions a number of requirements for the redesign. Some of the requirements relevant to this assignment are listed below. We will come back on them later in this report.

- The LDMCR needs to appear to have more space than the previous models and/or the models of Driessen's competitors. (This is measurable with user testing)
- The designs used in the new concept need to improve the experience of the end users (measurable with user testing)
- The beds should look and feel clean
- There has to be a mean of personal refreshing
- The LDMCR must possess storage space for personal items (preferably locked)
- The LDMCR needs to be able to house between 6 of 8 people at once

To get an impression of the redesigns that have to be tested, figure 7 to figure 17 gives an overview of the invented designs.

figure 7. Concept Frens Pries

figure 8. Concept Frens Pries

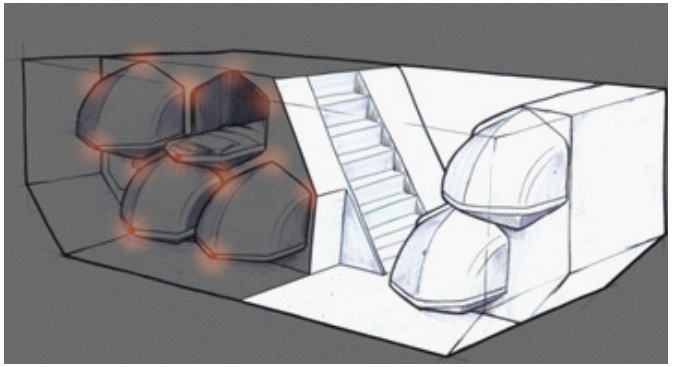


figure 9. Concept minor group 'Closing Off'

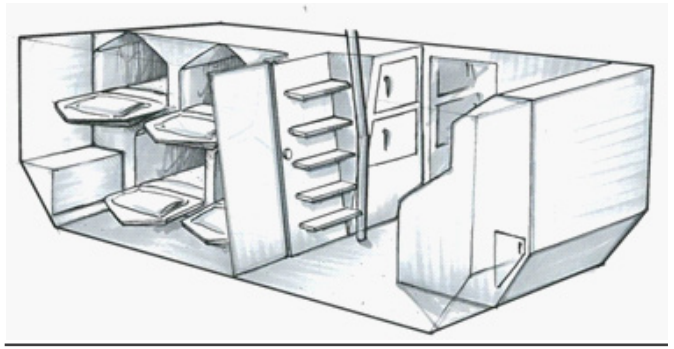


figure 10. Concept minor group 'Closing Off'

figure 11. Concept minor group 'Flexibility'

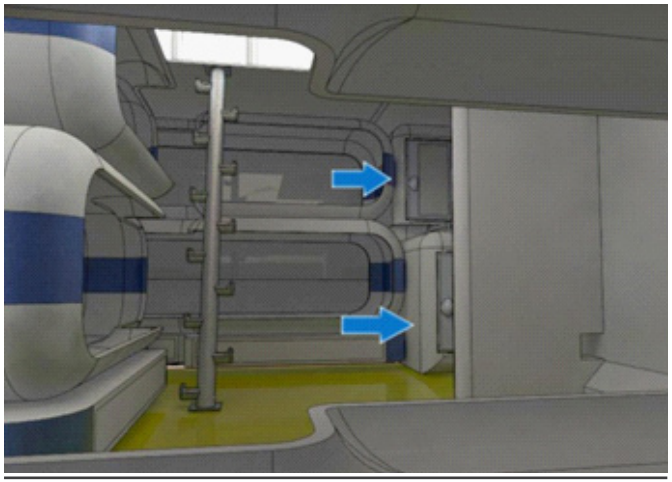


figure 12. Concept minor group 'Nurturing'

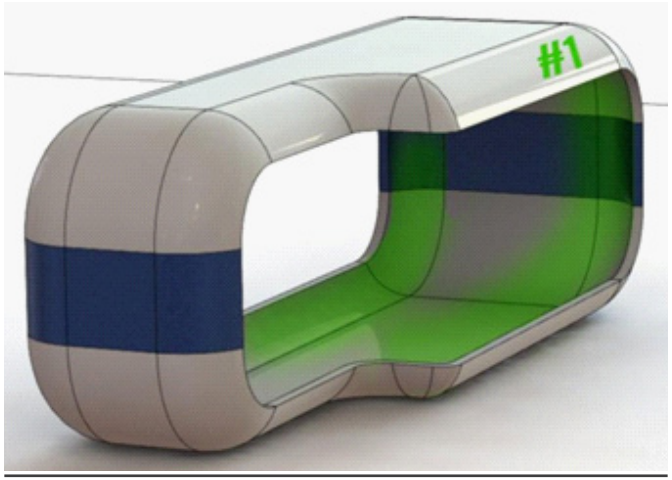


figure 13. Concept minor group 'Nurturing'

figure 14. Concepts minor group 'Look and feel'

figure 15. Concept Pieter Hövels

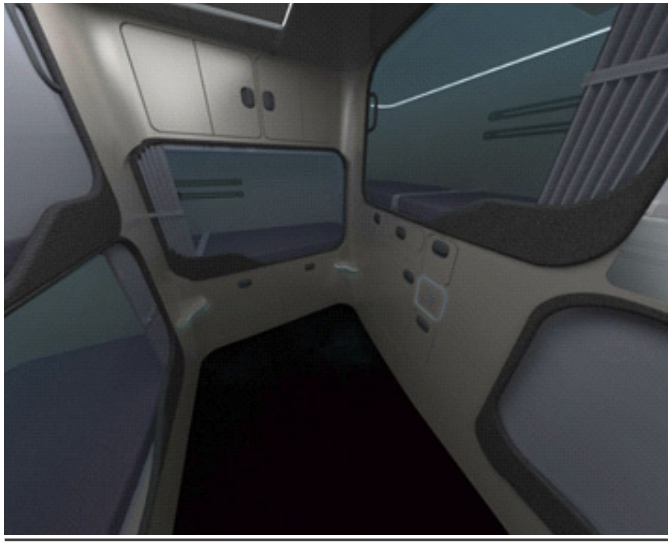


figure 16. Concept Pieter Hövels

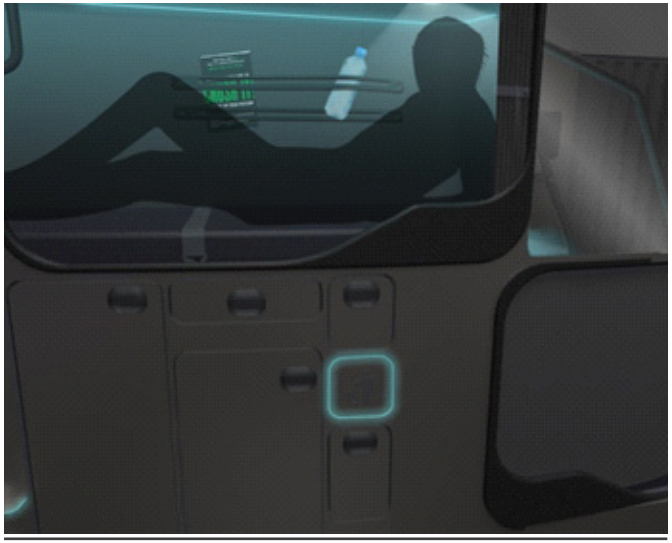


figure 17. Concept Pieter Hövels

1.5.2. Virtual reality

The last few years you increasingly hear the word 'virtual' and in many places there is searched for the implementation of virtual reality. A lot has been developed and there still is a lot to be developed. Virtual reality has a broad spectrum of applications, for example virtual libraries, virtual games, virtual help desks and virtual crash tests with cars.

Virtual reality (VR) is an apparent reality, it is a digital reality that is created with techniques and that can be perceived in different ways. With virtual reality it is possible to experience worlds that do not really exist, with the stimulations of all senses. Virtual reality is often only associated with visual representation of an apparent reality, but also physical and audio feedback can be used to create a virtual reality. There are even applications that use taste and smell to create a virtual world. Situations can be adapted to something completely different and people can come into situations where they otherwise never could or dared to come.

In the field of industrial design research is done about how virtual reality can be used in the design process. With virtual reality digital models of the designs can be build and made ready for production. Also virtual models can be tested according to a wide range of different properties, this process is called virtual prototyping. G. Gary Wangs has defined this as follows:

Virtual prototype, or digital mock-up, is a computer simulation of a physical product that can be presented, analyzed, and tested from concerned product life-cycle aspects such as design/engineering, manufacturing, service, and recycling as if on a real physical model. The construction and testing of a virtual prototype is called virtual prototyping.[2]

Virtual prototyping makes it possible to build and compare several designs faster and cheaper, because it is not necessary to build complete physical models. Virtual reality also makes it possible to place several concepts in the right context without building or visiting the context physically.

In many places research is conducted on virtual reality and virtual prototyping. One place where this happens, is the Virtual Reality Laboratory (VR-lab) at University of Twente. With a wide variety of VR-tools they search for useful applications with virtual reality. They, for example, perform different types of simulations, use virtual reality in meetings with businesses and have the possibility to do user tests with the aid of VR.[3]

1.6. Action plan

After the reasons and background information of the assignment became clear, there was made an action plan to complete the assignment. First, a clear scope with what Driessen exactly wants with the assignment must be outlined. In chapter two this scope of requirements and wishes of Driessen will be described. In addition to picture what Driessen wants, it is also important to see what they already tried in concept-testing and virtual reality. The current situation of Driessen will be described in chapter three. After this there will be looked at concept-testing and virtual reality in general. How they are applied in other places then Driessen, serves as inspiration for the further design process, this will be chapter four. In the three chapters a complete image of what Driessen wants, what Driessen already has and what happens outside of Driessen with VR and concept-testing is described.

In chapter five the developed concepts will be shown and described. Next in chapter six a consideration between the different concepts is made and an advice for Driessen is described.

At last, I will show the conclusions of my work and give some recommendations for future work to use virtual reality in the business of Driessen.

2. Requirements

In order to get a good advice on how Driessen can use virtual reality for concept-testing, it is important to find out what exactly is required to test the concepts of the LDMCR. Following, a framework will be outlined which can be used later for finding solutions. The framework will guide the search for solutions and make clear where VR-tools are needed. What would Driessen achieve with testing the concepts and what should be the results of a test? What are the most important characteristics of the crew rest to be tested? When, during the design process, testing should be done and by whom? What kind of interaction with the design is desired? These question and more will be answered in this chapter.

2.1. Why should it be tested?

The designed concepts are developed using polled experiences of flight attendants (FA). The crew members have explained how they experience the crew rest and what should be improved. Bases on this information, a number of concepts is devised which should improve the experience of the crew rest for the flight attendants. First Driessen wants to test the concepts with some flight attendants, so that the actual end user can give feedback on the redesign. This might help to make a choice for a redesign and could possibly result in design adjustments.

Driessen also wants to use the test setup at exhibitions. On an exhibition tests can also be done in order to gather feedback about the concepts. Besides that the 'test setup' can serve as a presentation tool for potential customers. Driessen would like to do all this by using virtual reality, not only because it is an easy way to demonstrate several concepts, but also because it becomes visible that Driessen is a company of the future. In addition, a virtual prototype ensures that people understand that the design is still in development, in contrast to a concept which is shown with a physical prototype.

2.2. What should be tested?

The redesigns of the LDMCR are created because the flight attendants do not have a pleasant experience in the current design. Testing the *experience* of the new designs is thus the main goal. In previous studies done by Driessen it is further specified what aspects of the crew rest the FA's experiences as unpleasant.[4] Apparently, the main cause of the unpleasant experience of the crew rest is how tight the space is. So the most important characteristic that must become clear in the tests is the physical size of the room.

In the next list the experiences important to test are shown:

- The physical size of the room
- The freedom of movement for the user (let them experience or show)
- The presence of other people in the same room
- The entrance in the crew rest from the aircraft
- The personal space from the FA's in the bunk (to say something about privacy)
- Effects of noise and light from other users in the crew rest
- The use of materials in the crew rest
- Features of the crew rest (e.g. mirror, space to freshen up and change clothes and space for safe storage of personal belongings)
- Features of the bunk (e.g. positions of the bed, climate control, lights, screen)

2.3. When should it be tested and what should the result be?

Driessen wants to test the concepts early in the design process, so that the feedback of the user can help in making a choice between the concepts. Driessen wants to focus explicitly on the concept-testing. Because the phase of co-design is already passed, users will give feedback on concepts and don't have a focus on creating new ideas. Driessen wants to do the tests after multiple concepts are created and use the feedback from users to choose a proper redesign and possibly do some adjustments to the redesign.

This is what Driessen currently wants. Depending on the success of the method for concept-testing designed in this assignment, it might be used more frequently, perhaps as a tool for co-design. However, this is not the starting point of the assignment.

2.4. How should it be tested?

First Driessen wants to do the tests with the end user of the crew rest, the flight attendants who were approached in earlier studies and a co-design session. This will be done because it is easy to come in contact with this group again and is it good to show that Driessen has listened to the input they have provided for the concepts. The test can be performed on any – but easily accessible – location in the Netherlands. In consultation with the crew members a moment should be scheduled so that the test can be done in one day. Various concepts will be presented to the users. After that they can give feedback on the experience of the redesigns with – for example – an interview or a survey. The time to set up should be short and the users do not need any understanding of virtual reality to do the test.

At first these tests may be done once at a fixed location in the Netherlands, but Driessen wants to work towards a mobile setup. The flight attendants mentioned before are all Dutch but it is advisable to also test the concepts with people from other cultures. A mobile setup makes it easier to reach people from other cultures.

The wish exists to use a mobile setup for testing concepts on the exhibition in Hamburg in April 2013. Zodiac Aerospace has reserved a large space on this expo, Driessen will be

able to use only a small portion of this space. If necessary Driessen can hire a separate room apart from the square meters on the exhibition floor. People can be guided to that room individually to do the tests. At the exhibition, people from a mixed company can be asked for testing the redesigns of the LDMCR. An advantage of this is that a large number of different people from different cultures can give feedback on the concepts. But the competitor of Driessen will also be among the public at the exhibition , therefore the confidentiality of the concepts is a lot harder with this way of testing. It is an option to take out a patent for some ideas in advance. If the test is performed on an exhibition, it is important to keep the time per test to set up as short as possible as well as the time in which one can do the test.

Whether Driessen should hire or purchase the setup depends on the final value of the system. If hiring is easily possible and Driessen wants to use the setup just two times per year, then hiring will be the best option. If the setup can be used more frequently, purchase will be considered. In advance can there be said little about this, the choice of hiring or purchasing will be made on the basis of the added value of the designed setup.

In short, the first tests will be done with the previously approached crew members and after that the setup can be used as a test setup for on exhibitions.

2.5. Summary

Driessen is looking for a new way to test the experience of the redesigns for the crew rest using virtual reality. And they have the wish to use this new way in the future as a presentation tool for potential customers.

The next list gives an overview of the expectations of Driessen for the concept-testing using VR:

- The test user must experience the experiences called earlier in this chapter.
- The time to set up the complete method must be kept as short as possible.
- People must be able to use the setup without prior knowledge of VR.
- The first tests are performed with the earlier approached flight attendants.
- The first test may take place at a fixed location, but in the future a mobile setup is needed.
- In the future the concept can be used for the presentation of the redesigns to potential customers, for example on exhibitions.

Driessen does not have further requirements – for example about the price, the space it occupies and whether Driessen will buy or hire the setup. It all depends on what the developed solutions would be and on which fields they have added value. The requirements of Driessen were made clear in this chapter and by more consultation in the development of the solutions for the use of virtual reality it will become more clear what suits best for Driessen.

3. Current situation

Now that it is clear how Driessen thinks about testing their concepts, more research is needed to gain insight into the current situation of Driessen. In this chapter an overview of this research is shown. Research has been done to what digital models Driessen uses and how current methods are in line with the wishes for the new way of concept-testing in virtual reality. Also there is looked at the tests that Driessen has already done with the concepts.

3.1. Current use of virtual reality

Driessen uses SolidWorks to create virtual models. With a SolidWorks model of the crew rest Driessen has once made a walkthrough, so that you can navigate through the crew rest on a computer using the mouse and the arrow keys. This was a basic visualization of the LDMCR with only the shape of the base construction, as can been in figure 18.

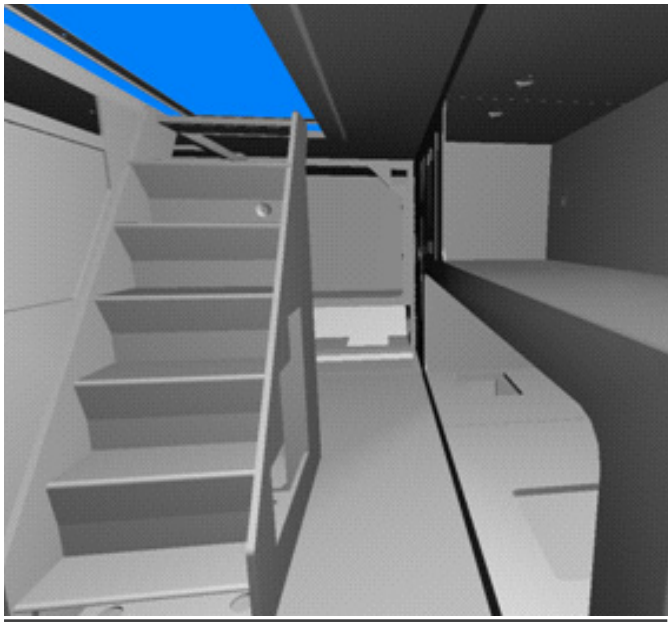


figure 18. Screenshot of walkthrough LDMCR

For the galleys which Driessen has developed, a configuration system is build. Using Microsoft Excel is it possible to indicate which modules must be included in the galley. After that a simple graphical representation of the galley, including the selected modules, is shown. A screenshot of the system can be seen in figure 19.

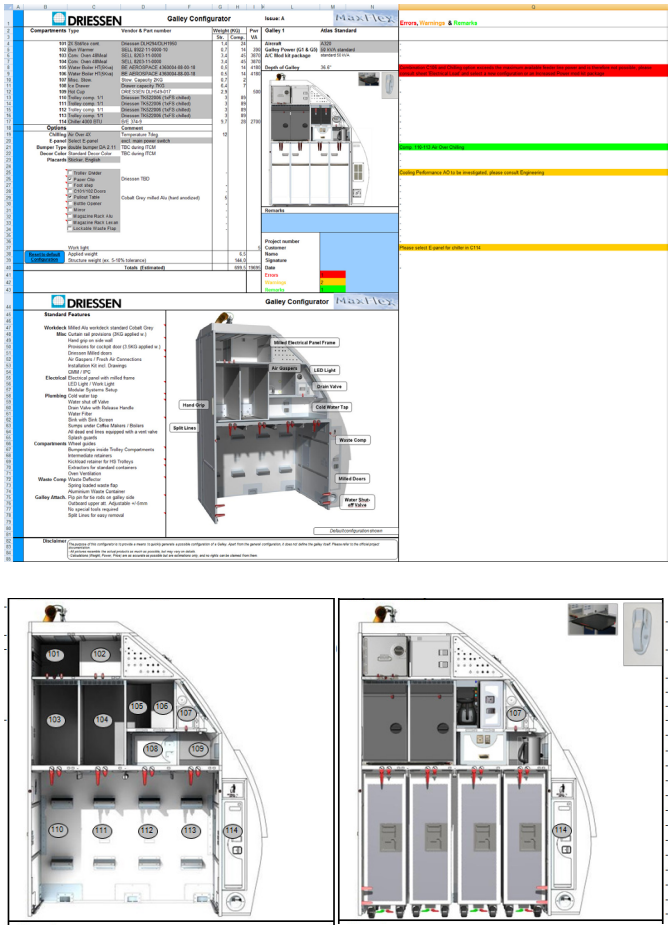


figure 19. Configuration system for galleys Driessen

Driessen also has contacted two companies about the possibilities to display the crew rest using virtual reality. These companies are the Dutch company Visionair 3D[5] and the German company IC.IDO[6] (part of the ESI-group).

Visionair 3D is mainly focused on the visualization of architecture. They change a building drawing into a virtual 3D representation of the exterior and the interior of buildings. The company has different systems to display virtual visualizations, one of them is known as a CAVE. A CAVE is an area surrounded by projection screens in which a user can walk through a virtual environment. There will be a more detailed explanation about the CAVE later in this report. There has been a conversation with Visionair 3D and Driessen about the possibilities for Driessen to use virtual reality.[7] It appeared that VR is useful for Driessen in the presentation of their concepts. Using examples that Visionair 3D can give in the future, the added value of the techniques of Visionair 3D can be evaluated. The company has offered Driessen a CAVE for a week on an exhibition (including the preparation) for a price around 25.000 Euros. The consideration of what Visionair 3D offered is discussed later in this report.

IC.IDO (ESI-group) calls itself the pioneer and world leader on the field of VR and 'Virtual Engineering Solutions'. IC.IDO searches for solutions using VR for the whole process of product development, from design to production. They use several VR-systems to visualize virtual models. The most used system is a setup with series of screens which show a 3D environment when users wearing 3D goggles. With a remote controller the user can navigate through the virtual environment and interact with the 3D models. There is no concrete offer made by IC.IDO to Driessen, but in November IC.IDO comes to Alkmaar for a consultation about the possibilities for Driessen to use the techniques from IC.IDO.

Both companies have expensive solutions for the questions of Driessen. Therefore it is good that the University of Twente searches for the best solution for Driessen to use virtual reality to test their concepts.

Driessen has earlier attended a graduation presentation of a master student of Delft University of Technology. This student, Joep Steenbeek, has researched for his graduation project how a Dutch aircraft manufacturer (Fokker) can present their designs for VIP rooms in airplanes to customers. It appeared that the customer not always understood entirely how the design actually would be. This problem can be minimized by the use of visualization of the design using virtual reality and 3D-models. The most innovative idea that was invented in this project is the use of augmented reality when configuring the VIP room with a customer. With placing physical cards with graphical representations of parts of the room on a surface, a VIP room can be configured. When the customer looks to this configuration with glasses with displays (later in this report there will be written more about this VR-tool), the cards become 3D models by displaying that models on the displays of the glasses. In this way the physical configuration with cards on a surface comes to life and it is more clear how the VR room will look.[8]

One last point about how Driessen already uses VR. The several redesigns for the LDMCR are developed to a different level of detail, from a simple sketch to a detailed CAD model in SolidWorks. The concepts that are only sketched would have to be converted into a digital 3D model to be used in a virtual environment.

3.2. Current way of concept-testing

So far Driessen has almost done nothing for testing their concepts, because the last years they developed a standard LDMCR with a few variations possible. In the development of the redesigns it is important that Driessen pays attention to concept-testing, because the improvement of the experience of the crew rest is the purpose of the redesign.

The concept developed by Frens Pries is evaluated on the Schiphol airport. To show the different aspects of the redesign, he printed six A5 papers with renders and an A4 paper with the overview of the complete crew rest. With this he interviewed several flight attendants. In every interview three of the six aspects of the redesign were discussed, so there was room to give longer reactions per aspect than when all the aspects had to be discussed each interview. Because not everyone is familiar with the existing LDMCR they compared the redesign also with other existing build in crew rests.[9]

Pieter Hövels did not really test his invented design, he only wrote a plan to perform a user test. He proposed to make some renders of his redesign and e-mail them with a digital survey to several flight attendants. In this way he wants to give the crew member an impression of the redesign with pictures and get some feedback using a survey.[10]

The visualization of the concepts for concept-testing does not go beyond creating pictures of renders. The redesign may be much clearer by creating a more realistic visualization that comes closer to the perception of the end user of the crew rest. Here is the space for the development of the use of virtual reality to the concept-testing of Driessen.

4. Virtual reality and concept-testing

In the second chapter an overview of the requirements and wishes of Driessen is shown. In the following chapter the current situation and knowledge of Driessen is described will be described. For this chapter some research is done how virtual reality in concept-testing is used in other fields beside Driessen, typically focused on crew rests. These research results will be presented first and after that a broader research of existing VR-techniques is shown. The knowledge gained in this study can be used to create concepts for using VR in concept-testing of the crew rest.

4.1. How is VR already used as tool for concept-testing?

Concepts can be tested for several properties and on the basis of various requirements. For example a test can be used for determining the maximum load a design can endure, to get a picture of the consequences of exposure to certain weather conditions or to simulate the life cycle of a product. Virtual testing is mainly applied for analyzing simulations of the concept designs. These simulations are mostly technical and visual simulations.

Technical simulations

Virtual reality makes it possible to test concepts for technical requirements without creating a real physical model. This can for example be used for studying the effects of loads, air resistance or temperature fluctuations. All can be done with the usage of the finite element method, of which visualizations can be found in figure 20 and figure 21.

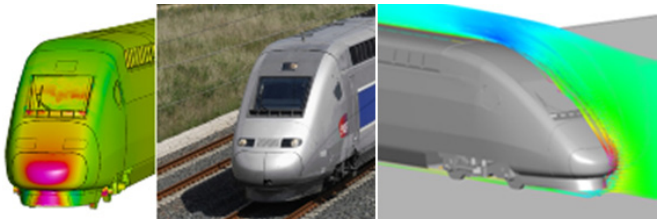


figure 20. Finite element analysis of a train

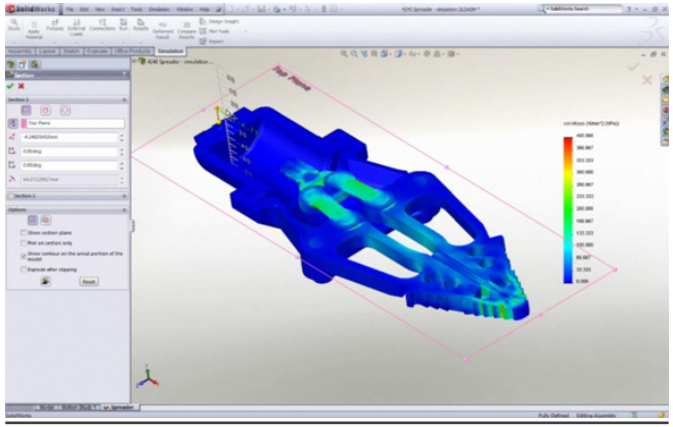


figure 21. Finite element analysis of a hydraulic spreader

Simulations using virtual reality are often used in the automotive industry. Crash tests can easily be simulated in virtual reality, so only at a later stage crash tests with real cars need to be done. An example can be found in figure 22.

figure 22. Physical and virtual crash test

Visual simulations

Besides the mentioned technical simulations, VR is also used for the virtual visualizations of designs. Often used for design presentation, but also used for gathering feedback about ideas. VR is for example used in architecture. Architecture can be shown by a walkthrough on a screen, so a user can walk through the designed environment in virtual reality. Mainly focused on displaying the design and interaction between the person who walks into the virtual environment and the environment is missing. Other examples are the design of a supermarket or an operating room as can be seen in figure 23.

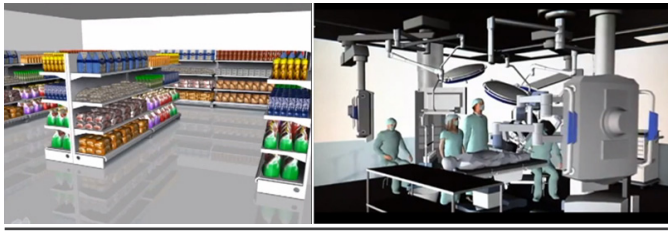


figure 23. Visual simulations

Virtual reality is increasingly used in a wide spectrum of applications in product development. Companies around the world use VR for ergonomic studies, virtual assembly and factory floor schemes.[11] However, the most tools for testing the concepts with virtual reality are designed for a later design stage, if the concept is almost completely defined. [12] The challenge is to look at how virtual reality can be used early in the design process. Then adjustments to the concept are still possible and evaluations of the usability still affect the design.

C. Noon et al. has worked for improving the use of virtual reality in design processes and found the problem that people do not well understand how CAD programs work. Only users who understand the software can say something useful about the (virtual) designs.[11] He developed a system that uses virtual reality in an early design stage of creating concepts and testing them, called Advanced System Design Suite (ASDS). However, this system is also not very suitable for doing usability tests with the end users of the evaluated designs. This system will also stick to display a virtual design on a 2D-display and does not exploit the potential of VR to bring the user closer to the (virtual) product.

Found about concept-testing and virtual reality, are simulations of certain (user) situations one hand and on the other a 3D model of a design that can be seen on a simple display. In the scientific field not much can be found about concept-testing with the focus on usability. How a user experiences a product and how the user interacts with the product is still not much tested with virtual reality. In the current applications of virtual concept-testing focus lies on the product itself, without involving the context, the user and the use of the design. That is the challenge of this project: to make VR useful for testing how users experience concept designs. VR makes it possible to place concepts in their context and then involve users into this context.

It is something were slowly research is growing, but it is clearly still in the early stage of a promising journey. Here follows the description of two examples in which virtual reality is used for the evaluation of designs.

VRADU

M. Mahdjoub et al. developed the Virtual Reality Aided Design of Use (VRADU).[13] This method consists of three globe design activities based on VR: "Product usability analysis with VR tools", "Product and related use and ergonomic evaluations with VR tools" and "Product and related use design with VR tools". In the second design activity, the evaluation of the product and related use with VR tools, the end user is the one who can use the design via a virtual reality, while someone else is observing the user.

The setup of the VRADU (see figure 24) consist of three big screens with a 3D view and several sensors to capture the movement of person in the VRADU. With this setup simulations can be made, the user can be placed in the context or the designer can make adjustments to the (virtual) design.

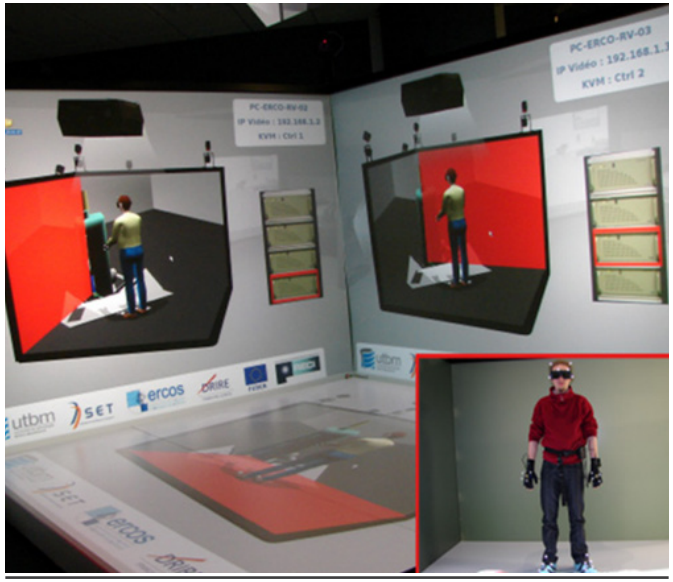


figure 24. VRADU

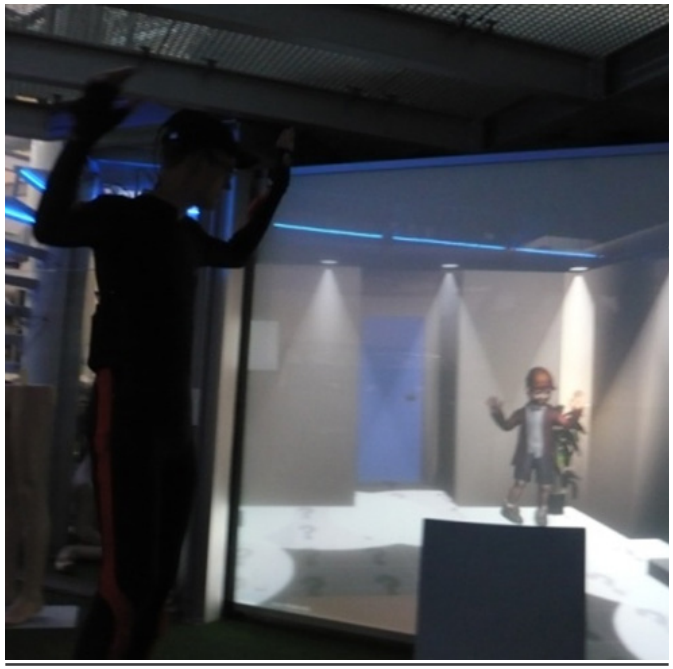


figure 25. Test setup for presenting from a virtual environment

Presentation from virtual environment

For an assignment for the study Industrial Design Engineering at the University of Twente a setup is created which enables a presenter to present from a virtual environment. [14] The setup consist of two separated rooms, connected to each other by a network. In one room, the presenter room, the presenter wears a suit with full motion captures recording all movements of the presenter. In the other room people look to the presentation on a big screen. The screen shows a virtual environment with a virtual character walking around in this environment. The virtual character is controlled by the presenter in the presenter room. The presenter can see and hear the public and thereby also react on what happens in the presentation room. The public will have direct interaction with a virtual person and a design can be tested by analyzing the acts of the virtual character. An illustration of a test at the VR-lab of the University of Twente can be seen in figure 25.

Summarized, more tools for testing concept designs are needed. It appears that virtual reality can bring solutions for this need. However, this requires still much development. Often only complex models are analyzed and virtual reality is not used in early design stages. VR is mainly used for completion of designs and preparation of production, not for conceptual design. And if virtual reality is used for concept design, there is often a focus on how the designer can use virtual reality without involve the end user in this process. Involve the user in a virtual environment with concepts and analyze how the user experiences the design. There is the challenge for the further development of the use of virtual reality in concept-testing.

4.2. Existing VR-tools

After describing how VR already is used for concept-testing the next paragraph will show a broader view of the possibilities of VR. Techniques may be discovered which never were linked with concept-testing in the first place. A short overview of existing VR tools is shown in this section.

Short overview

Tools for visualization

- 3D-screen
- Theatre Projection Screen
- Holographic display
- Portable 3D System
- CAVE
- ImmersaDesk
- Elumens
- Head-mounted display

Tools for visualization (focused on interaction with user)

- Screen with interactive 3D-projection (IC.IDO)
- Touch Table
- Touch wall

Tools for the detection of persons

- D-Imager
- Omnidirectional treadmill

Other techniques

- Full-flight simulator
- Haptic technology

4.2.1. Tools for visualization

3D-screen

Nowadays they are increasingly promoted: 3D screens. For the first generation 3D-screens wearing glasses was required. The next generation, on the market, contains screens were 3D effects can be observed without glasses. Slowly the 3D-screenshare getting better. Earlier 3D-screens show the 3D effect looking from only three fixed angle-positions, but a great improvement over the last years is made.

Theatre projection screen

The VR-lab of the University of Twente has a curved screen [3] that allows a group of viewers to emerge in a virtual environment. The large projection screen is 3 meter in height and 8 meter wide and is connected to a 7.1 surround system. This properties can be used for presentations and simulations.

figure 26. Theatre projection screen VR-lab

Holographic display

The parabolic mirror of the holographic display images an object floating in front of the user. The screen can show (without wearing some 3D glasses) objects in 3D with a diameter up to a half meter.[3]

Portable 3D System

The University of Groningen owns a portable 3D system, [18] consisting of two projectors and a large projection screen. The projectors are assembled with two different polaroid filters perpendicular to each other. The users wear glasses with the same polaroid filters for the left and right eye. These filter combination results in a left eye image of the upper projector and visa versa. This polaroid separation to each eye makes it possible for the brains to convert the two images to one image with specific depth information resulting in a 3D view for the user. There are two ways to project on the screen: frontal projection on a screen of 2.25 by 4 meter and rear projection on a screen of 1.5 by 2.67 meters.

CAVE

A CAVE (Cave automatic virtual environment) is a setup with three to six walls inside a cube-shaped space.[19] On every wall (a part of) the virtual environment is projected. The user will be surrounded by screens and can make simple movements inside the created virtual environment. There are many different types of CAVE systems. Some CAVEs even have a projection screen on the floor[20] and other simplified types only consist projection screens in the front, left and to the right. With head tracking sensor glasses the position and angle of view of the user can be captured and used to adapt a specific screen combinations connected to the user position. There is enough software available for visualizing a virtual environment in a CAVE and connect the user to the screens as much as possible.

In most cases, the walls of the CAVE are rear projected. This way, he persons in the cave do not cause shadows on the screens. However, this takes more space than inside projection on the screens. Visionair 3D owns a CAVE system that uses frontal projection. This CAVE system requires a floor of four by four meters, which is significantly less than usual CAVE systems. [21]

A disadvantage of CAVE systems are projections smaller than the screen sizes. In that case the visualization of the whole CAVE will be disturbed.[7]

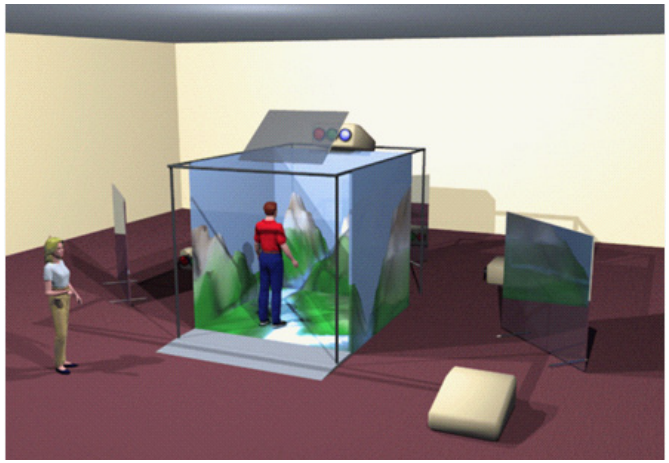


figure 27. CAVE

ImmersaDesk

The ImmersaDesk is a portable screen under an angle of 45 degrees. It is a variant on the CAVE, in which the user is not surrounded by projection screens, but stands before a tilted screen. The user is now able to look forward and down in the virtual environment. When wearing 3D glasses a 3D projection can be seen.[19] An advantage of the ImmersaDesk compared to the CAVE is that it is much more mobile and takes much less space.[22]

Elumens

The Elumens[3] is a hemisphere positioned close to the user containing a screen with a diameter of 150 centimeters and a view angle of 160 degrees. Through the shape of the screen the user has an immersive experience of the virtual environment he is in. The Elumens is used for presentations, simulations and entertainment.

Head-mounted display

A Head-mounted display (HMD) is worn on the head and shows on a virtual 3D visualization. There are two main types: a HMD in the form of glasses and a helmet. Below this a large variety of variations can be found. A HMD can close the full reality and show a complete new virtual environment, as shown in figure 28. There are also HMDs that are transparent and project additional information and images on the existing reality, which is called augmented reality. An example that uses this principle is the Google Glass, which can be seen in figure 29.

figure 28. Carl Zeiss HMD

figure 29. Google Glass

4.2.2. Tools for visualization (focused on interaction with user)

Screen with interactive 3D-projection (IC.IDO)

The earlier mentioned IC.IDO (part of the ESI-group) uses a system with a big projection screen on which a user (wearing 3D glasses) can see a 3D image. With two remote controllers a user can navigate through virtual environments and move the hands displayed on the screen. With these hands is it possible to interact with virtual objects. The user can pick up and move things in the virtual environment.[25]

figure 30. Screen with interactive 3D-projection

Touch Table

The best known touch table is the Microsoft Surface, recently renamed as Microsoft PixelSense.[3] A touch table is a table containing a large touchscreen. Multiple people can use the touch table at the same time by moving their fingers over the screen. The touch table does not recognize fingers only, also objects (with a tag on the bottom) and shapes can be recognized. The table can be used horizontally as well as vertically.

PixelSense is used in public environments and is also used by sellers to discuss the options of a purchase with the customer using virtual reality.

Touch wall

In the virtual reality laboratory at the University of Twente stands a big multi-touch wall.[3] This multi-touch wall uses rear-projection. Therefore, there is on the screen no shadow of the people who stand in front of the screen. The screen is three meters width and two meters high and recognizes several objects touching the screen with cameras and infra red light.

4.2.3. Tools for the detection of persons

D-Imager

The D-Imager is a 3D Sensor of Panasonic.[26] The D-Imager uses light sensors to create a 3D profile of the environment. From this 3D profile software can recognize people and their movements. There are many different applications which can be supported by the D-Imagers. It is possible to use it in a CAVE to convert movements of a person to a movement through the virtual environment; to navigate, at a certain distance, through a system on a screen or to use it for playing games and convert movements to a character on a screen. The D-Imagers is comparable with the Microsoft Kinect.[27]

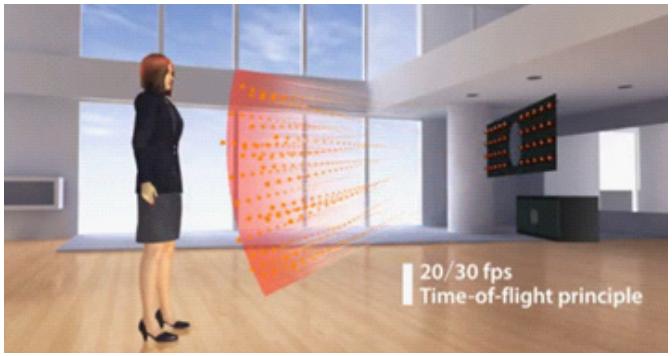


figure 31. D-imager

Omnidirectional treadmill

The omnidirectional treadmill[28] is a treadmill on which can be walked in any direction. A computer can track the walk direction and speed, so a user can walk an endless distances in any direction through a virtual reality. See also figure 32.

figure 32. Omnidirectional treadmill

4.2.4. Other techniques

Full-flight simulator

CAE is a huge company on the field of flight simulators. One of the products of CAE is a full-flight simulator used, for example, to train pilots.[29] The pilot takes place into the simulator, which is equipped like a real cockpit. On a screen the pilot sees a virtual environment flying through. By the movements of the complete simulator the pilot has the feeling of flying with a real airplane.

Haptic technology

Haptic technology enables haptic feedback to an observer. With forces, vibrations and movements the sense of touch is stimulated.[30] Examples are the vibrations of a steering wheel by a computer game or a touch screen which gives a small force back when the screen is touched. University of Twente has haptic arms that can give feedback to a user through forces. This is among other things used in the practice of operations. A surgeon can move a haptic arm and sees his movement in a virtual surgery. If he touches the body of the virtual patient with his tool, he feels some real resistance in the haptic arm. See figure 33 for an example of such a haptic arm.

figure 33. Sensible Phantom Omni in VR-Lab University of Twente

Conclusions

There are already many different ways to use VR. The overview above shows how much is possible with VR and gives insight in the existing techniques that eventually can be used for concept-testing of the crew rest. This overview and the underlying research serve as the basis for the further design process.

5. Concepts

In this chapter the concepts created for using virtual reality in the concept-testing of the crew rests of Driessen, the LDMCR, are presented.

The concept development is done in three steps. First a brainstorm is done by formulating seven sub questions. After creating ideas as answers to these questions, several ideas were combined to create different concepts. In the following pages I will introduce each concept and discuss the advantages and disadvantages of them.

Finally I will show all the generated ideas and concepts combined in four final concepts. These are the ones which were discussed with Driessen. In the next chapter a proposal is made with the best way for Driessen to use VR.

5.1. Brainstorm

First a brainstorm was done by using the next sub questions, which gave direction to the concept development:

1. How can you communicate a tight space with VR?
2. How can you experience limited freedom of movement with VR?
3. How can you communicate the bunk experience with VR?
4. What kind of physical interaction takes place with obstacles in the crew rest?
5. How are other people shown in the crew rest?
6. How do you enter the crew rest?
7. How can the test be carried out?

For each question there were made idea sketches. An example can be seen in figure 34. All other sketches and the ideas written down per question can be found in Appendix C. This is the concept presentation send to Driessen on October 20, 2012.

5.2. Ideas

All the ideas of the brainstorm are combined into nine ideas for a setup for using virtual reality in concept-testing. In the following pages all the ideas were shown and discussed.

figure 34. Idea sketches

1. Physical construction of the basic of the LDMCR

A visualization of this idea can be seen in figure 35.

The basic form of the LDMCR is physically constructed. The user can walk into the crew rest and experience the narrow space. The user is wearing a Head Mounted Display by which he can see a visualization of the different concepts. When more than one person is walking in the LDMCR at the same time, the complete room should consist of green screens. With augmented reality the HMD displays the virtual environment around the other people in the room.

The room can be just an empty space with only stairs or it can be filled with real objects, or mock-ups from the concepts of the LDMCR.

Outside the room there is a screen which displays the view of the user(s) in the crew rest. With a sound connection it is possible to talk to the person inside the crew rest.

It is an interesting concept which is very useful for concept-testing: the experience of a real LDMCR becomes very clear. This concept needs quite a lot of further development.

Concept-testing

+ The test is in a real narrow space
+ The user must stand in a certain position
+ It is possible to test bunks in the crew rest with a simple mock-up
+ The entrance looks a lot like the real entrance of the LDMCR
– It is difficult to test different stairs

Presentation (e.g. on an expo)

+ The experience of a real LDMCR become very clear
– It takes a lot of space
– The construction is not easy movable
– It can be a barrier for someone to step into a 'black box'
– It takes a lot of time for the setup

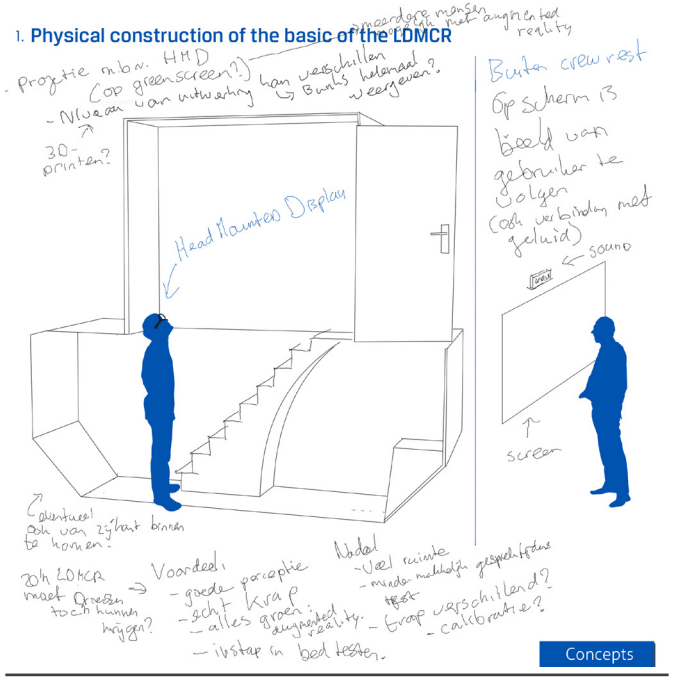


figure 35. Idea 1

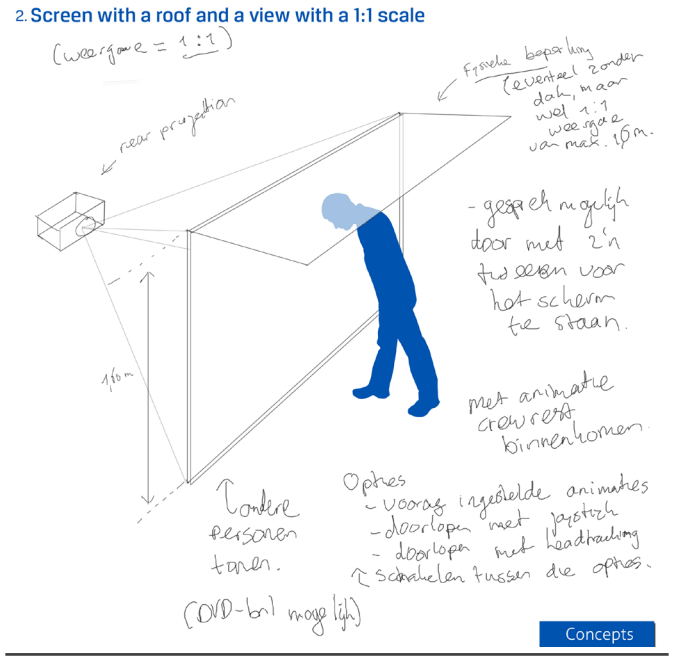


figure 36. Idea 2

2. Screen with a roof and a view with a 1:1 scale

A visualization of this idea can be seen in figure 36.

This concept consists of a screen with a rear projection and when the user stands in front of the screen there is a roof above his head. The height of the screen (and the roof) is 1.60 meter, the maximum height of a crew rest. On the screen the crew rest is shown on a 1:1 scale. It is possible to use 3D-glasses to see the environment in 3D. Animations can be used to show the entrance and how it would be to have more than one person in the room. The user can navigate through the crew rest with a joystick.

This concept is easy to setup and the real constrains of the crew nest become clear. But it is not very immersive and users have to learn how they can navigate through the virtual environment .

Concept-testing

+ The user experiences the maximum height of the crew rest
+ It is easy to stand with more people in front of the screen and test it
– Testing the bunk is difficult
– It is not very immersive

Presentation (e.g. on an expo)

+ It does not take a lot of space
+ The screen can be seen from a distance an attract people to the presentation
+ The entrance of the crew rest can be shown by animations
– It is not good for your presentation when people have to stand in an unpleasant position
– It is not very immersive

3. View of virtual environment with HMD only

A visualization of this idea can be seen in figure 37.

The user wears a HMD with head tracking and can walk on a marked field. With the head tracking the user sees what he would see in the real LDMCR at that specific height. So, when the user's head is above 1.60 meter , the HMD turns black. Next to the field where the user is walking there is a screen which displays the view of the user.

Concept-testing

+ The user experiences a narrow space
+ Head-tracking brings the person in a certain position
– The user can not point to an object he wants to say something about
– It is hard to test the bunk (to solve this you can put some physical objects in the field)

Presentation (e.g. on an expo)

+ It is possible give a realistic view of the concepts
+ It takes less time to setup
– It takes a lot of space
– Other people cannot easily see what the user sees
– It can be a barrier for someone to wear a HMD

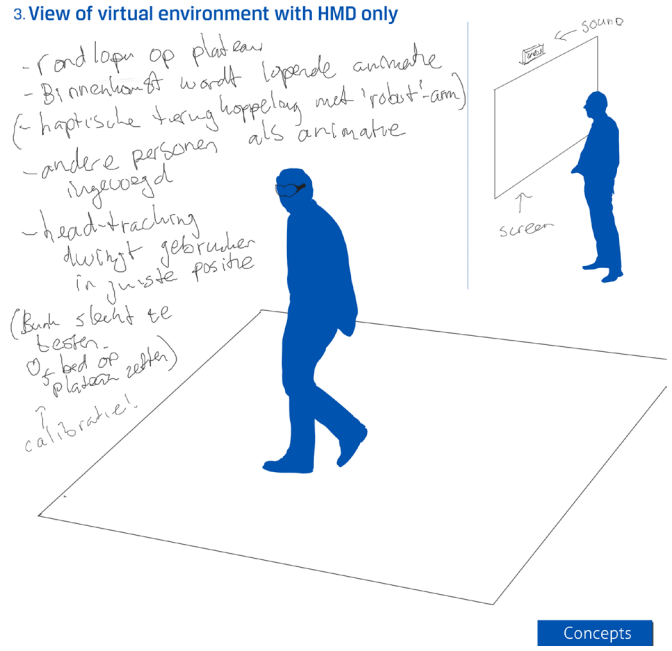


figure 37. Idea 3

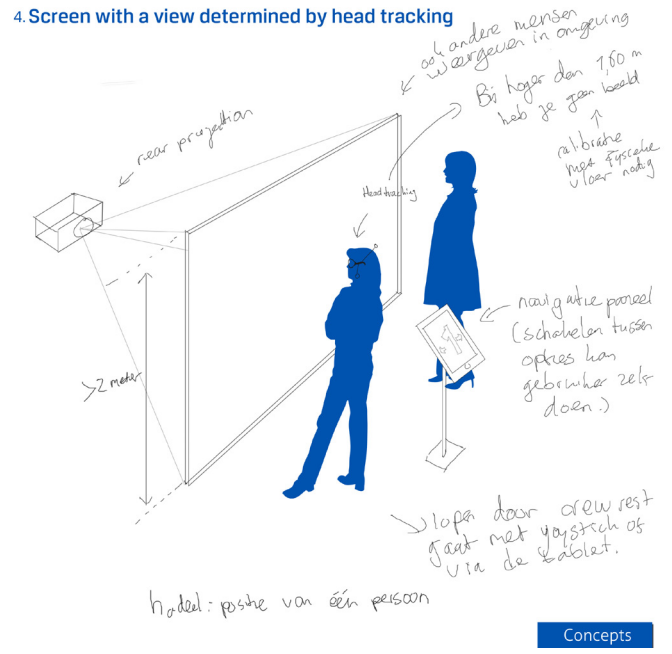


figure 38. Idea 4

4. Screen with head tracking

A visualization of this idea can be seen in figure 38.

One person in front of the screen wears a head tracking device. The view projected on the rear of the screen is specific for the person wearing that device. With a navigation panel on a tablet the user can switch between the concepts and evaluate these. Walking through the crew rest is possible with a joystick or the tablet. This concept is easy to build, al the techniques are easy to buy or to hire. IC.IDO (part of the ESI-group) builds systems like this.

Concept-testing

+ It is a concept that shows an immersive virtual environment (by the head tracking)
+ With head tracking you can show a black screen if the user is above the maximum height of the crew rest
– It shows only the view of one person

Presentation (e.g. on an expo)

+ Other people can easily follow what the user sees.
+ The screen can easily be used for showing animations of the crew rest (e.g. of the entrance)
– It shows only the view of one person
– People have to wear a VR-tool

5. Screen with user in virtual environment

A visualization of this idea can be seen in figure 39.

This concept is a lot like concept 4. The difference is that in this concept all the people in front of the screen are detected by 3D-sensors (D-Imager/Microsoft Kinect) and translated into a virtual character in the virtual environment. In this way the user can experience the position of standing in the crew rest by seeing himself in the virtual environment.

Concept-testing

+ The user can easily feel the possible positions to stand in the crew rest
– Without head tracking the virtual environment is less immersive

Presentation (e.g. on an expo)

+ It is an attractive feature to see yourself translated as a virtual character
+ The screen can easily be used for showing animations of the crew rest (e.g. of the entrance)
– It is not an intuitive navigation

6. Variations in the use of projection screens

A visualization of this idea can be seen in figure 40.

Different projection screens are possible in the presented ideas. A curved screen gives a more immersive virtual environment, but is more expensive than a flat screen. Also will it cost more time to setup a curved screen. A compromise between these options is placing two screens under an angle to each other.

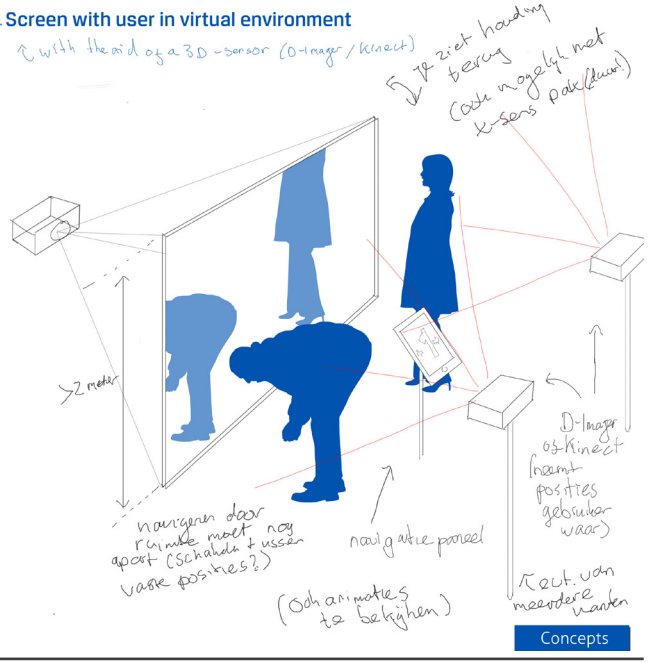


figure 39. Idea 5

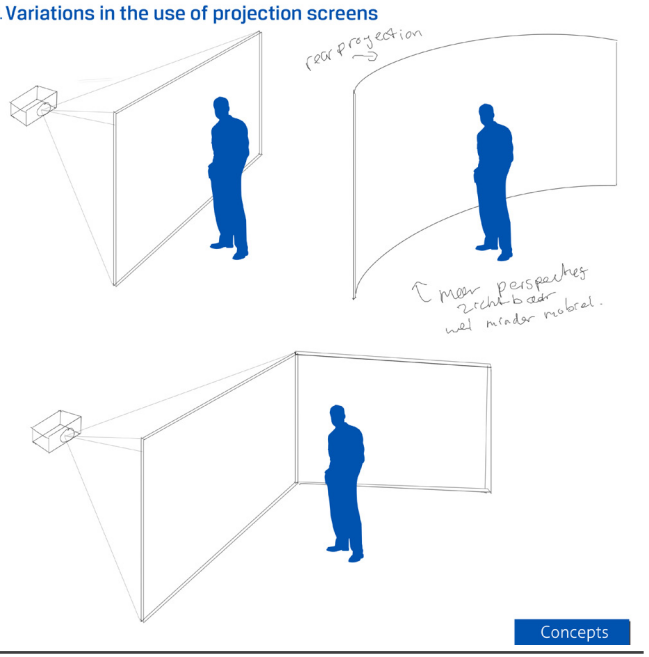


figure 40. Idea 6

7. Elumens – hemispherical display

A visualization of this idea can be seen in figure 41.

The Elumens is an existing VR-tool. In a hemispherical display you can navigate through the narrow space of the crew rest. The user sits on a chair before the display and can navigate with different tools through the LDMCR .

Concept-testing

+ The Elumens gives an immersive 3D-experience
+ It is possible to show the dimensions without standing in a unpleasant position
– The user cannot experience the possible positions in the crew rest because he has to sit down

Presentation (e.g. on an expo)

+ It is a very mobile system
+ It is possible to show the dimensions without standing in a unpleasant position
+ It is easy to setup

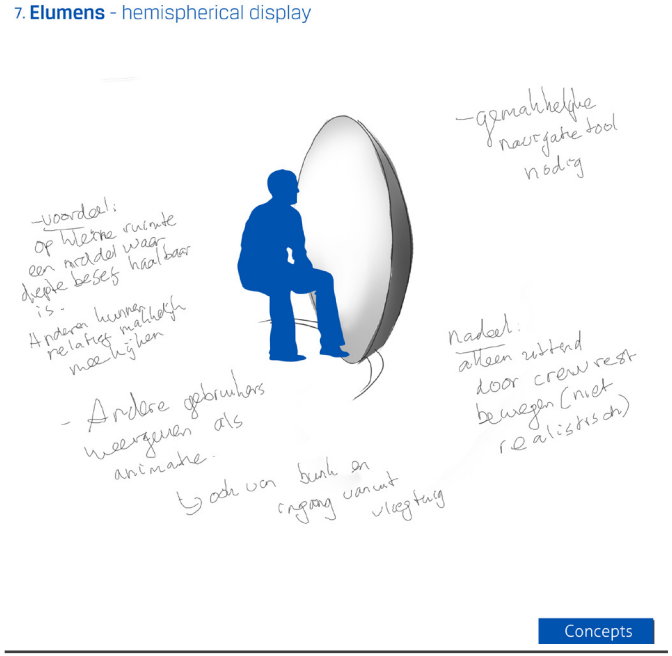


figure 41. Idea 7

8. Touch table in combination with real objects

This concept consists of two screens, see figure 42. The horizontal screen is a touch screen with a technology that can recognize objects and tags standing on the table. So, if you put a physical character on the table, the computer recognizes this and knows in which direction he looks. On the horizontal table the user can see a top view of the crew rest. When he moves the character over the table, the computer knows where in the crew rest the character stands and in which direction he looks. On the vertical screen the view from the character is displayed. In this way the user can get an idea of the proportions of the crew rest without having to walk through a 1:1 virtual environment.

Instead of only displaying a top view of the crew rest it is possible to put physical objects on the table. These objects can be recognized and displayed on the screen. This can be used for co-design. When the focus is concept-testing or concept presentation a (3D-printed) scale model can be used on the screen. Moving the character through the scale model results in a virtual visualization of the concept on the vertical screen. This concept does not cost a lot of time to build.

In this case the computer only recognizes the position and the direction of the view. If a user is given different characters with different positions it is better to see which positions are pleasant in the crew rest. With further research a character can be developed which can be completely tracked by a computer. In this way the screen can display different characters in every chosen position .

Concept-testing

+ It has an intuitive and interactive navigation
– It is difficult to experience the different positions

Presentation (e.g. on an expo)

+ It is easy to setup
+ It has an intuitive navigation
+ It does not take a lot of space
+ It is possible to show the dimensions without standing in a unpleasant position

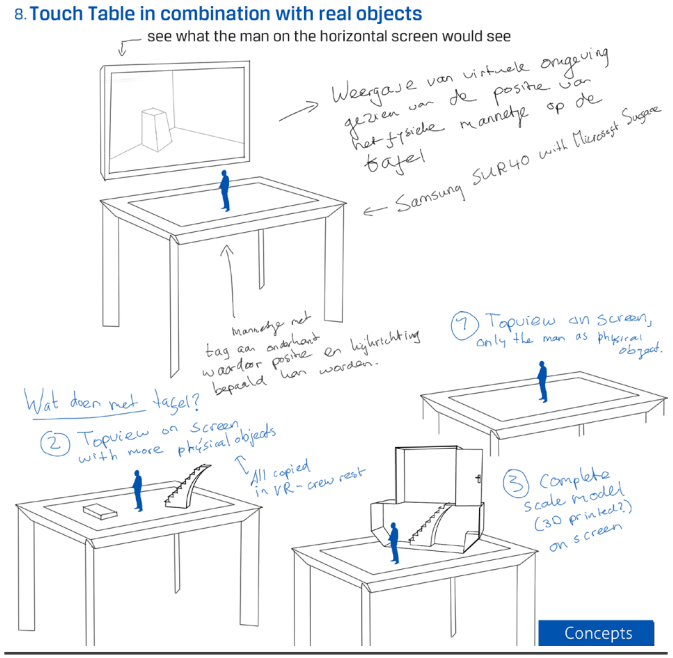


figure 42. Idea 8

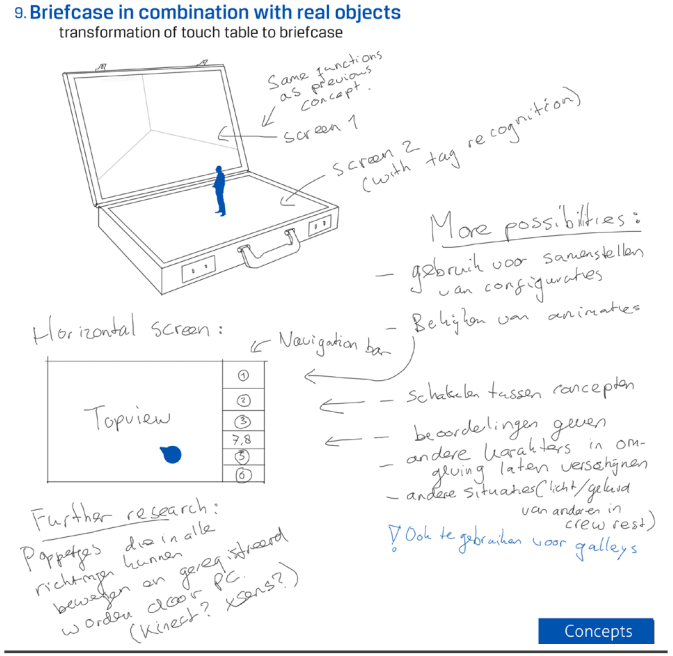


figure 43. Idea 9

9. Briefcase in combination with real objects

This concept is a more mobile variation of concept 8, see figure 43. Both screens of the previous concept are transformed into a briefcase. The horizontal screen is a touch screen and has tag recognition. This briefcase can be used to show and test the concepts. On the touch screen there is a navigation bar (this is also possible in concept 8) where you can choose different options. For example you can switch between the view of the character to animations of the crew rest or you can put features on in the crew rest to evaluate these. Also can you switch between concepts and is it possible to use this 'briefcase' for the configuration of the crew rest (and galleys) with customers. This concept takes more time to develop than concept 8, because concept 8 consists of already built VR-tools .

Concept-testing

+ It has an intuitive and interactive navigation
– It is difficult to experience the different positions

Presentation (e.g. on an expo)

+ It is very easy to take with you to potential customers
+ It is easy to setup
+ It has intuitive navigation
+ It is possible to show the dimensions without standing in a unpleasant position
– It is too small to use on an expo

5.3. Concepts

There are many differences between the shown ideas. They differ in mobility, weight, size, feasibility for on exhibitions, how much development is still needed, interactivity with the user and the way of displaying virtual reality. Idea 1 takes more time develop then others, but is very interesting for concept-testing. Idea 7 is very easy to get ready for Driessen and is more interesting for presentation of the concepts. Idea 3 is a concept with an immersive virtual environment, ideas 8 and 9 have more interaction with physical objects and idea 4 is interesting for showing concepts and talking about them.

All the ideas were discussed with Driessen and after that four different concepts were created. These four concepts are presented in the following pages.

5.3.1. **Concept A** - Physical room

Concept A (see figure 44) is like idea 1 as described above. People can walk, via real stairs, in a room with the same dimensions of a real LDMCR. With a HMD the person inside the crew rest can see how the crew rest will look like. Outside the crew rest other people can see on a screen what the person inside the crew rest is seeing.

Experience other persons

There are three options to experience other persons in the (virtual) crew rest. The easiest option is to show only virtual characters in the virtual environment. If there is more than one person in the crew rest, the reality has to be mixed with the virtual reality. It can be done with a HMD with two camera's filming the people in the green room. In this way the people can be easily cut out of the green environment and be placed in the virtual projection of the HMD. It can also be done using a transparent HMD and augmented reality. This way the HMD displays the virtual crew rest around the other people in the room, only on the green screens.

Experience the bunk

The bunk can be experienced in two ways. It is possible to give only a visual experience by showing the bunk with all the features. The other way is to place a simple bed with

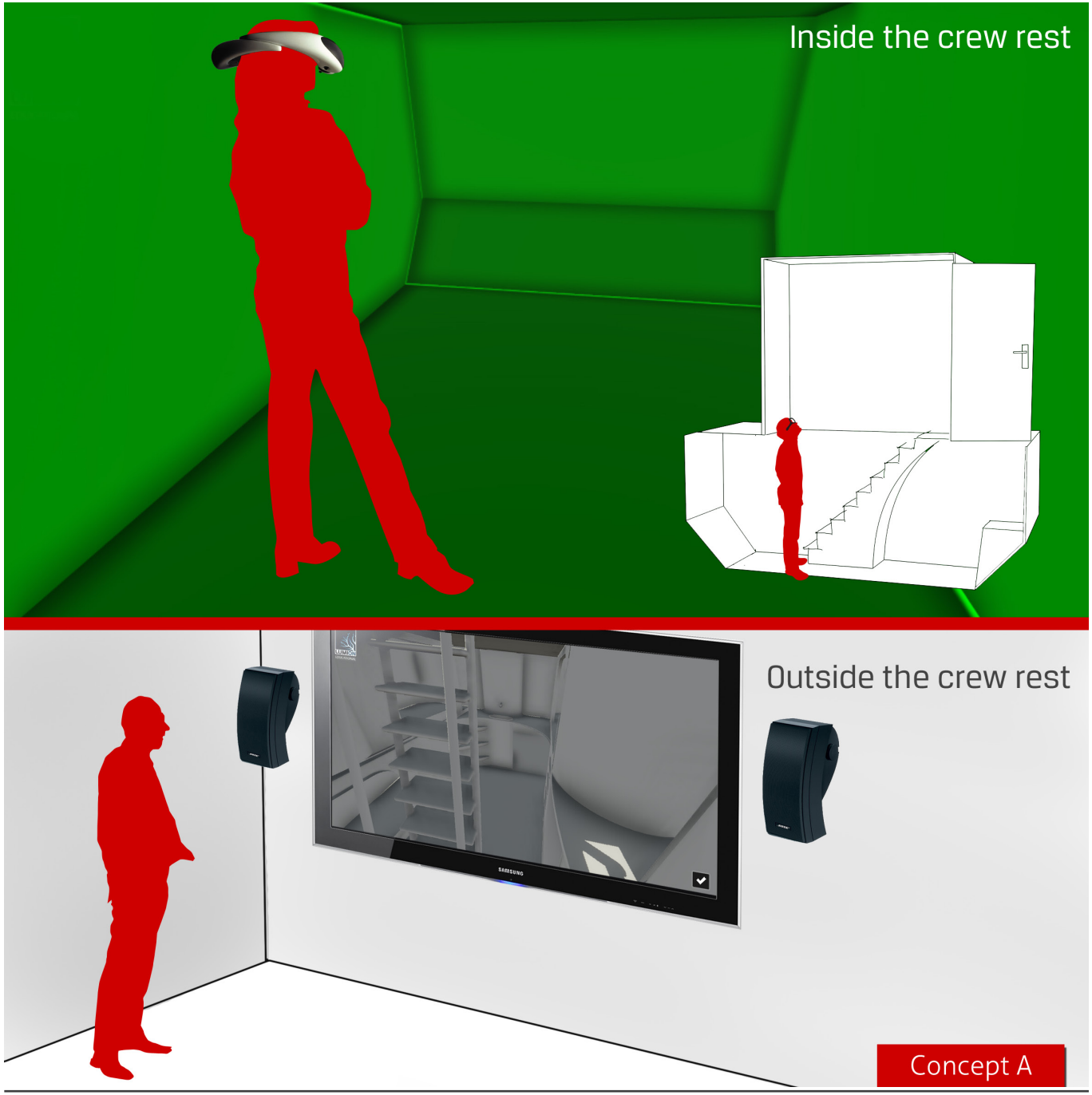


figure 44. Concept A

mattress in the green room, so a bunk can be used. The bunk can be experienced by displaying the bunk and the crew rest when the person lies on the bed.

Other physical objects can be placed in the room besides the bed - possibly created with a 3D printer. The test person can touch the objects and experiences his freedom of movement better; this increases the experience of the LDMCR.

The green screens can be made of an assembly of thin wooden plates or thin plastic panels. To make the box easier to transport the screens can be made of green fabric.

It can be concluded that this concept is a good setup for a realistic experience of Driessen's concepts and to test them. Concept A is less interesting as a presentation tool - for example on exhibitions - because it is not very easy to transport and the user has to wear VR-tools which completely close him off from reality.

5.3.2. **Concept B** - Big screen

Concept B (see figure 45) is a combination of ideas 4, 5 and 6 presented above. A big screen of about 2 meters high and body capturing with the Kinect or D-Imager are the basis for this concept. The visualization of other people in the virtual crew rest can be done in two different ways: by only showing virtual characters or by converting the tracked bodies into a character in the virtual environment. It is easy to switch between these options, because both are controlled by software. Both options let the user understand the dimensions and proportions of the crew rest better.

The screen can be made in different variants. A flat screen is the easiest and cheapest option, a curved screen gives a better immersive experience.

To show the right 3D view for the person in front of the screen, head tracking is needed. A Kinect or D-Imager can be used for the head tracking. For a more accurate head tracking a user could wear a special head tracking device.

figure 45. Concept B

A tablet which can be used to select features of the crew rest and control other crew members in the LDMCR stands In front of the screen. It can also be used for evaluating the different concepts and switch between them or to select animations, for example of the entrance of the crew rest.

The way of navigation through the virtual environment is further researched and described at page 22.

This concept can be used for concept-testing. There is no physical interaction with objects and the bunk is difficult to test, but the proportions become clear by showing the right view using head tracking. This concept can also be used for concept presentation. The big screen enables that more than one person can look at the redesigns for the LDMCR.

5.3.3. **Concept C** - Hemispherical display

This concepts (see figure 46) consist of an already existing VR-tool: the Elumens. It is a simple, compact and easy movable application that gives an immersive 3D experience. A user can sit down while navigating through the virtual space, which is ideal for longer tests. Concept C is an attractive setup for concept presentation, in particular on an exhibition. The hemispherical display can be created in different sizes if more people at once want to see the virtual environment.

Because the user is sitting, the crew rest can be seen from the height of the user. This makes it possible to experience the real proportions of the crew rest.

To experience other FA's in the crew rest, they can be displayed as virtual animated characters. With a user interface some animations can be selected or features in the crew rest can be switched on or off.

The biggest problem of the existing Elumens is the way of navigation. It is not an intuitive way because you have to use a mouse and a keyboard. To improve the way of navigation of the Elumens, a brainstorm is done. The results of the brainstorm can be seen in the box on page 22.

figure 46. Concept C

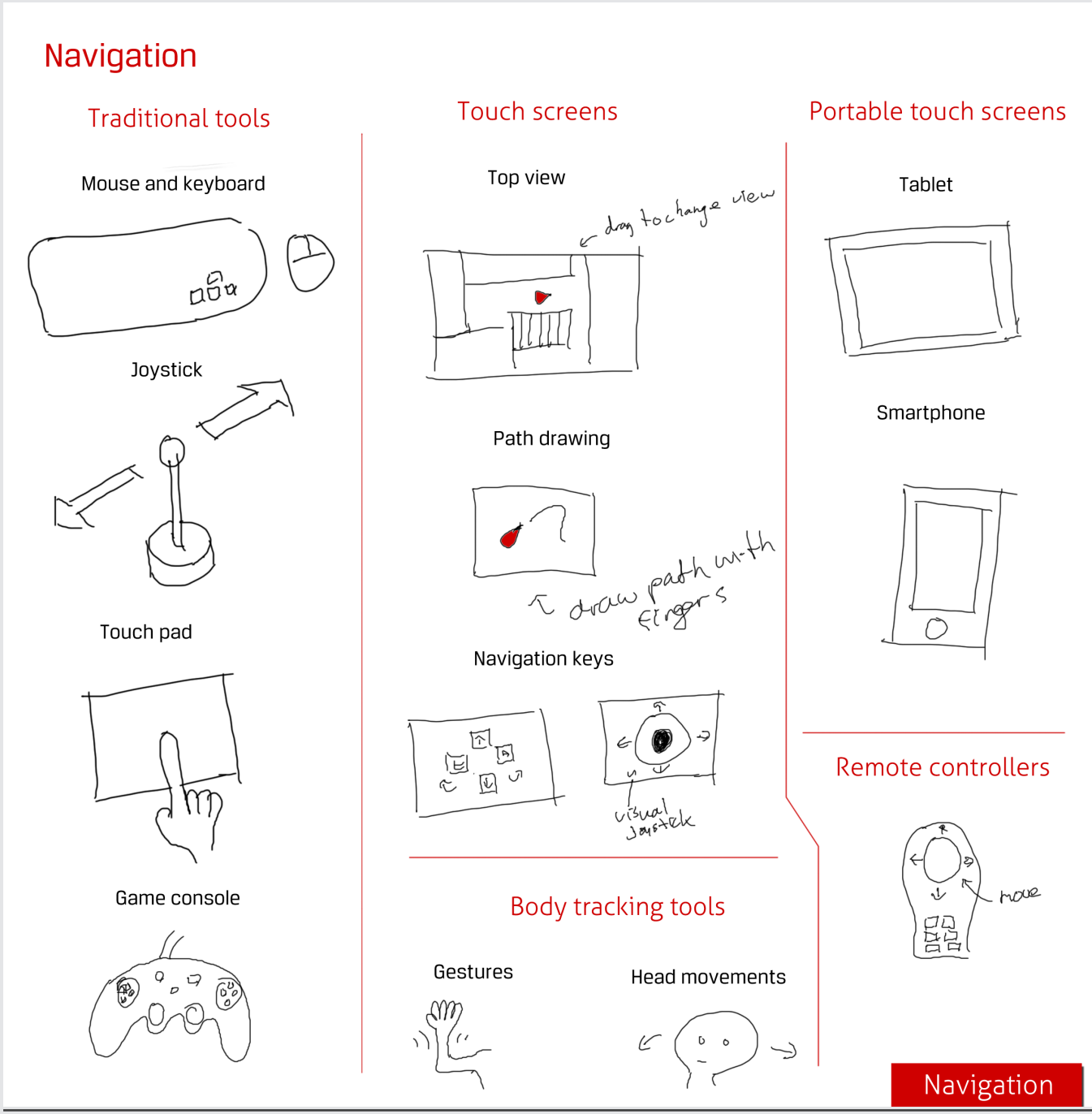


figure 47. Navigation brainstorm

Navigation brainstorm

To obtain more insight into the way of navigation through a virtual environment a brainstorm is done. In figure 47 some results of the brainstorm are shown.

For concept C the pre-existing ´Elumens´ is used. The standard navigation tool for this hemispherical display is a mouse and a keyboard. This is not a very intuitive way of navigating, so research is done to find a better way to navigate for people without experience with walking through virtual environments. Also for concept B the way of navigation needs more explanation, so the brainstorm is not only focused on one concept but looks at the improvement of all kinds of navigation tools for all the concepts.

The results of the brainstorm are shown below:

Traditional tools

Traditional navigation tools are a mouse and keyboard, a joystick, a touch pad and a game console.

Body tracking tools

With body tracking tools all body movements can be tracked en converted to a movement in the virtual environment. When, for example, you bow your head to the right this results in turning to the right in the virtual environment. [15]

Remote controllers

With a remote controller users can navigate through an environment. Navigation can be done by moving a stick or using buttons.

Touch screens

Touch screens can be used in many different ways. For example by placing a character in a top view and move it to change the view or drag a path in front of it to move him.[16] Also navigation keys or a virtual stick can be used.

Portable touch screens

Besides fixed screens, also portable variants can be used.

5.3.4. **Concept D** - Touch Table

Concept D (see figure 48) is created in the continuation of ideas 8 and 9 shown before. On the horizontal screen a top view of the crew rest is shown. With tag recognition the touch table ´knows´ were the physical character stands and in what direction he looks. The view of the character is displayed on the vertical screen.

More physical objects can be added to the virtual top view of the LDMCR , for example a model of a bunk or the stairs. It is also possible to build a complete 3D maquette and place it on the touch screen. If the maquette does not have a floor, the screen can still recognize the tag of the character on the screen. In the future a character can be developed which is not recognized by a tag on the bottom but with full body capturing. Then the character can be placed in every conceivable position and it can be copied to the virtual environment on the vertical screen.

The test user can experience the proportions of the crew rest without a 1:1 view. By showing a top view the navigation is intuitive and the user understands well what he sees in the crew rest.

Besides the top view also a menu is displayed on the horizontal screen. In this menu the user can select animations, place other characters in the crew rest or turn features on or off.

This setup is a very attractive application for an exhibition. The disadvantage of this concept is that spare parts are often stolen on exhibitions, this is something that still needs a solution.

Concept D can be used for concept-testing but is especially valuable for concept presentation.

Mobile variant

Idea 9 describes a mobile variant of idea 8. The idea was to create a smaller variant of idea 8 in a brief case. The mobile variant is further developed and four different setups are invented. The invented ideas are listed below and can also

figure 48. Concept D

be seen in figure 49.

- Create a 'suitcase' of two smaller screens. The horizontal screen must have the Microsoft PixelSense technology for tag recognition.
- The existing touch table with PixelSense can be used without legs. So the mobile variant can be the touch table without legs and with a 40 inch display as cover. This is a much bigger and heavier variant than the idea just described. The advantage is that this idea also can be used with legs on - for example - an exhibition.
- The concept can also be worked out without the PixelSense technology. Instead of using a physical character with a tag, a visualization of a character on a touch screen can be used. This character can be moved with fingers on the touch screen. In this case, concept D can consist of two 40 inch (touch) screens, this is lighter than the previous described mobile variant.
- As a smaller variant of the previous idea, a dual screen laptop can be used. Both screens are touch screens, so it is easy to use for this application.

These four ideas must be worked out more detailed to choose the best option. So far it shows what the possibilities are of the mobile variant and that it is a feasible idea.

5.4. Conclusions

In three steps four concepts are developed. The concepts are very different from each other. One is especially good for concept-testing, another for presentation of the redesigns. In the next chapter a concept proposal for Driessen is given, this way they know what is the best option to use virtual reality for what they want.

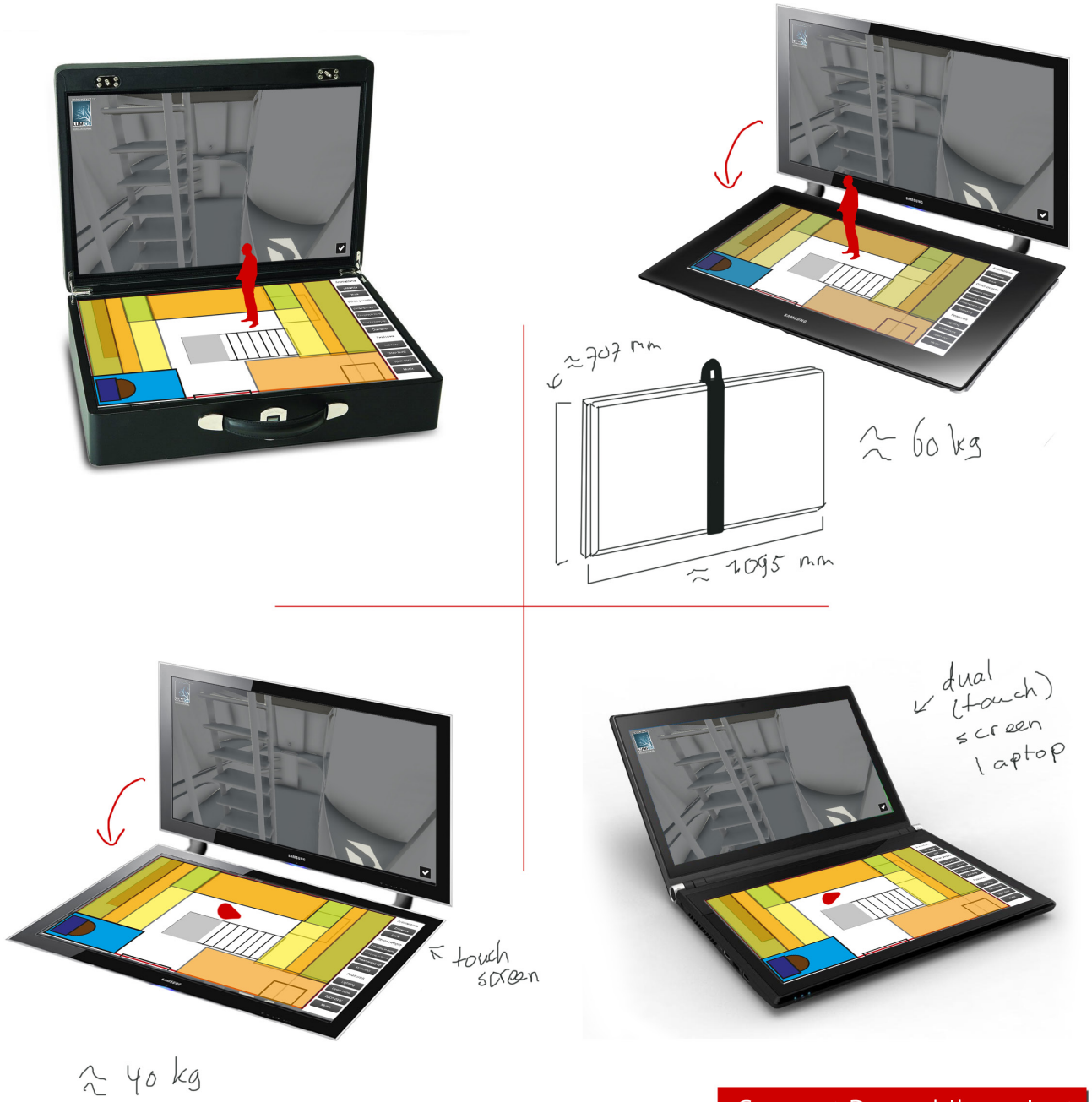


figure 49. Concept D - mobile variant

Test with 3D software

To obtain more insight into the connection between the software Driessen uses and the software that can be used for displaying virtual environments, a test with different 3D software packages was done.

The 3D models of Driessen are created in SolidWorks. This software cannot be used for displaying the redesigns in a virtual environment. To open the SolidWorks model in an application that can be used for walking through a VR environment, the model has to be converted to another file format. For this test the model is exported as a STL file. This file is loaded in Autodesk 3DS Max and then the materials and lights can be added and edited. Next the file can be exported as a COLLADA file. This file format can be used for interactive 3D applications, which can be used to display the design in a virtual environment. For this test Lumion is used for displaying the models in VR. In Lumion materials and lights can be edited with an easy user interface.

The test is done with all the available models of the redesigns for the crew rest. The results of this test can be seen in figure 50.

After doing this test, I heard about the SimLab Composer. [17] This software can convert models from many different formats. The SimLab Composer can convert a SolidWorks file directly to a COLLADA file. With the use of the STL format via 3DS Max the complete model is converted into one part. With the SimLab Composer all the parts remain intact, so the materials of the parts can be edited separately in Lumion.

This test shows the possibilities of converting the SolidWorks models of Driessen to a model in a virtual environment. The results of this test can be used for the further development of using virtual reality in concept-testing of the crew rest.

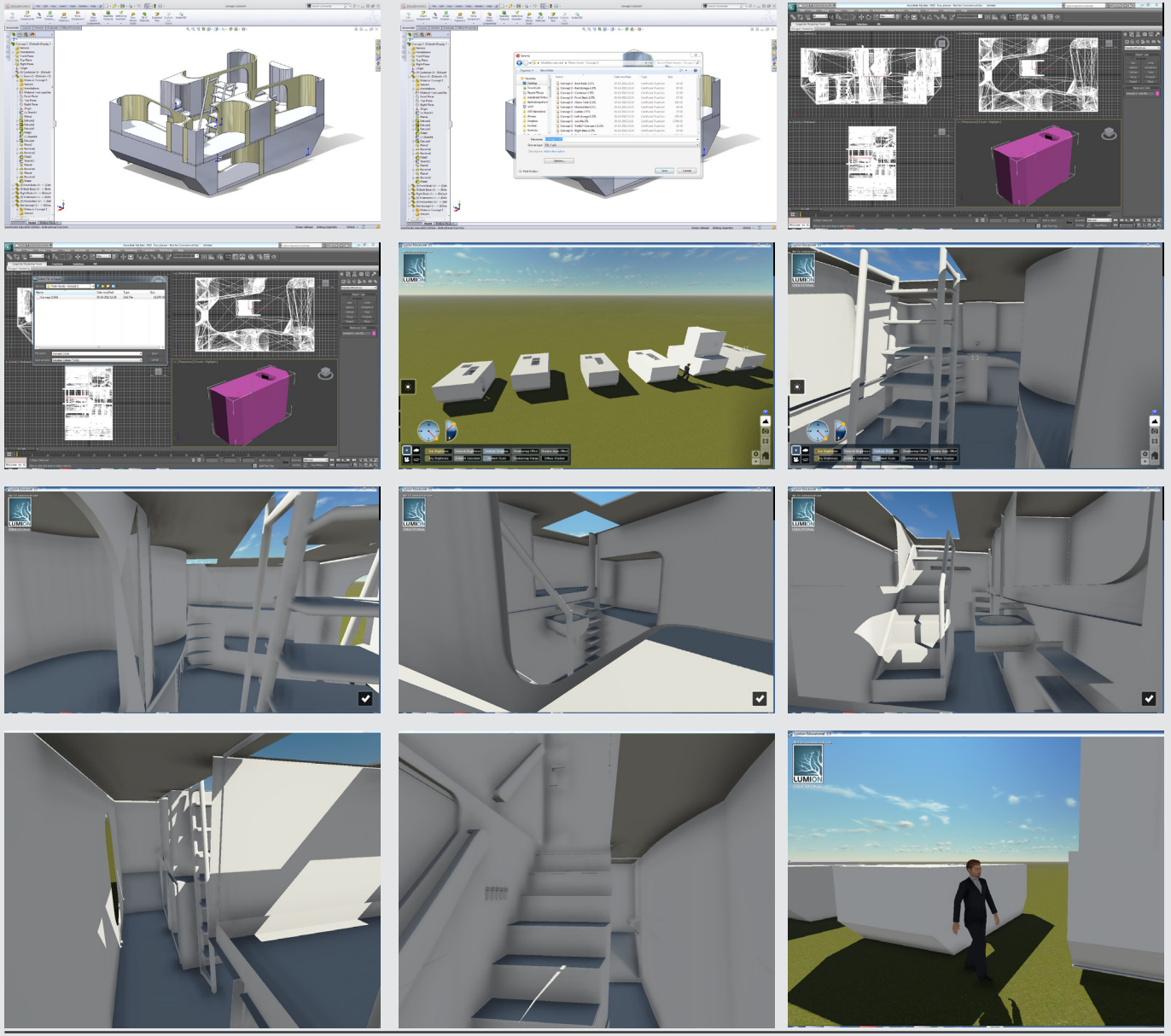


figure 50. Screen shots of the test with SolidWorks, Autodesk 3DS Max and Lumion

6. Advice

Driessen wants to know what is the best way to use virtual reality in the concept-testing of the redesigned LDMCR. Besides this Driessen is also searching for a method to use VR in concept presentation to potential costumers and for communication between Driessen's locations. Because the big differences between these three purposes, in this chapter a different concept will be advised for every purpose. First the advice for the main purpose of the assignment will be described. After that an advice for a setup for concept presentations, especially on exhibitions, is given. At last, a short advice for the use of virtual reality for communication between different locations is described.

6.1. Concept-testing

The first objective of this assignment is to advise Driessen how they can use virtual reality in concept-testing. The best way of testing the concepts and let a user experience the developed redesigns is with the ideas described in Concept A, the physical setup of the crew rest. With this concept the user can experience the previously mentioned characteristics of the redesigns better than with all the other concepts.

It takes some time to explain the technique used for the tests, so it is advisable that the test users have enough time to experience the way of testing. The HMD works and navigates intuitively, but it takes some time to become acquainted with it. It must be taken into account that it will also take some time to build the complete construction.

Driessen has to take several steps to prepare this design before testing it with FA's. In this chapter an advice for the further development of this setup will be described. First a description of the physical setup is given and after that a description of the software needed for this design.

Hardware

Basic construction

The setup consists of a frame of light weight metal profiles. The configuration of the beams can be seen in figure 51. It has the same dimensions as the LDMCR: 1.6 meters high, 4 meters wide and 2.6 meters deep. At one side of the frame are placed four vertical beams. Two of them can be used for fixing a flat screen and the other two beams for the entrance of the construction.

figure 51. Basic frame

To create a closed room for doing the tests, this light weight construction will be filled with plastic panels, as can be seen in figure 53. Many different companies create light weight panels. For example, Eriks (at Alkmaar, the Netherlands) creates 'Rocklight', a robust and light weight PP-plate material, which is used for wall panels. [31] The material can be seen in figure 52.

figure 52. Rocklight

For the audio connection between the test user in the LDMCR and the person outside the construction, sound boxes can be attached to the frame. For the visual connection, a flat screen is attached to the frame. On this screen the person outside the crew rest can see what the person inside sees. It is also possible to use a screen that can detect touches so the person outside can highlight objects in the virtual crew rest by touching them.

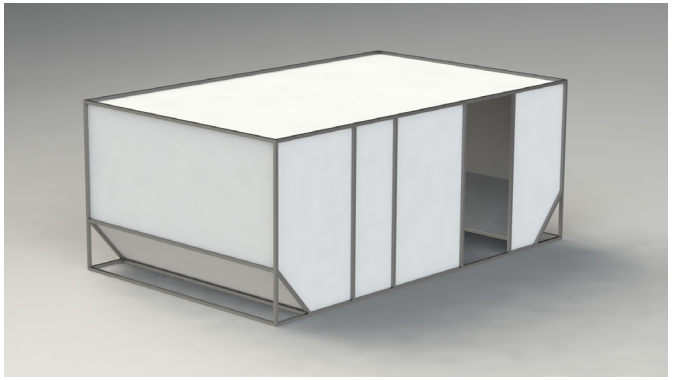


figure 53. Basic frame with panels

Besides the big screen, a tablet will be installed for more interaction between the person outside the LDMCR and the virtual environment. On the tablet the position of the person inside the VR crew rest is displayed. The tablet can also be used for switching between different concepts, adding animations of other FA's in the crew rest and turning features in the crew rest on or off. A visualization of the user interface on the tablet can be seen in figure 54.

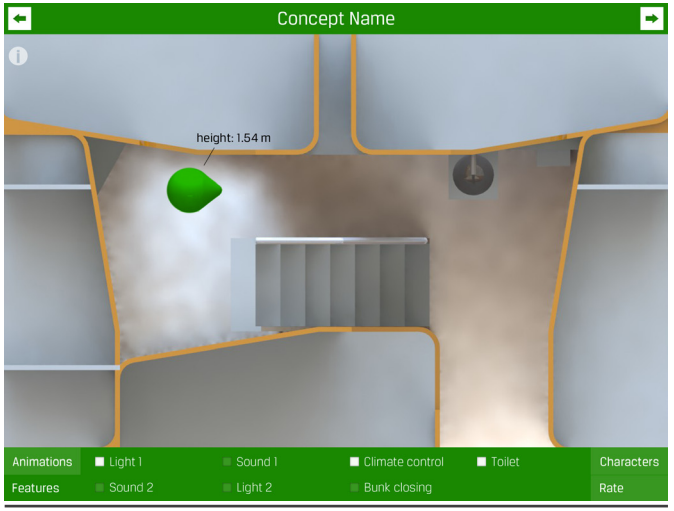


figure 54. User interface on the tablet

For the connection between all the mentioned features a computer system is needed. For the configuration of the complete construction, see figure 55.

Head mounted display

There are many different types of head mounted displays. This purpose has several requirements for the HMD. First the HMD needs build-in head tracking so the computer system knows where in the crew rest the person stands and in what direction he looks. The HMD also needs a high resolution for a realistic representation of the designs, a way to play sound (or the possibility to add earphones) and the possibility to show a realistic 3D view. Many HMDs only show a screen at a certain distance, but for this application a more immersive 3D experience is needed to give the user a real experience of the virtual concepts. In addition to all these requirements, it is desirable that the HMD can be connected wireless to a computer system. If not built-in, the test user has to wear a microphone besides the HMD for the audio connection with the person outside the crew rest.

The two best HMDs for the concept-testing of the crew rest are the Personal 3D viewer (HMZ-T2) of Sony[32] and the Oculus Rift, a product from kickstarter.com.[33] These products are displayed in figure 56.

The HMZ-T2 has two OLED displays, a resolution of 1280x720, head tracking, build-in headphones and weighs about 0.33 kilograms. It can be connected to an output device with HDMI. This head mounted display has a field of view of 45 degrees and it can be purchased online for thousand Euros.[34]

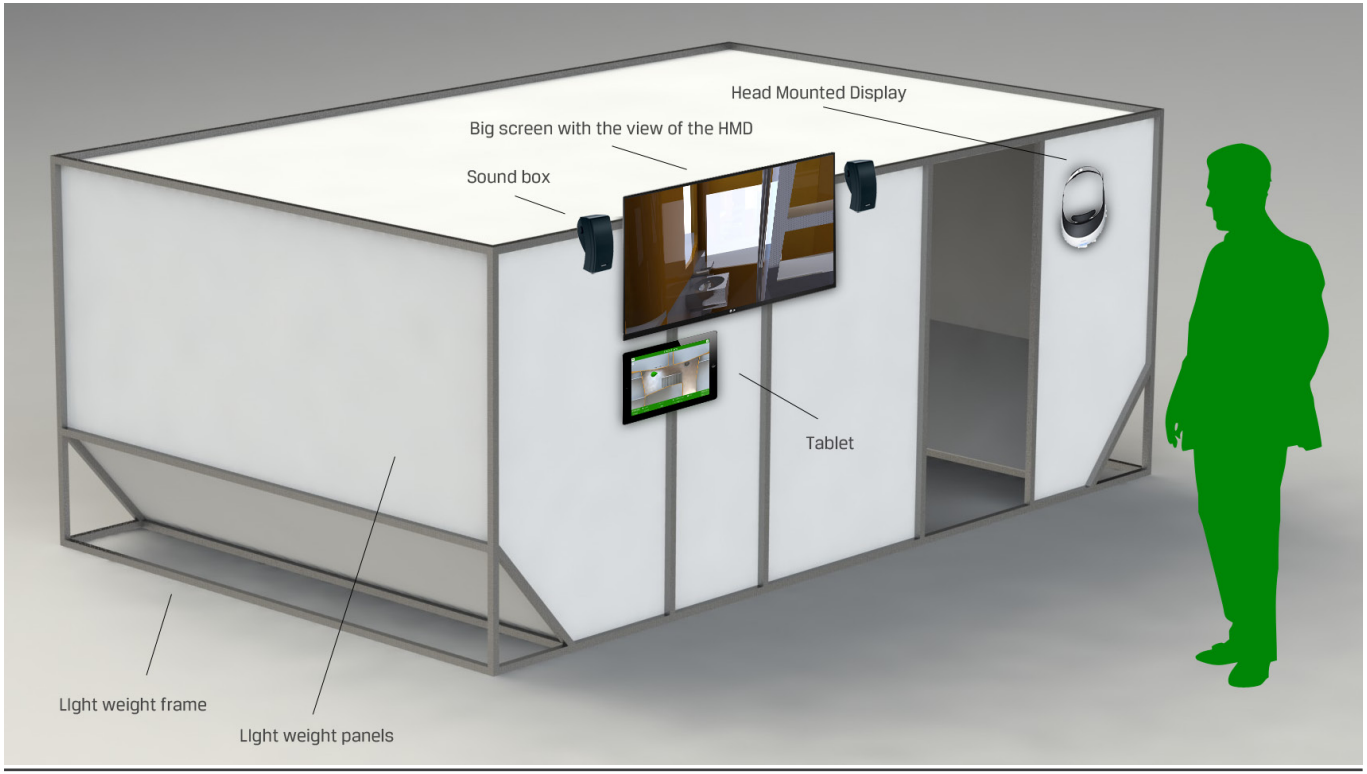


figure 55. Advice for concept-testing

figure 56. Sony HMZ-T2 (left) and Oculus Rift (right)

The Oculus is still in development and is expected in January 2013. This device has a much larger field of view: 110 degrees diagonal and 90 degrees horizontal, so this head mounted display is more immersive. The resolution is 1280x800 and the device has head tracking with six degrees of freedom. The device weighs about 0.22 kilograms and can also be connected with HMDI. The Oculus can be pre-ordered now for $300 USD.

The calibration of the HMD is very important, because the whole experience of the crew rest and the physical limitation of the movement consist of displaying the right view at the right position. For the calibration, the HMD must be put at a fixed location, which also can be seen in figure 55. If the system knows the position of that location, the HMD can be calibrated from that point.

Optional extensions

It is an option to also build the stairs and the door on the top of the crew rest, as visualized in figure 57. This gives a better experience of the entrance of the crew rest, but is not necessary for the experience of the crew rest. The user can also see the stairs and the entrance from the floor of the crew rest. For this extension stairs inside and outside the setup are needed and a light frame with panels for the box on the top. This makes the setup more complex to build. The construction must be stronger and there should be paid attention to the safety of the test user. Therefore it is possible to build this extension for a better experience but it makes the setup much more complex.

Another optional extension is a physical model of a bunk. The model can be placed in the same position as a bunk in the virtual LDMCR. This way the user can lie down in a bunk and experience it with all its features. It is recommended to use such a way for better testing the bunk. Besides a physical model of a bunk, it is also possible to build other objects of the crew rest physically. More objects in the crew rest give more physical constriction and therefore a more realistic experience of the crew rest. A disadvantage of physical objects is that is makes it less easy to switch between different concepts.

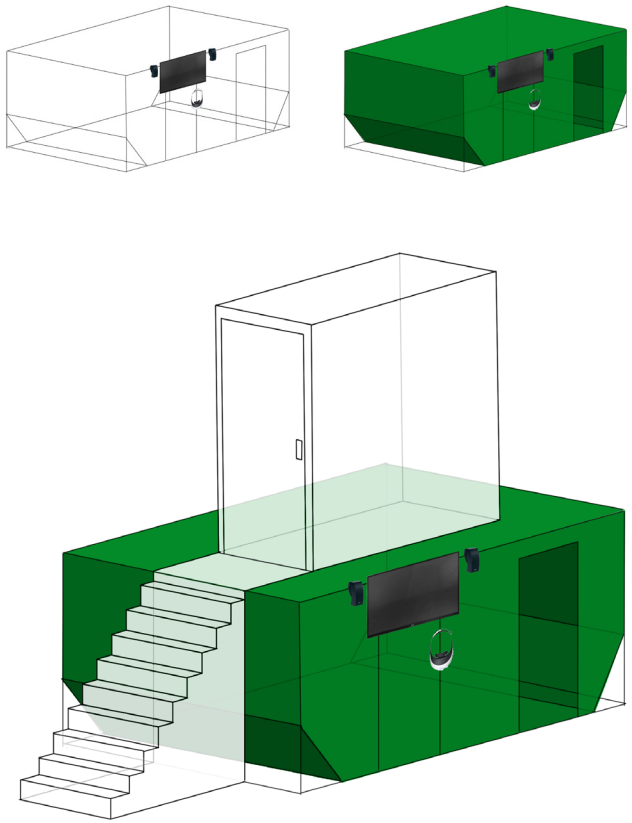


figure 57. Optional extension

Software

For proper functioning of this setup some software is needed. There already is software available for this application, but still some specific software has to be written. A 3D visualization program like Quest3d can be purchased and supplemented with a self-written framework to make all the parts of the system to work properly. In the following list an overview of the requirements for the software is given. With this list a programmer can build the software and connect each part of the setup.

Creating a virtual environment

First software is needed for creating a realistic virtual environment. Driessen has SolidWorks models of the concepts which have to be imported into a virtual environment with the correct light effects and materials. It is desirable that Driessen can easily adjust the appearance of their concepts and place them into a virtual environment. More about this process is already written on page 25.

Displaying the virtual environment

After the virtual environment with the crew rest is created, the software should show the environment. First a connection with the HMD is needed. The HMD needs two views of the environment for the two eyes, a bit shifted relative to each other to show a 3D effect. Besides displaying the virtual crew rest with the HMD, it should also be displayed on the screen outside the crew rest.

Calibration

Good calibration is needed for displaying the right view on the right place in the crew rest. The software should make it easy to calibrate, for example by resetting the HMD when it is hanging on a pre-determined location. Beside the calibration of the right view on the right place the scale of the view is also important. The user should experience the LDMCR with a scale of 1:1.

Interface on a tablet

At last the usage of the tablet should be integrated in the system. The user interface should be build and also the connection between the tablet and the displayed virtual environment. With the tablet live interaction with the virtual crew rest is needed. On the tablet features of the crew rest and animations of other people in the crew rest can be switched on or off and there can be switched between different concepts.

Conclusions

The written plan can be used by Driessen to build this setup for the concept-testing of the redesigns for the LDMCR. This concept can also be used on an exhibition, but it is mainly focused on concept-testing. To further develop this application a HMD should be purchased and tested. The first step of the software can be build and the view of the HMD can be tested without the complete construction. After this the parts for the setup can be purchased and assembled. The physical setup can be build and the software specific for this setup has to be written. After doing this and completing the construction, some tests can be done. When the setup is working properly it can be used for concept-testing.

6.2. Concept presentation

The solution for concept presentation is based on concept C with a touch screen as navigation tool. It is a solid setup that can be used for concept presentation at exhibitions. The user has an immersive experience and can use a character on the touch screen to walk through the virtual crew rest. The hemispherical view with a scale of 1:1 gives a realistic representation of the redesigns. This presentation tool is an attractive and intuitive setup for an exhibition. It is also a practical solution for this purpose, because the start up time is low, it is easy movable and it has no loose parts that can be taken by the public.

To create an advice for the use of virtual reality in concept presentation based on concept C, research is done on the use of the hemispherical display. The usage of more than one projector, spherical mirrors or fisheye lenses for the best projection and different shapes and size of the display are explored. A summary of the research can be found in the next section. After that, an overview of the setup with the chosen techniques is described.

Research on the hemispherical display

To choose the best way to use the hemispherical display and the projection on it, research is done on existing methods of using hemispherical displays.

Ergonomics

The first aspect that is researched is the field of view of a normal person and several relevant dimensions of the body. This knowledge is used for determining the place of the projector and the size and shape of the screen. A.J.H. Haak and D. Leever- van der Burgh of University of Delft have done research on the dimensions of the human body.[35] In figure 58 some conclusions of their work are shown. In this picture can be seen that the normal field of view in the vertical plane has an angle between 120 and 143 degrees. In the horizontal plane, the maximum angle of view with sharp vision is 120 degrees. The limit of the view has an angle of 188 degrees – just a little more than a semicircle.

Besides this knowledge about the human ergonomics,

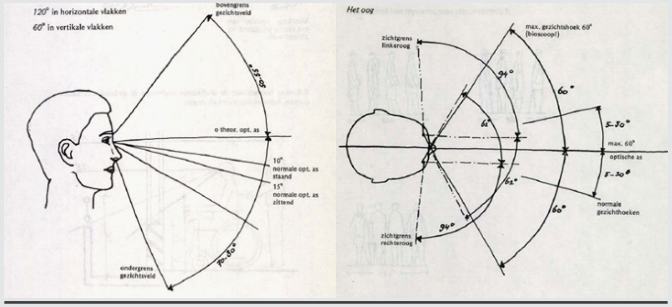


figure 58. Field of view

some dimensions of the human body are relevant for this research. Delft University of Technology has an online anthropometric database.[36] From this database some dimensions of the human body of a mixed international population are explored and listed below:

- The buttock-knee depth has a mean of 560 mm and a standard deviation of 64 mm.
- The popliteal height has a mean of 413 mm and a standard deviation of 55 mm.
- The sitting height has a mean of 868 mm and a standard deviation of 78 mm.

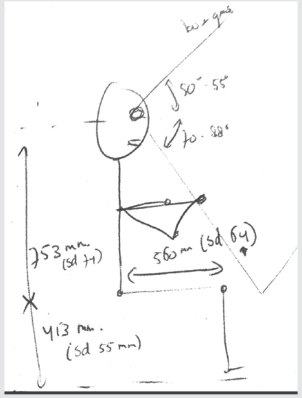


figure 59. Human body

All this knowledge is used in the further development of the setup for concept presentation.

Projection with mirrors

A spherical mirror can be used to project on a hemispherical display and move the projector from the center of the screen to another location. Paul Bourke, Swinburne University, Melbourne, has done much research to this kind of projection.[37][38] Bourke developed a dome with a spherical mirror on the ground in the center of the dome and a projector placed behind a gap in the screen. This configuration can be seen in figure 60. In figure 60 also a photo can be seen of a dome with a height of 3 meters.

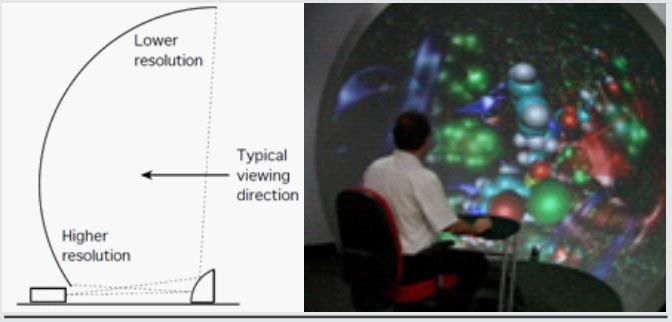


figure 60. Dome with mirror projection

More information about spherical mirror projection can be found at the FAQ-page of Paul Bourke.[39]

Based on this knowledge, some sketches are made with different locations of the projector and the mirror. These sketches can be seen in figure 61.

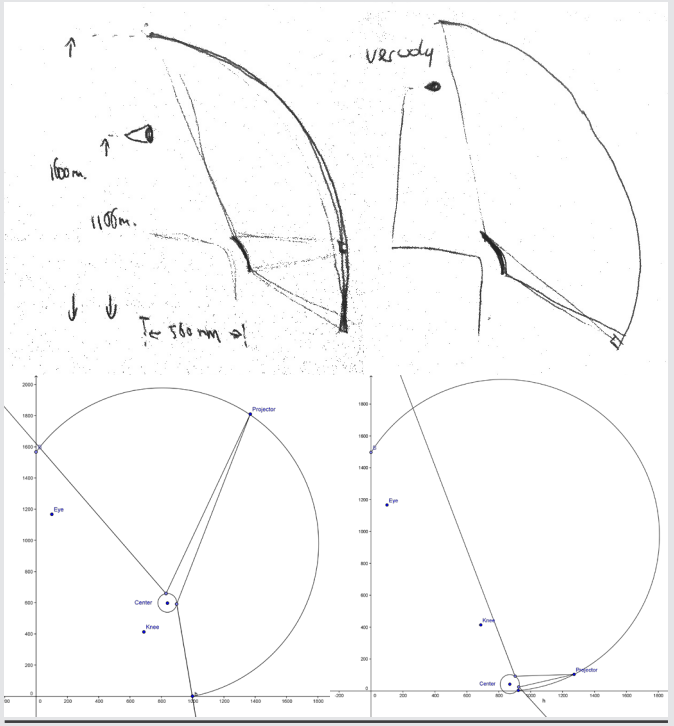


figure 61. Sketches with spherical mirror projection

Projection with fisheye lenses

Another way of projecting on a hemispherical display is using fisheye lenses. Fisheye lenses are ultra wide-angle lenses that can create hemispherical images. An example of a fisheye lens and the view through this kind of lens can be seen in figure 62.

figure 62. Fisheye lens

These lenses can also be used for hemispherical displays. Navitar (New York) creates different applications with fisheye lenses. One of their applications looks much like the setup advised in this report, a picture of it is shown in figure 63.[40] Navitar has many different lenses for many different applications. The projectors of the Navitar Hemistar HS28 serie has a focus range from 300 mm to infinity, a projection angle above 180 degrees and the possibility of HD resolution. [41] This kind of projector can be used for the setup for concept presentation.

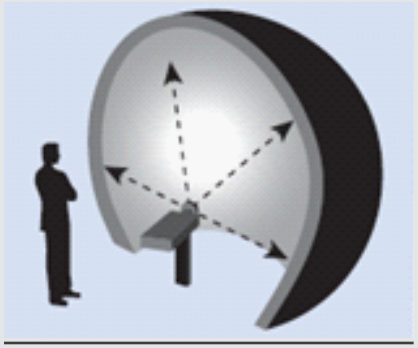


figure 63. Fisheye projection

Projection with more than one projector

For higher resolution, more than one projector can be used. Besides the development of solutions with one projector and a spherical mirror, Paul Bourke developed domes with more than one projector, as shown in figure 64. A disadvantage of these setups is that it is still impossible to stand in the hemispherical display without interrupting the projectors.

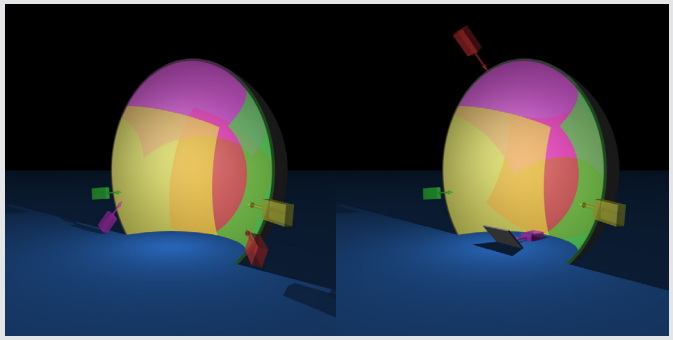


figure 64. Domes with four projectors

Other ways to place the projectors and the mirrors are visualized in figure 64. If the spherical mirrors are placed in front of the knees, the user can sit in the hemispherical display instead of in front of it. This gives a more immersive experience because the user can only see the virtual environment. For a more immersive feeling the display can be projected from the back. In that case the user can sit everywhere in the dome without disturbing the image. The disadvantage of a setup like this is that the construction takes much more space than with front projection.

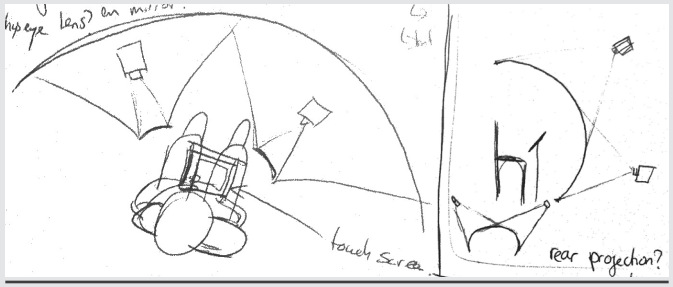


figure 65. Domes with four projectors

The hard thing of using more than one projector is the calibration of the different (overlapping) projections on the screen. Edge blending software to blend different projections on one screen keeps getting better.

Size and shape of the screen

To find the best size and shape of the screen used for this setup, different options have been reviewed. For a complete immersive experience, the screen should have a vertical angle of 143 degrees and a horizontal angle of 188 degrees (see figure 58). An overview of some different screens can be seen in figure 66. In the conclusion an advice is described with the best shape and size for this setup.

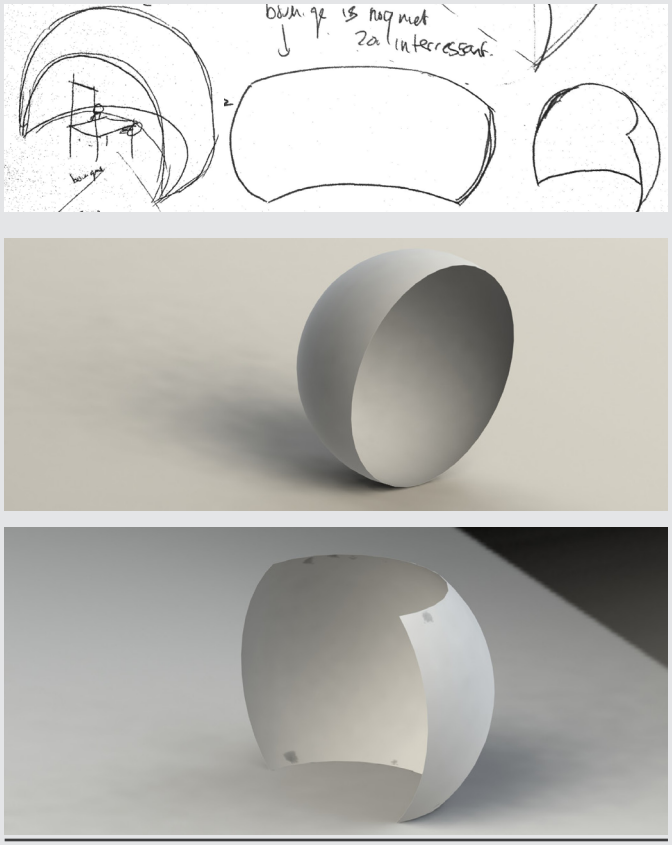


figure 66. Shapes for the display

Conclusion of the research

Many configurations are possible to create the setup. A balance needs to be found between the immersive experience and the reliability of the system when used on an exhibition. A more immersive setup is also a more complex setup. Using more than one projector gives a more immersive feeling because the user can sit in the hemispherical display instead of in front of it and the display can have a higher resolution, as shown in the results of the research. The disadvantage is the challenge of blending the projection of each projector. In particular on an exhibition the setup must be robust and reliable, so it is advised to use one projector.

By placing a big black border around the screen with no projection, the immersive feeling is much better than with the existing Elumens. With this border with no projection, the user can sit inside the hemispherical display and is not disturbed by movements and lights in his environment.

Using spherical mirrors, the user can also sit closer to the hemispherical screen. The projector can be placed behind a gap in the screen and only a mirror has to be placed in the center of the dome, so there is more space for a user. It takes more space in the dome if a projector with a fisheye lens is placed in the center. Nevertheless, the use of a fisheye lens is advised for this setup. A fisheye lens is much more reliable for on exhibitions, because the mirror is vulnerable and projecting using mirrors needs more calibration of the system. And by using a black border around the projection area of the screen it is not needed for the immersive experience that the user has more space in the center of the dome and can sit closer to the screen.

It can be concluded that the configuration of the existing Elumens is a good basis for the setup for concept presentation. The shape and size of the screen fit well in this application and with a border with no projection around the screen, the experience of the virtual crew rest is more immersive. The projector must be replaced with a newer one that has a lighter output, produces less noise and has a higher resolution.

Hardware

The basis of the construction is a frame, which makes it possible to fix the display and the projector on the correct position. The frame is supported by a stand of a semicircle with a radius of 92 centimeters. A visualization of the frame can be seen in figure 67.

In the frame a hemispherical projection screen can be mounted. The screen consists of a part with projection and a big black border around it. The black border reduces distraction by lights in the surrounding area, which gives a more immersive experience. The part with projection is 1.6 meter high, the same as the height of the crew rest. Several factories produce custom made hemispherical screens, also called domes.[42][43] A picture of the construction with the screen can be seen in figure 68 to figure 70.

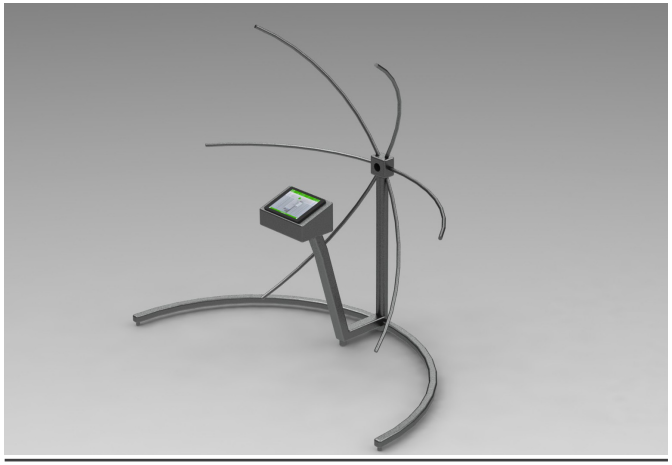


figure 67. Basic frame

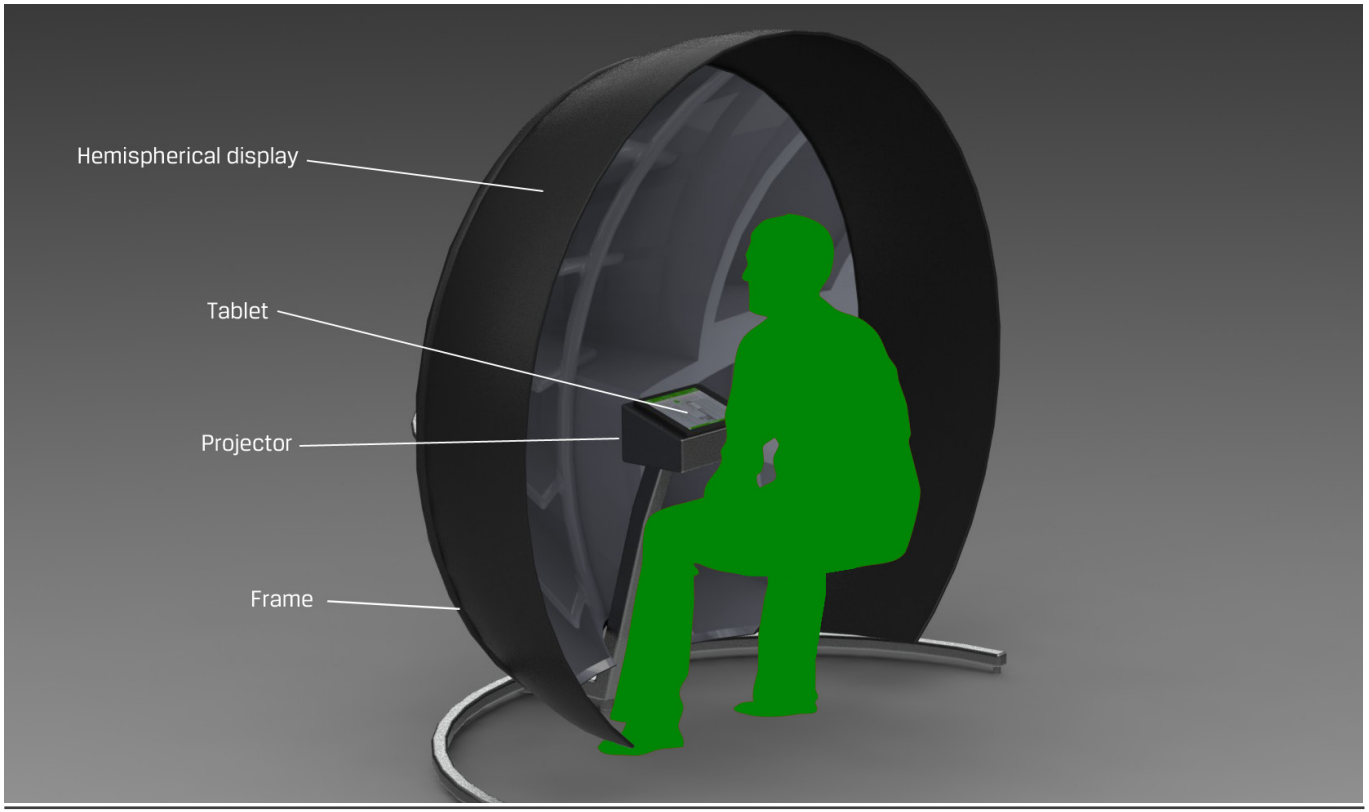


figure 68. Advice for concept presentation

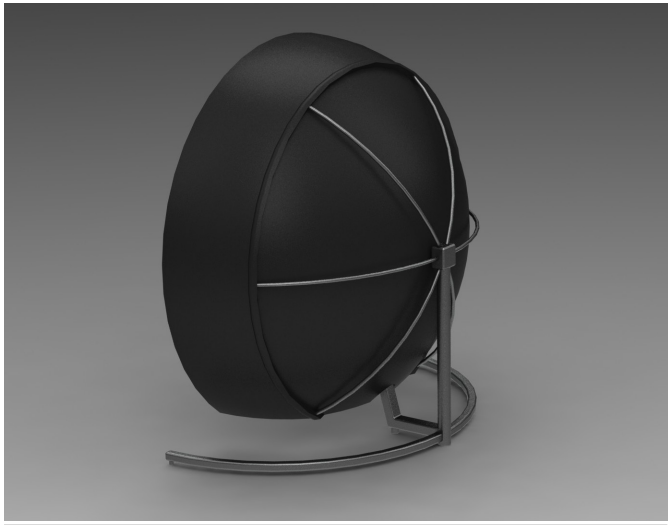


figure 69. Construction

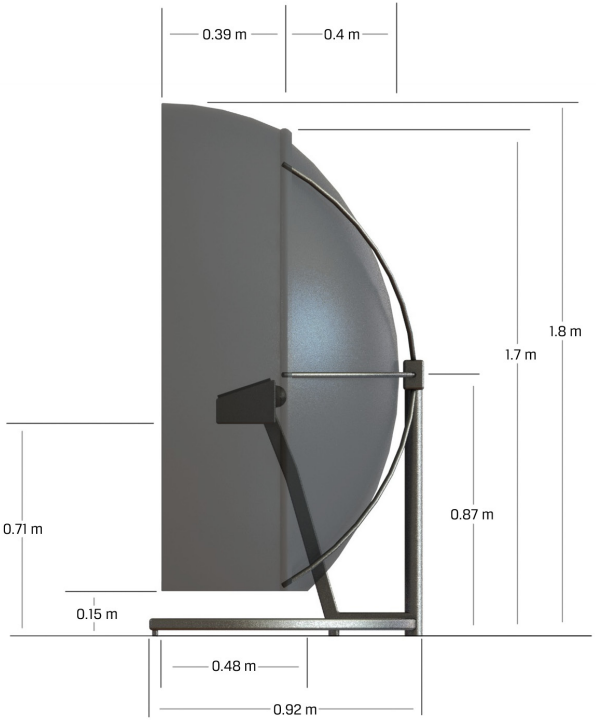


figure 70. Dimensions

For the hemispherical projection a projector with fisheye lens is advised. For this application a projector is needed which can focus on a short distance and have a high resolution. For fisheye projection a square aspect ratio is better. Projectors like the projectors of the Navitar Hemistar HS28 serie[41] can be used for this setup.

For navigating through the virtual crew rest the user can move a character through a top view on a tablet, as also visualized in figure 71. The touch screen can also be used for selecting animations, turning features of the crew rest on or off, placing virtual characters in the crew rest and rating all the concepts.

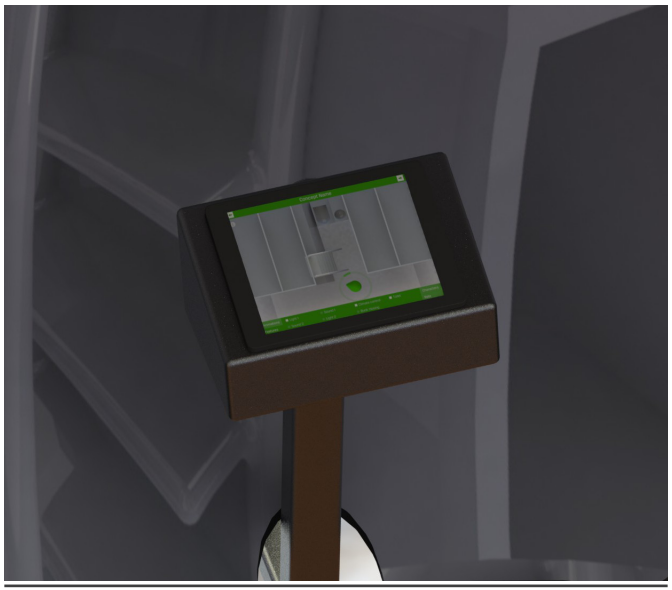


figure 71. Tablet

The last part needed for the setup is a seat for the user. A normal adjustable chair is enough for this application.

Software

As described in the advice for concept-testing, software is needed. A part of the software can be purchased and a part of the software has to be written. In the following list an overview of the requirements for the software is shown.

Creating a virtual environment

This requirement is already described in more detail on page 28, in the advice for concept-testing.

Displaying the virtual environment

When the virtual environment is created, it must be shown on the hemispherical display. The software has to show the right view of the crew rest via the fisheye lens of the projector. For this, the software must convert the view of the virtual LDMCR to a fisheye visualization.

Calibration

As described in the previous advice, calibration is an important part of the realistic reproduction of the crew rest. The projector should display a view that has a scale of 1:1 on the hemispherical display. If the software can easily change the scale of the view, with testing the right scale of the visualization can be chosen.

Interface on a tablet

As described in the advice for concept-testing, software is needed for the interface on the tablet. For this application the connection between the position and movement of the virtual character in top view and the view on the screen is important. Besides this navigation tool, the user can change several settings, which must immediately change the virtual representation of the crew rest.

Conclusions

This setup is a mobile and attractive solution for concept presentation of Driessen's redesigns on exhibitions. It can also be used for concept-testing, but this solution mainly focused on the presentation of concepts. The frame and the screen have to be custom made, but parts of the construction already exist. To build this configuration, Driessen should purchase the (custom made) parts and the software. After this, the parts can be assembled and the software adjusted to this specific application. Finally Driessen has the ideal tool for presenting their redesigns.

6.3. Concept communication

Driessen also wants a tool for the communication between several locations. This was not the main focus of the assignment, but an advice can be given after all the research that has been done. The solutions for the communication tool Driessen wants are mainly focused on the software system. In this report only a global advice will be given.

For the communication about Driessen's concepts a system as can be seen in figure 73 is advised. On the horizontal screen a top view of the crew rest is displayed. In this top view every location has a unique character, as also can be seen in figure 73, which can be moved in the crew rest. By clicking on a character the view of that virtual character is displayed on the vertical screen. In this way people on different locations can see the view of the crew rest. With a video and audio connection the people can see and talk to each other. By pointing something on the top view the object highlights on the displays at the other locations. One of the locations is the 'master location' that can change the settings of the virtual crew rest. That location can start animations, change features and switch between the concepts. The view on the horizontal screen of the master location can be seen in figure 73.

A short description will be given of the needed hardware and software for this application. This advice needs much further development, but a basis is given in the following description.

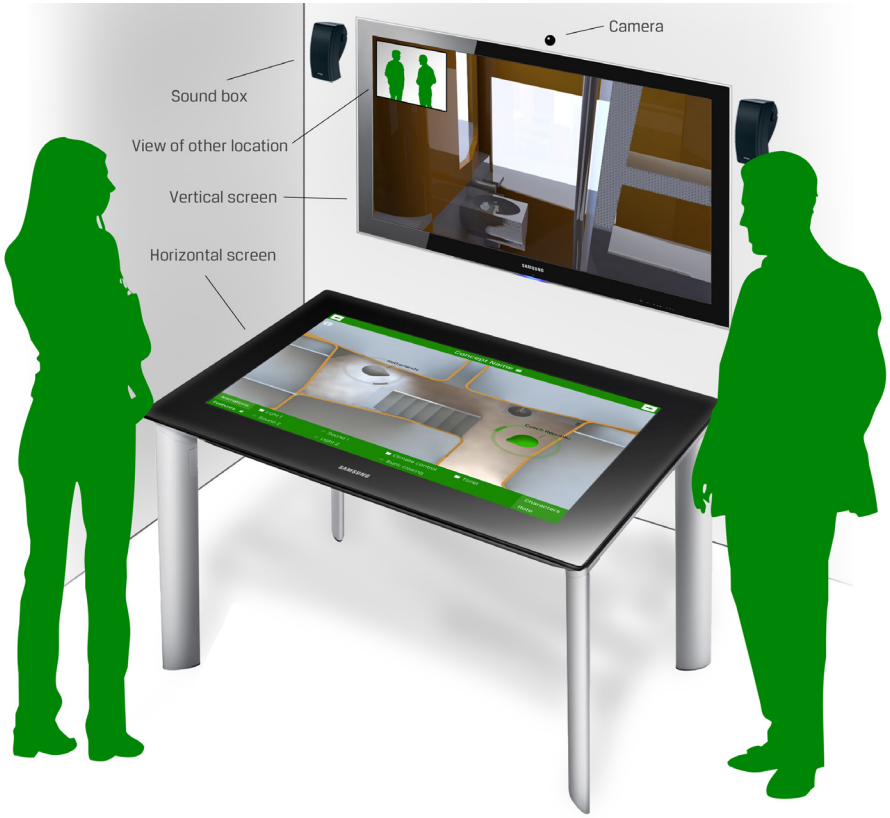


figure 72. Advise for concept communication

Hardware

The hardware consists of two main parts, the horizontal navigation panel and the vertical screen. The navigation panel can be a normal tablet, a big touch screen or the earlier shown touch table with Microsoft PixelSense. The vertical screen can also have different sizes, depending on the size of the group that must be reached. Also, the screen can have different shapes: a flat screen is possible, but also the hemispherical screen described in the setup for concept presentation on exhibitions. Driessen can choose what kind of screens they want, depending on what their exact goal is with the communication tool.

Besides the two screens, a camera and a microphone are needed for the communication between the locations. For the connection between all the parts of the setup, a computer system is also required.

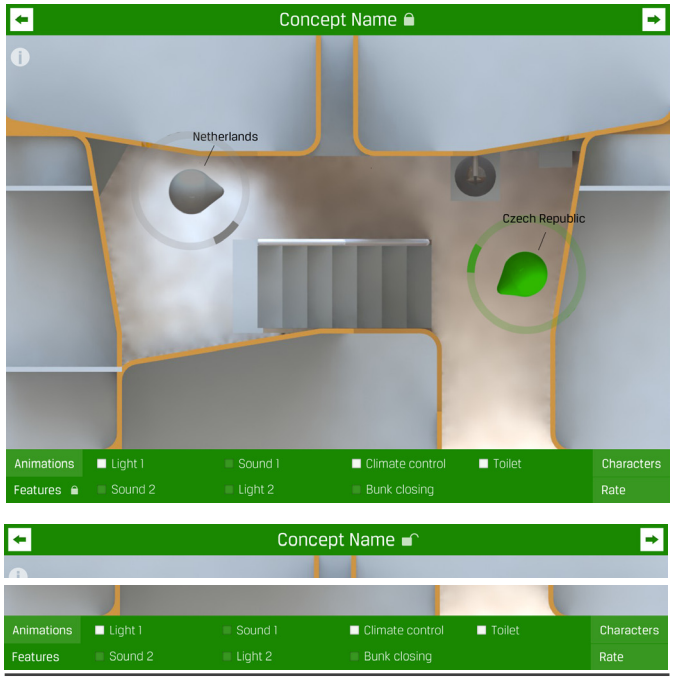


figure 73. User interface (top: normal, bottom: master)

Software

The network system between the different locations is the most important part of the software. Besides that, the interface of the touch screen has to be built, in connection with the virtual visualization of the redesigns on the vertical screens.

Conclusions

If Driessen wants to build this tool, further development is needed. Maybe this concept can be developed in collaboration with IC.IDO, a company with experience in the field of virtual concept communication over a physical distance. Driessen can use this advice (and the software written for the setups for the concept-testing and concept presentation) as basis for the communication tool that has to be built.

6.4. User interface

In all the described recommendations, an interface on a touch screen is shown. This user interface will be explained in more detail here. The interface has the same basis in every recommendation, as visualized in figure 74. On the screen, a top view of the crew rest with one or more characters is displayed. In every advice, the character has a different function. It shows the location of the user with the HMD, it can be used to change the point of view on the hemispherical display or it shows a person on another physical location. In the top of the screen the name of the concept is displayed and the option to switch between concepts is presented. By clicking on the information button the user can read more information about the user interface and the concept. On the bottom of the screen is a menu with four items: 'Animations', 'Features', 'Characters' and 'Rate'. Each item has a different content, which will be described now.

Animations

In the animations menu an animation can be selected and played, for example animations from the entrance, the bunk or the possibilities of freshing up, see figure 75.

Characters

In the character menu, several other flight attendants can be placed in the virtual environment, see figure 76. By selecting characters in the virtual crew rest, the presence of others in the tight space of the LDMCR can be experienced.

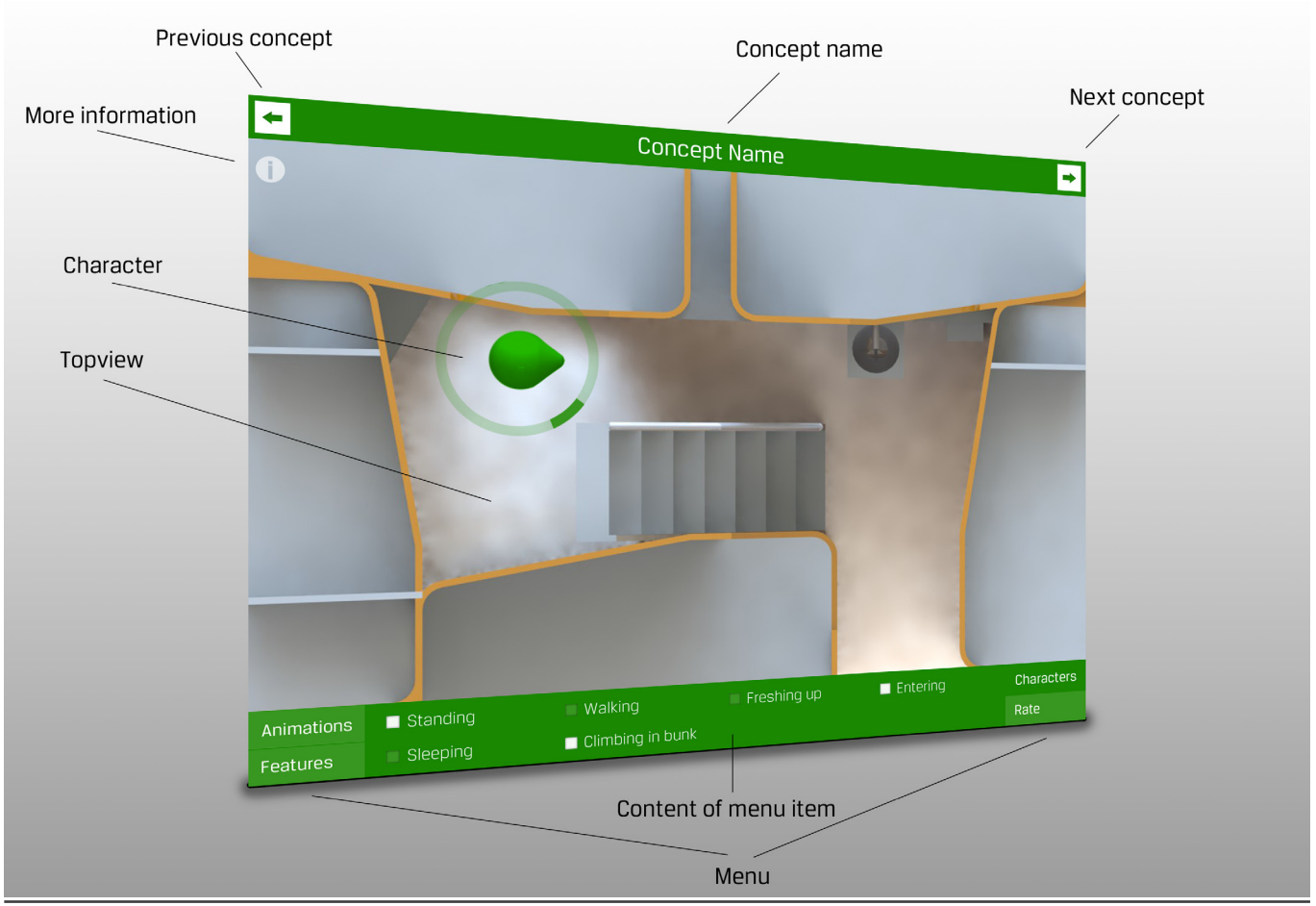


figure 74. User interface

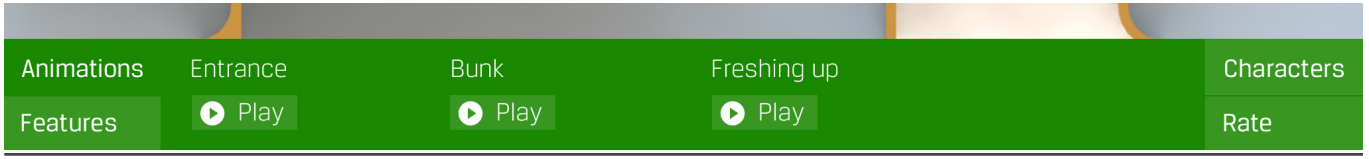


figure 75. Animation menu

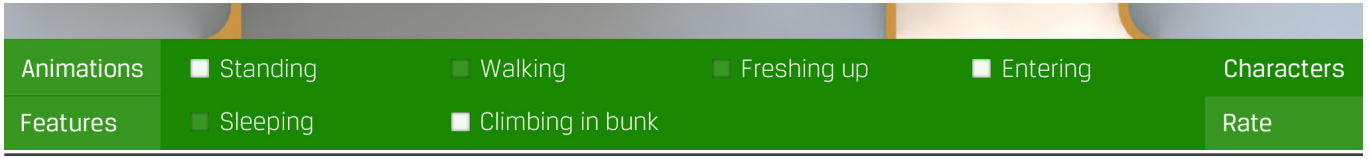


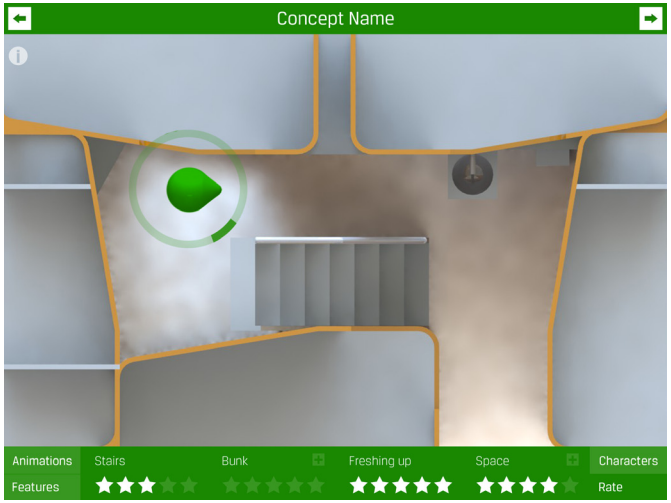
figure 76. Characters menu

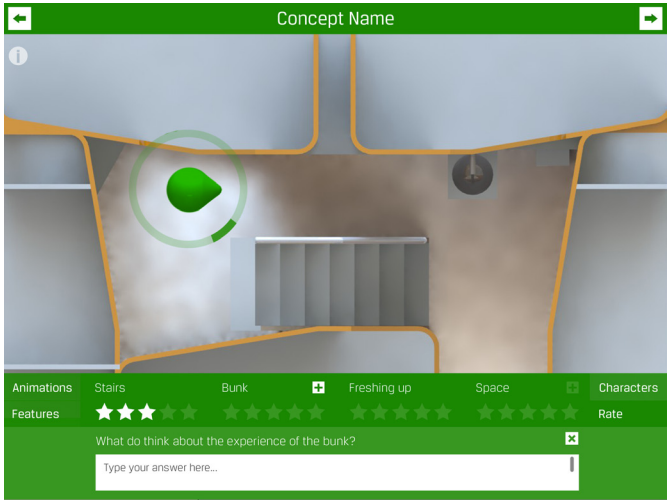
Features

In the feature menu, several features can be switched on or off, see figure 77. So the user can see and experience the effects of the features in the crew rest.

Rate

The last menu is the rate menu, in which the concepts can be reviewed, see figure 78. The data can be used by Driessen to evaluate the redesigns. Different parts of the redesign can be rated by giving stars. It is also possible to ask questions, which can be answered using a keyboard on the touch screen.





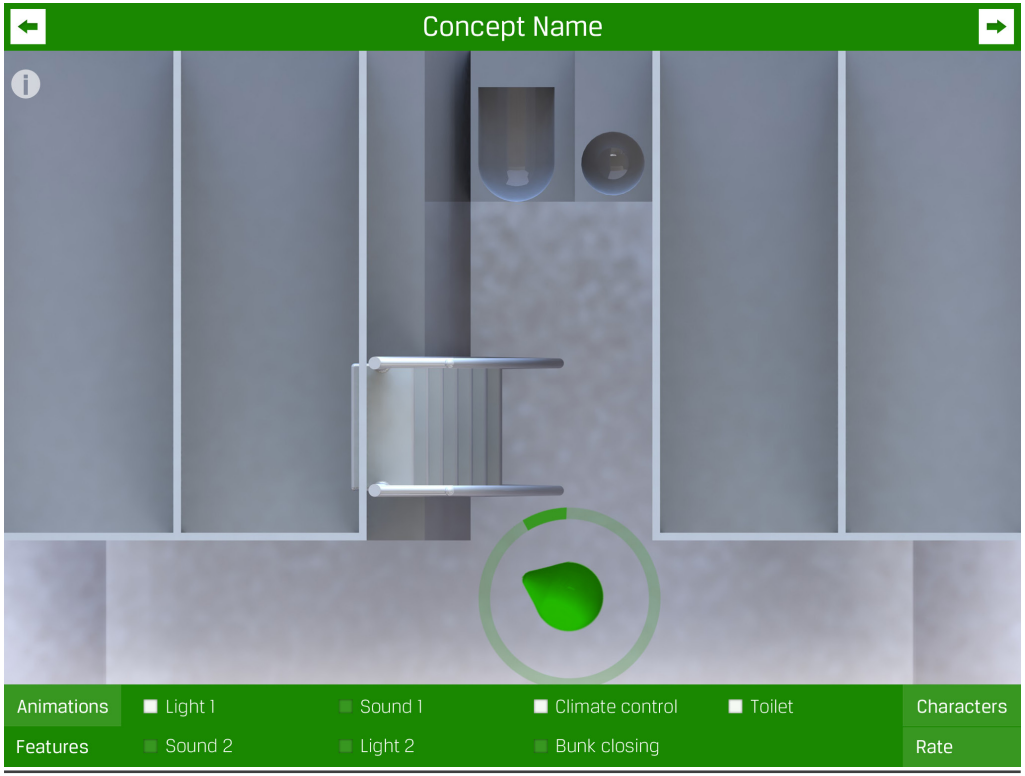


figure 77. Features menu

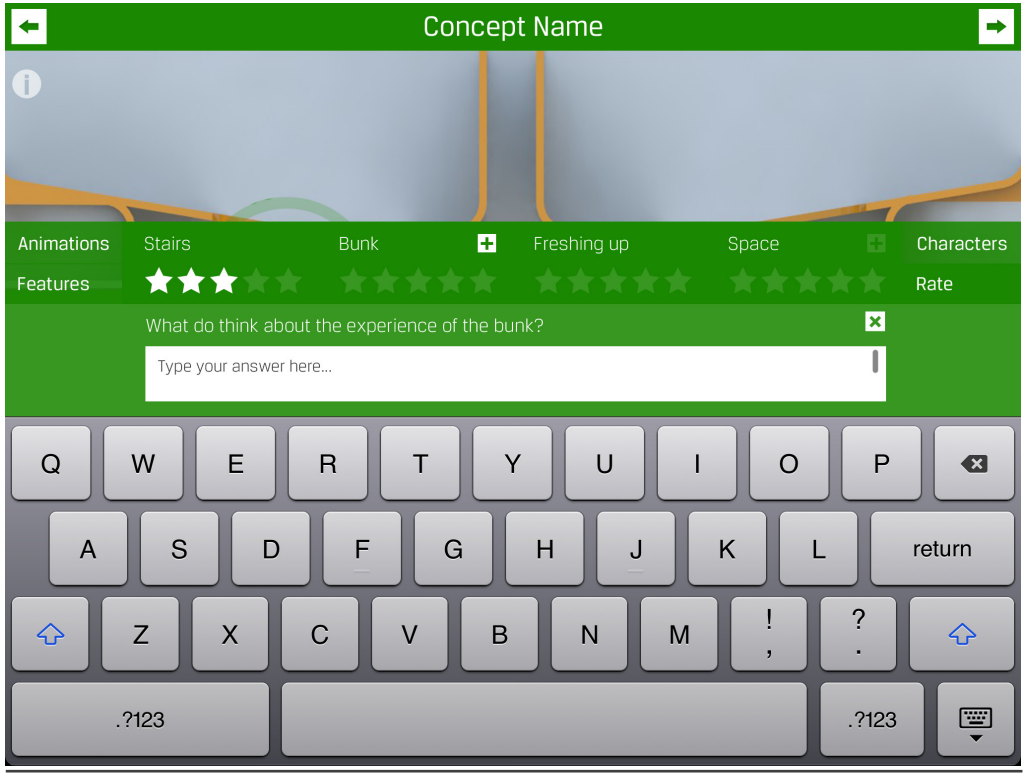


figure 78. Rate menu

6.5. Overview

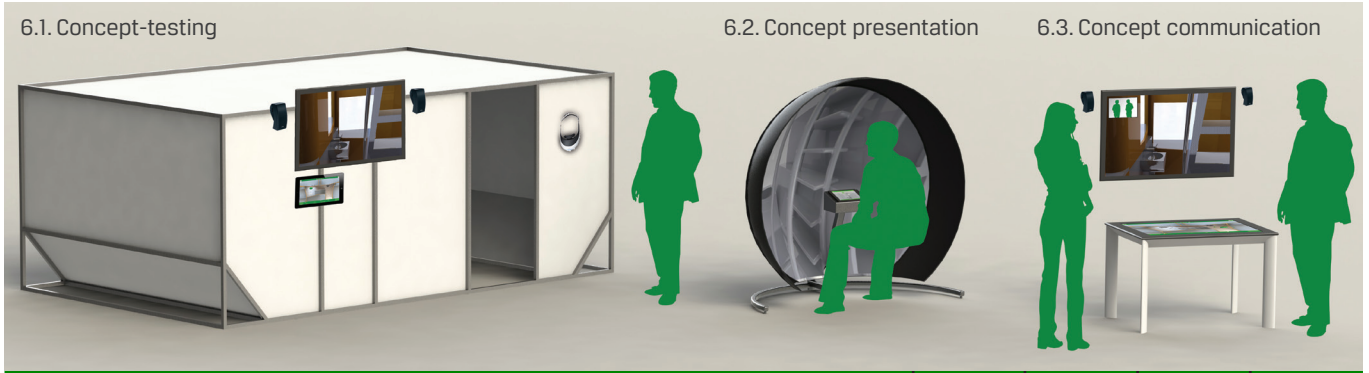
The requirements of Driessen for this assignment were shown in chapter 2. Every setup, described in section 6.1. (for concept-testing), 6.2. (for concept presentation) and 6.3. (for concept communication), is compared to these requirements. All the formulated requirements are achieved, but in three separate setups instead of one. As described earlier, the requirements for the three purposes differ too much to fit in one setup. In table 1 an overview can be seen of the comparison between the advised setups and the requirements.

Every setup gives another impression of the experience of the crew rest, which can be seen in table 1, requirement 1. For example, the setup of section 6.1. gives a more realistic impression of the crew rest, which is needed for testing the concepts. The second requirement is about the time needed to set up, what differs for each setup. In section 6.2. a more mobile setup is described that has a shorter time to set up then the one in section 6.1. For this reason, the setup for concept presentation is a better setup for on an exhibition.

The third requirement is also achieved: people can use each setup without prior knowledge of virtual reality. The setups described in section 6.2. and 6.3. can be used with less knowledge of virtual reality than the setup for concept-testing. This is not a problem, because in the case of concept-testing, the user has more time to get familiar with the VR-techniques.

With the setup for concept-testing is it possible to test Driessen's concepts with the earlier approached flight attendants (rqmt. 4) and it can also be used as a mobile setup (rqmt. 5). If this setup is not mobile enough, the setup for concept presentation can be used for testing on - for example - airports. At last, also requirement 6 is achieved: it is possible to use a setup for the presentation of the redesigns to potential customers.

See figure 79 to figure 82 for a visual overview of the described advices for Driessen.



Requirements		6.1.	6.2.	6.3.
1. The test user must experience these things:	V	26	19	19
The physical size of the room	*V*	*3*	*2*	*2*
The freedom of movement for the user	*V*	*3*	*1*	*1*
The presence of other people in the same room	*V*	*3*	*3*	*3*
The entrance in the crew rest from the aircraft	*V*	*3*	*2*	*2*
The personal space from the FA's in the bunk	*V*	*3*	*3*	*3*
Effects of noise and light from other users in the crew rest	*V*	*3*	*1*	*1*
The use of materials in the crew rest	*V*	*3*	*3*	*3*
Features of the crew rest	*V*	*3*	*3*	*3*
Features of the bunk	*V*	*2*	*1*	*1*
2. The time to set up the complete method must be kept as short as possible.	V	1	3	3
3. People must be able to use the setup without prior knowledge of VR.	V	2	3	3
4. The first tests are performed with the earlier approached flight attendants.	V	-	-	-
5. The first test may take place at a fixed location, but in the future a mobile setup is needed.	V	-	-	-
6. In the future the concept can be used for the presentation of the redesigns to potential customers	V	-	-	-

table 1. Comparison of requirements and the described advices

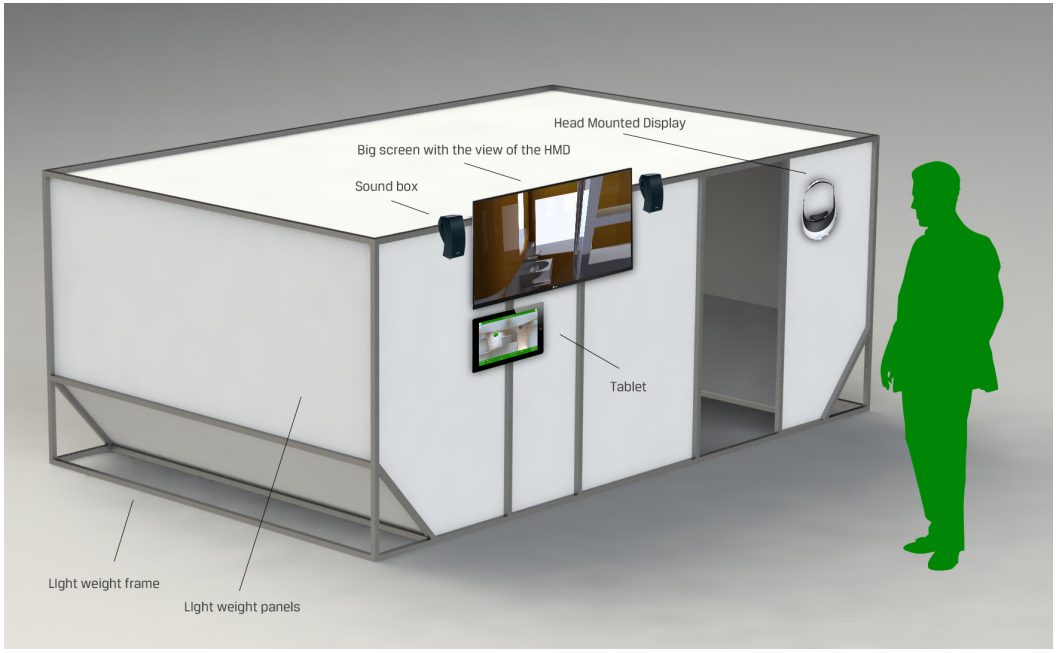


figure 79. Advice for concept-testing

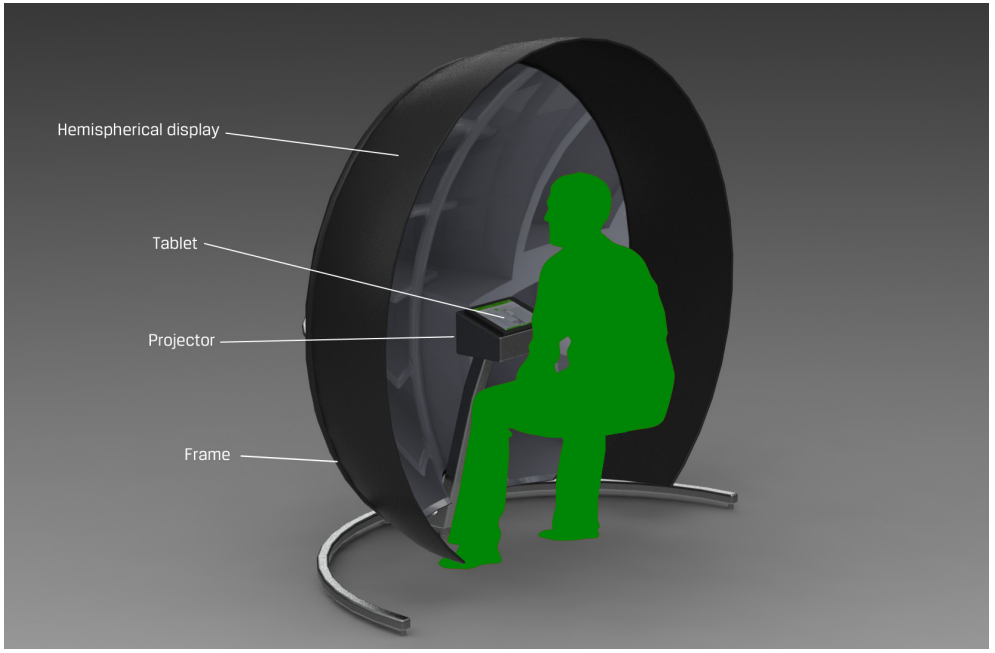


figure 80. Advice for concept presentation

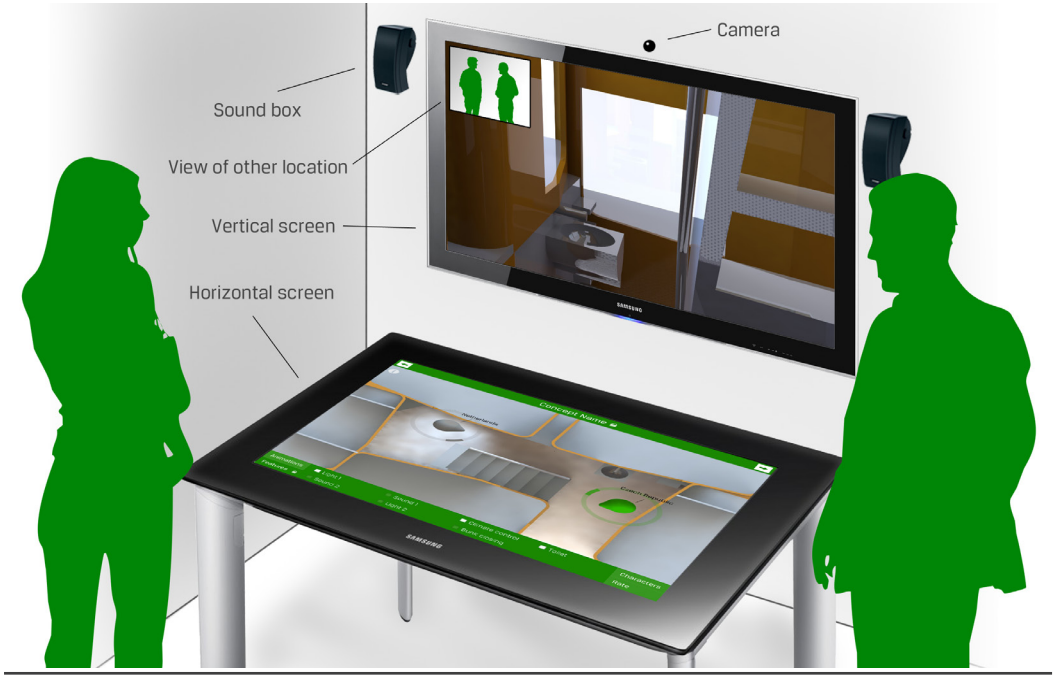


figure 81. Advice for concept communication

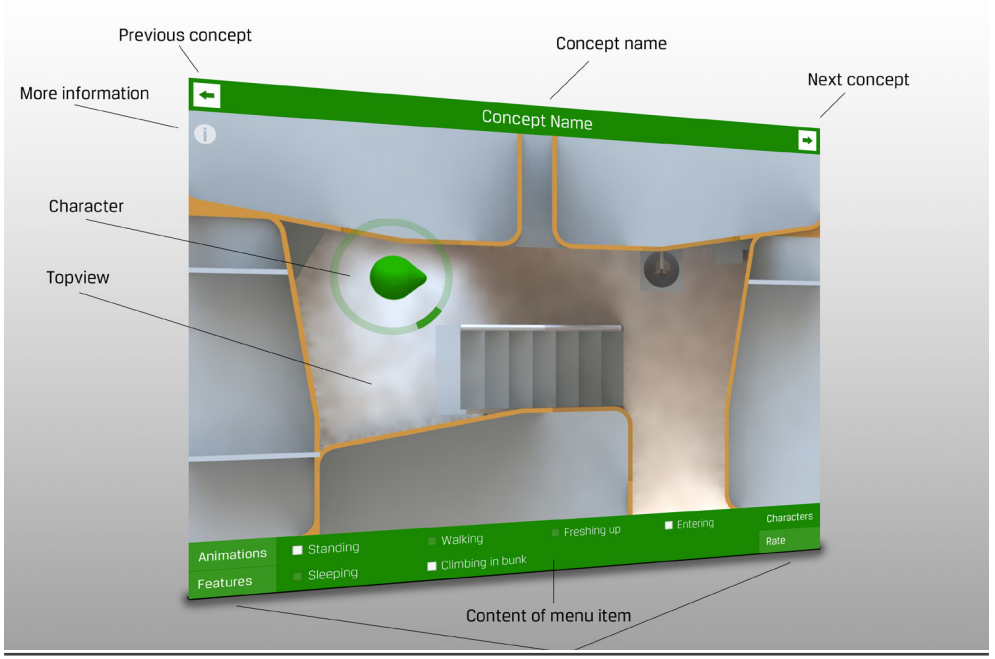


figure 82. Advice for the user interface

7. Conclusions and recommendations

During the assignment it became increasingly clear that Driessen not only wants a VR-tool for concept-testing, but also for concept presentation and concept communication. The focus of the assignment changed to give Driessen an advice for each of the three purposes. The initial idea was to give one solution for the three purposes, but during the development it became clear that the purposes differ too much to suggest only one setup. So, for concept-testing, concept presentation and concept communication another way of using virtual reality is suggested. Because three advices had to be given instead of one, the level of detail is a bit lower. But the described advices give Driessen a good idea of the possibilities of using virtual reality and are a basis for a real built VR-tool. In each advice the setup and what is needed to further develop the tool are described. Now Driessen has the choice what is the next step in this process.

I think virtual reality is a good way for Driessen to test and show the experiences of the redesigns for the LDMCR. It is easy to show others the concepts and to compare different concepts and evaluate them. But, besides the use of virtual reality for concept-testing, it is recommended to test some parts of the crew rest physically. For some objects the complete experience cannot be communicated realistically with virtual reality. For example the experience of the bunk is not complete with virtual reality only: the feeling of the mattress and the physical limitation of the length of the bed is missing without some physical objects. So virtual reality is valuable for Driessen, but sometimes an overlap is needed between the virtual and the real world, which is also described in the advice for concept-testing.

There is another good reason for Driessen to invest in the development of the use of virtual reality: the use of virtual reality shows that Driessen is an innovative business, which is promising for the products they develop.

Finally, Driessen can also use this report as a basis for the implementation of virtual reality in the development of other products and for other purposes. The given advices can be translated for example to the concept-testing, concept presentation and concept communication of galleys. If the underlying system is build and there is a connection between a VR-environment, an output signal for viewing the environment and the shown interface for on a tablet, it is easy to import models of other products. The system can also be used in other setups with other purposes, for example on a dual screen laptop (figure 49) to bring the designs closer to a customer.

I hope my research and the given recommendations will help Driessen to take advantage of using virtual reality in their process of product development.

Teun Jelle Lassche

References

Here you can find all the references used for this report.

[1] Driessen [online]. Available from: ‹http://driessen.com/pub/aboutdriessen/companyprofile/index.html›. [Accessed October 20, 2012].

[2] G. Gary Wang (2002). Definition and Review of Virtual Prototyping. J. Comput. Inf. Sci. Eng. Volume 2, Issue 3, Pages 232-236.

[3] VR Laboratry - University of Twente [online]. (2009). Available from: ‹http://www.vrlab.ctw.utwente.nl/›. [Accessed October 22, 2012].

[4] From the graduation report of Frens Pries and Pieter Hövels (p.p.36-37).

[5] Visionair 3D [online]. Available from: ‹http://www.visionair3d.com/›. [Accessed October 8, 2012]

[6] IC.IDO [online]. Available from: ‹http://www.icido.com/en/index.html›. [Accessed October 8, 2012]

[7] From the minutes of the meeting 'Demonstration of Visionair 3D Virtual Reality systems' on 19 October 2010, in Eindhoven.

[8] From the minutes of the presentation of Joep Steenbeek's graduation project for Fokker Services: 'The Development of Dedicated Prototype Tools for the Design of VIP Aircraft Interiors' on 17 December 2010, at Delft University of Technology.

[9] Frens Pries (2011). Graduation report 'Safehaven, creating a better crew rest experience'. Page 66.

[10] Pieter Hövels (2012). Graduation report 'Lower Deck Mobile Crew Rest; User Centred Design'. Page 60.

[11] Christian Noon, Ruqin Zhang, Eliot Winer, James Oliver, Brian Gilmore, Jerry Duncan (2012). A system for rapid creation and assessment of conceptual large vehicle designs using immersive virtual reality. Computers in Industry, Volume 63, Issue 5, June 2012, Pages 500-512.

[12] Lihui Wang, Weiming Shen, Helen Xie, Joseph Neelamkavil, Ajit Pardasani (2002) Collaborative conceptual design — state of the art and future trends. Computer-Aided Design, Volume 34, Issue 13, November 2002, Pages 981-996.

[13] Morad Mahdjoub, Davy Monticolo, Samuel Gomes, Jean-Claude Sagot. (2010) A collaborative Design for Usability approach supported by Virtual Reality and a Multi-Agent System embedded in a PLM environment. Computer-Aided Design, Volume 42, Issue 5, May 2010, Pages 402-413.

[14] Teun Jelle Lassche (2011) Vrije Opdracht - Presenteren vanuit een virtuele omgeving, juli 2011

[15] A. Fuhrmann, D. Schmalstief, M. Gervautz. (1998) Strolling Through Cyberspace With Your Hands In Your Pockets: Head Directed Navigation In Virtual Environments. Virtual Environments, June 1998, Pages 216-227.

[16] Takeo Igarashi, Rieko Kadobayashi, Kenji Mase, Hidehiko Tanaka. (1998) Path drawing for 3D walkthrough. Proceedings of the 11th annual ACM symposium on User interface software and technology (UIST '98), Pages 173 - 174.

[17] SimLab Soft - 3D Software Done Right [online]. (2012) Available from: ‹http://simlab-soft.com/›. [Accessed November 6, 2012]

[18] RUG - Mobiele 3D set [online]. (2012) Available from: ‹http://www.rug.nl/cit/hpcv/faciliteiten/Mobiele3DSet. [Accessed October 9, 2012]

[19] Wikipedia - Cave automatic virtual environment [online]. (2012) Available from: ‹http://en.wikipedia.org/wiki/Cave_automatic_virtual_environment ›. [Accessed October 10, 2012]

[20] RUG - RealityCube [online]. (2012) Available from: ‹http://www.rug.nl/cit/hpcv/faciliteiten/RealityCube ›. [Accessed October 10, 2012]

[21] Visionair 3D [online]. (2012) Available from: ‹ http://www.visionair3d.com/visionair360/about.html›. [Accessed October 10, 2012]

[22] Marek Czernuszenko, Dave Pape, Daniel Sandin, Tom DeFanti, Gregory L. Dawe, Maxine D. Brown. (1997) The ImmersaDesk and Infinity Wall Projection-Based Virtual Reality Displays. Computer Graphics, May 1997

[23] Wikipedia - Head-Mounted Display [online]. (2012) Available from: ‹http://nl.wikipedia.org/wiki/Head-Mounted_Display›. [Accessed October 10, 2012]

[24] Stereo 3D [online]. Available from: ‹http://www.stereo3d.com/hmd.htm#chart›. [Accessed October 10, 2012]

[25] Youtube - IC.IDO Virtual Reality: Virtual Review and Virtual Build - Automotive [online]. (2012) Available from: ‹ http://www.youtube.com/watch?v=nNNWxh6I28k›. [Accessed October 10, 2012]

[26] Youtube - Panasonic 3D Sensor: D-Imager [online]. (2010) Available from: ⟨http://www.youtube.com/watch?v=UGGKh3cyc7w&feature=related⟩. [Accessed October 10, 2012]

[27] Kinect [online]. (2012) Available from: ⟨http://www.xbox.com/nl-NL/Kinect⟩. [Accessed October 10, 2012]

[28] Wikipedia - Omnidirectional treadmill [online]. (2012) Available from: ⟨http://en.wikipedia.org/wiki/Omnidirectional_treadmill⟩. [Accessed October 10, 2012]

[29] CAE [online]. (2012) Available from: ⟨http://www.cae.com/en/sim.products/cae.7000.series.asp⟩. [Accessed October 10, 2012]

[30] Wikipedia - Haptic technology [online]. (2012) Available from: ⟨http://en.wikipedia.org/wiki/Haptic_technology⟩. [Accessed October 10, 2012]

[31] Eriks [online]. (2012) Available from: ⟨http://eriks.nl/nl/producten-en-diensten/kunststoffen/compleet-leveringsprogramma/reclamekunststoffen/kunststof-sandwich-panelen/rocklight/⟩. [Accessed November 9, 2012]

[32] Sony - HMZ-T2 [online]. (2012) Available from: ⟨http://www.sony.nl/hub/personal-3d-viewer⟩. [Accessed November 9, 2012]

[33] Kickstarter - Oculus [online]. (2012) Available from: ⟨http://www.kickstarter.com/projects/1523379957/oculus-rift-step-into-the-game⟩. [Accessed November 9, 2012]

[34] Sony - HMZ-T2 - Technical specifications [online]. (2012) Available from: ⟨http://www.sony.co.uk/product/personal-3d-viewer/hmz-t2/technical-specifications⟩. [Accessed November 9, 2012]

[35] A.J.H. Haak, D. Leever-van der Burgh. (1980) De menselijke maat. Delfste Universitaire Pers, 1980

[36] Dined [online]. (2012) Available from: ⟨http://dined.io.tudelft.nl/ergonomics/database.html⟩. [Accessed November 20, 2012]

[37] Paul Bourke. (2005) Using a spherical mirror for projection into immersive environments. Available from: ⟨http://paulbourke.net/papers/graphite2005/graphite.pdf⟩. [Accessed November 20, 2012]

[38] Paul Bourke - Dome [online]. Available from: ⟨http://paulbourke.net/dome/⟩. [Accessed November 20, 2012]

[39] Paul Bourke - FAQ-page [online]. Available from: ⟨http://paulbourke.net/dome/faq.html⟩. [Accessed November 20, 2012]

[40] Navitar - HemisStart 180 Projection [online]. Available from: ⟨http://www.navitar.com/pdf/HemiStar_180_Projection.pdf⟩. [Accessed November 20, 2012]

[41] Navitar - Hemistar Angle Sheets [online]. Available from: ⟨http://navitar.com/pdf/Hemistar_Angle_Sheets.pdf⟩. [Accessed November 20, 2012]

[42] Cleardome - Photodomes [online]. Available from: ⟨http://www.cleardome.com/photodomes.htm⟩. [Accessed November 20, 2012]

[43] Complex Plastics - Hemispheres price list [online]. (2007) Available from: ⟨http://www.complexplastics.com/hemispheres/pricelist/HEMISPHERES%20PRICE%20LIST%203-30-2007.pdf⟩. [Accessed November 20, 2012]

Figures

figure 5. Figure 2 from graduation report Frens Pries

figure 6. Edited photo from research at Delta Airlines A330 LDMCR, December 12, 2010, DSCN0538.JPG

figure 20. Available from: ⟨http://www.esi-group.com/industries/ground-transportation⟩. [Accessed October 9, 2012].

figure 21. Available from: ⟨http://www.solidworks.com/sw/products/solidworks-simulation.htm⟩. [Accessed October 2, 2012].

figure 22. Available from: ⟨http://www.youtube.com/watch?v=qbnFhOYLPCA⟩. [Accessed October 2, 2012].

figure 23. Available from: ⟨http://www.simt.com/3dvrc/demonstrations/default.asp⟩. [Accessed October 2, 2012].

figure 24. [13]

figure 26. Available from: ⟨http://www.vrlab.ctw.utwente.nl/eq/Images/CurvedScreen-rijsimulator01.jpg⟩. [Accessed October 9, 2012].

figure 27. Available from: ⟨http://www.cs.indiana.edu/classes/b582/presentations/hardware/cave/cave.ideal.gif⟩. [Accessed October 10, 2012].

figure 28. Available from: ⟨http://www.instablogsimages.com/images/2010/09/07/carl-zeiss-head-mounted-display_rXKfY_24702.jpg⟩. [Accessed October 10, 2012].

figure 29. Available from: ⟨http://4.bp.blogspot.com/-_LjZ8zORhrU/UBZSTpL8yfI/AAAAAAAAASA/sRCVm6pDno4/s1600/google+glass.jpg⟩. [Accessed October 10, 2012].

figure 30. Available from: ‹http://www.youtube.com/watch?v=nNNWxh6I28k, 0:50›. [Accessed October 10, 2012].

figure 31. Available from: ‹http://www.youtube.com/watch?v=UGGKh3cyc7w&feature=related›. [Accessed October 10, 2012].

figure 32. Available from: ‹http://en.wikipedia.org/wiki/File:ARL_ODT.jpg›. [Accessed October 12, 2012].

figure 33. Available from: ‹http://www.vrlab.ctw.utwente.nl/eq/Images/phantomomni.jpg›. [Accessed October 10, 2012].

figure 52. Available from: ‹http://eriks.nl/producten/images/614/Rocklight.jpg›. [Accessed November 10, 2012].

figure 56. Available from: ‹http://www.sony.nl/res/images/image/94/1237483535594.jpg› and ‹https://s3.amazonaws.com/ksr/projects/269543/photo-full.jpg›. [Accessed November 9, 2012].

figure 58. [35]

figure 60. Available from ‹http://paulbourke.net/dome/arrangement.pdf› and ‹http://paulbourke.net/miscellaneous/hershfield/vmd2s.jpg›. [Accessed November 21, 2012].

figure 62. Available from ‹http://www.nikonweb.com/fisheye/fisheye_6mm.jpg›. [Accessed November 22, 2012].

figure 63. Available from ‹http://www.navitar.com/pdf/HemiStar_180_Projection.pdf ›. [Accessed November 22, 2012].

figure 64. Available from ‹http://paulbourke.net/dome/iDome/asym1.jpg› and ‹http://paulbourke.net/dome/iDome/sym1.jpg›. [Accessed November 21, 2012].

Fill out this form within the given boxes in English or Dutch. Return it to your UT-mentor and a.p.vandenbeukel@utwente.nl as **Word**-document.
Plan of approach for: | *Plan van aanpak voor:*

Het maken van een plan voor het gebruik van virtual reality bij het testen van conceptontwerpen voor 'crew rests' voor vliegtuigen.

Organization: | *Opdrachtgever:*

Driessen Aerospace Group NV, Zodiac Aerospace Alkmaar

Student's name:

Teun Jelle Lassche
S1004166

Introduction | *Inleiding*

Organization: | *Opdrachtgever:*

Driessen Aerospace is gespecialiseerd in het ontwerpen, produceren en verkopen van hoge kwaliteit keukens en slaapplekken voor in vliegtuigen. Driessen levert zijn producten aan bijna alle luchtvaartmaatschappijen en fabrikanten van vliegtuigen en is marktleider op zijn afzetgebied. Het bedrijf bestaat uit vier takken: 'Galleys USA', 'Galleys Europe', 'Galley Equipement' en 'Cargo Equipment'. Driessen is onderdeel van Zodiac Aerospace, marktleider in het ontwerpen, produceren en verkopen van vliegtuiginterieurs en vliegtuigsystemen. Zodiac Aerospace heeft wereldwijd zo'n 20.000 werknemers in dienst. Bij Driessen zijn dat er ongeveer 2.200. De fabrieken van Driessen bevinden zich in Thailand, Californië (USA), Tsjechië en het Verenigd Koninkrijk.

Scope's background: | *Aanleiding voor de opdracht:*

Eén van de bedrijfstakken van Driessen draagt zorg voor de ontwikkeling van galleys voor Airbus. Een onderdeel hiervan is de slaapplek voor de bemanning van vliegtuigen, een zogenaamde 'crew rest'. Driessen maakt crew rests ('LDMCR's) die in het laadruim geschoven kunnen worden van een Airbus A330 of A340, waarin plek is voor zes tot acht bedden. Via een gat in de vloer van het passagiersdek in het vliegtuig kan de bemanning de crew rest bereiken. Op lange vluchten is een dergelijke slaapruimte of evt. een plek in de business class voor bemanningsleden verplicht.
Op dit moment is slechts één op de tien vliegtuigen van Airbus voorzien van zo'n type crew rest. Driessen heeft een zeer groot marktaandeel voor deze LDMCR's.
Driessen vergroot graag zijn afzet en heeft bekeken waarom er niet meer crew rests geplaatst worden in de vliegtuigen van Airbus. De drie grootste redenen blijken de volgende drie te zijn: de prijs is te hoog, het kost teveel ruimte in het vrachtruim en de bemanning maakt er liever geen gebruik van. De bemanning heeft soms liever een businessplaats in het vliegtuig om uit te rusten dan dat ze een plaats krijgen in een krappe crew rest. Uit onderzoek onder bemanningsleden is gebleken dat zij het op dit moment geen prettige ruimte vinden om in te verblijven.
Bij de prijs en de ruimte die de crew rest kost, is volgens Driessen weinig te winnen. Daarom is Driessen bezig gegaan met het herontwerpen van de crew rest, gericht op een prettigere beleving voor de bemanning. Er zijn al enkele ontwerpen gemaakt, maar hier zijn nog geen testen mee uitgevoerd. Bij de eerdere modellen heeft Driessen nauwelijks gebruikstesten gedaan met de concepten. Driessen is nu dus op zoek naar een goede manier voor het testen van de concepten en is benieuwd naar wat voor rol virtual reality hierin kan spelen. Het bouwen van een fysiek van model kost veel geld en meerdere modellen maken is dan ook vrijwel geen optie. Met virtual reality zou het eventueel mogelijk zijn om gemakkelijk en snel verschillende concepten te testen en bekijken. Dit scheelt een hoop tijd en geld en kan ook eerder in het ontwerpproces al gebruikt worden.

Samengevat is de aanleiding voor de opdracht dus dat Driessen Aerospace een manier nodigt heeft om efficiënt verschillende concepten te testen die gemaakt zijn voor het herontwerpen van de crew rest. Het gaat hierbij vooral om de beleving die de bemanning heeft bij de crew rest. Het zal bij het testen dan ook in eerste instantie niet nodig zijn om de omgeving fysiek te testen, het zoeken is allereerst naar een manier om de ontwerpen te testen op de indrukken en de sfeer die het oproept bij de bemanning die gebruik moet maken van de crew rest.

Aim of the project | *Doelstelling*

Het doel van het project is het opstellen van een plan hoe Driessen virtual reality het beste kan gebruiken bij het testen van de herontwerpen voor de crew rest. Hiervoor zal onderzoek gedaan worden naar wat exact getest moet worden aan de concepten en hoe op andere gebieden virtual reality gebruikt wordt bij concept-testing, al zal ook breder gekeken worden dan alleen de technieken die nu al gebruikt worden voor concept-testing. Het is van belang dat de virtuele weergave van de ontwerpen een goede indruk geven van de krappe ruimte van de crew rest. Er zal met Driessen gesproken worden over hun wensen en huidige manier van communiceren van concepten en er zal zelf op zoek gegaan worden naar mogelijkheden in VR, onder andere in het VR-lab van Universiteit Twente. In 10 weken zal er een advies zijn voor Driessen waarin staat of en hoe de concepten getest en weergegeven kunnen worden met behulp van virtual reality.

Questions | *Vraagstelling*

Hoe kan Driessen gebruikmaken van VR bij concept-testing van crew rests voor vliegtuigen?

1. Wat zijn de eisen voor het concept-testing?
    a. Wat moet er getest worden aan de ontwerpen?
    b. Wat zijn de belangrijkste kenmerken van de herontwerpen die over moeten komen bij het testen?
    c. Op welk moment in het ontwerpproces worden de testen uitgevoerd?
    d. Met wie zal het concept-testing uitgevoerd moeten worden?
    e. Waar moeten de testen uitgevoerd worden?
    f. Hoe moeten de concepten getest worden? (Bijvoorbeeld: Los van elkaar of verschillende concepten met elkaar vergelijken)
    g. Wat voor resultaten worden er van de testen verwacht?
    h. Wat moet er gebeuren met de resultaten van de testen?
    i. Welke eisen worden aan het concept-testing meegeven als het ook gebruikt moet kunnen worden op beurzen, als presentatie van de ontwerpen?
2. Hoe maakt Driessen op dit moment al gebruik van virtual reality?
    a. Wat voor soort digitale modellen worden gebruikt?
    b. In hoeverre sluiten de huidige methoden aan bij de eisen die Driessen heeft voor concept-testing?
3. Wat zijn de verschillende mogelijkheden van VR bij concept-testing?
    a. Hoe wordt VR op andere gebieden gebruikt bij concept-testing?
    b. Welke andere VR-technieken kunnen gebruikt worden voor een goede weergave van de ontwerpen?

4. Welke concepten zijn er bedacht om VR te gebruiken bij het testen van de ontwerpen?
    a. Welke technieken worden gebruikt?
    b. Welke methoden worden gebruikt?
    c. Hoe kunnen de ontwerpen ermee getest worden?
    d. In hoeverre sluiten de ideeën aan bij de eisen van Driessen?
5. Hoe kan Driessen dit gebruiken bij de presentatie van zijn modellen?
    a. Hoe kan dit gebruikt worden als communicatiemiddel over concepten tussen verschillende locaties van Driessen?
    b. Hoe kan dit gebruikt worden op presentaties van Driessen op beurzen?

Definition of used terms | *Begripsbepaling*

Galley: Module met keuken of slaapplekken voor in vliegtuigen
Crew rest: Een container met slaapplekken voor bemanningsleden van een vliegtuig die in het vrachtruim geschoven kan worden, het type waar Driessen Aerospace aan werkt
Vlieguig: Het vliegtuig waar de crew rest op dit moment voor gebouwd wordt door Driessen Aerospace, de Airbus A330 en de Airbus A340
VR: Virtual reality

Planning

De planning is bijgevoegd als een Excel-bestand.
Deze planning is nog redelijk globaal gehouden omdat op dit moment nog moeilijk in te schatten is hoeveel tijd alles gaat kosten en wat voor rol virtual reality werkelijk kan gaan spelen bij het concept-testing van Driessen.
Vanaf heden tot en met 10 november ben ik fulltime beschikbaar voor de opdracht, daarna ben ik vanwege vakken voor mijn studie nog voor ongeveer 25% beschikbaar voor de uitvoering van de opdracht.

Appendix B. Planning

Planning

Bachelopdracht

Teun Jelle Lassche

	Week 38	Week 39	Week 40	Week 41	Week 42	Week 43	Week 44	Week 45	Week 46	Week 47	Week 48	Week 49	Week 50	Week 51
	17-sep	*24-sep*	*1-okt*	*8-okt*	*15-okt*	*22-okt*	*29-okt*	*5-nov*	*12-nov*	*19-nov*	*26-nov*	*3-dec*	*10-dec*	*17-dec*
Tijd	100%	100%	100%	100%	100%	100%	100%	100%	25%	25%	25%	25%	25%	25%
Deadlines	PvA af											Conceptverslag		
Vraag 1														
Vraag 2														
Vraag 3														
Vraag 4														
Vraag 4														
Vraag 5														
Verslaglegging														

Appendix C. Ideas sub questions

1. How can you communicate a tight space with VR?

Ideas (figure 1)

- Project a tight space using a Head Mounted Display.
- Create a small CAVE.
- Make the proportions clear with a human model in the virtual environment.
- Construct a physical environment of some basic parts of the crew rest.

Ideas (figure 2)

- Use a screen with a maximal height and a 1:1 view of the crew rest.
- Use head tracking to determine the height of the head of the user. When the head is above a specific height (1.60 meters), the user cannot see the crew rest. This way you can bring the user in a certain position.

Ideas (figure 3)

- Use the Elumens, a hemispherical display.

2. How can you experience little freedom of movement with VR?

Ideas (figure 4)

- Navigate a human model through the virtual environment.
- Look at the freedom of movement in a visual simulation.

Ideas (figure 5)

- Walk through the environment with a HMD.
- Build (parts of) the crew rest physical.
- Use a 3D-sensor (e.g. D-Imager or Microsoft Kinect) to copy the position of a real person into a virtual character. So that the user can see and feel how he can stand and move in the crew rest.

3. How can you communicate the bunk experience with VR?

Ideas (figure 6)

- Use a physical bed for the experience of the materials and a HMD for displaying how the bunk looks.
- Test the ergonomics of the bunk with a simulation on a computer.

Ideas (figure 7)

- Test the experience of the bunk by showing animations or pictures on a (3D) screen.
- Build complete prototypes of the bunks.

4. What kind of physical interaction takes place with obstacles in the crew rest?

Ideas (figure 8)

- Build the physical contours of the LDMCR.
- Build (or print with a 3D-printer) some physical parts and display the crew rest with beamer projections or a HMD.
- Use a moving haptic arm to simulate the obstacles in the crew rest, while the user is wearing a HMD.

5. How are other people shown in the crew rest?

Ideas (figure 9)

- Use a camera to copy the people standing in front of a screen into the virtual environment.
- Walk with a number of people in a room with blue or green screens. All people are wearing a HMD that displays (with augmented reality) the virtual environment on the green screens.

6. How do you enter the crew rest?

Ideas (figure 10)

- Show the user pictures of the entrance of the crew rest.
- Show an animation of the entrance of the crew rest.
- Let the user walk into a 1:1 mock-up of the crew rest.

7. How can the test be carried out?

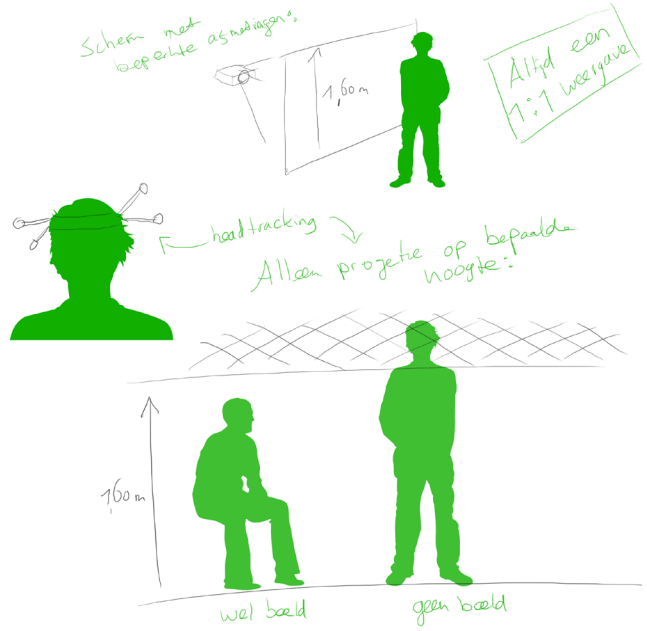
Ideas (figure 11)

Collecting the results of the test can be done:

- with an interview,
- with a survey,
- by filming or photographing the test,
- with a conversation during the test or
- by giving an evaluation on a tablet.

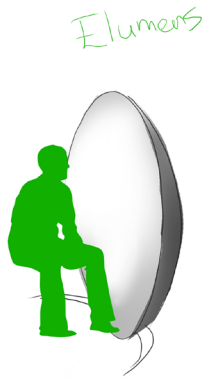
1. Hoe breng je in VR over dat je je in een krappe ruimte bevindt?

figure 1.



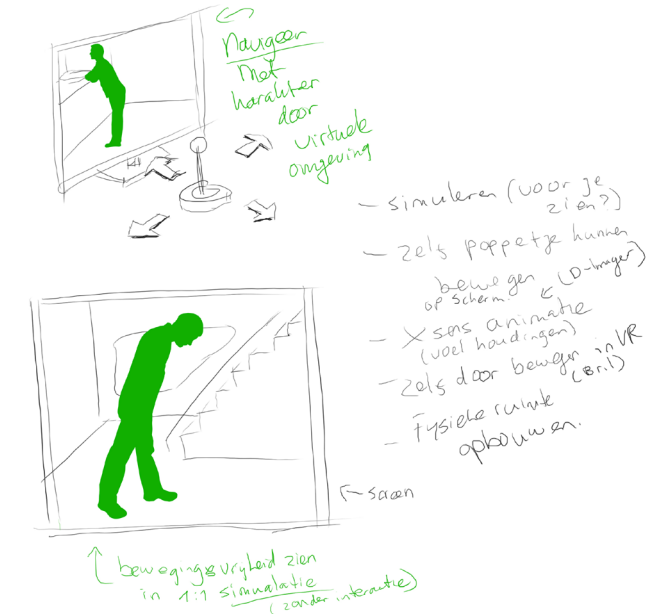
1. Hoe breng je in VR over dat je je in een krappe ruimte bevindt?

figure 2.



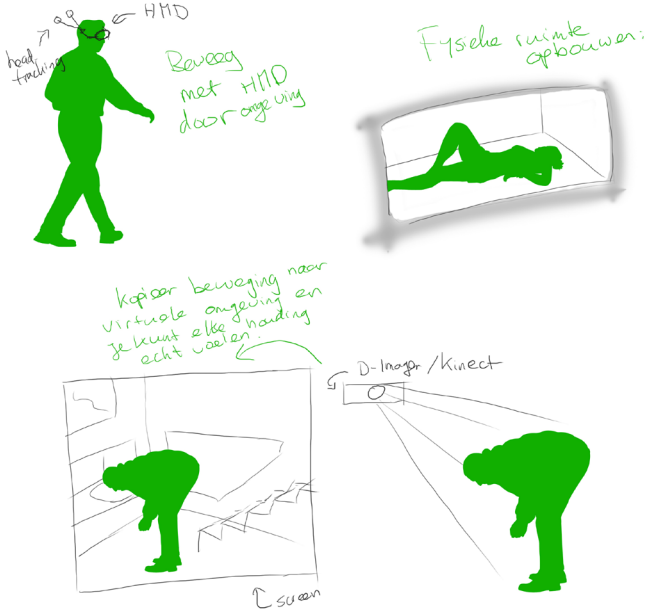
1. Hoe breng je in VR over dat je je in een krappe ruimte bevindt?

figure 3.



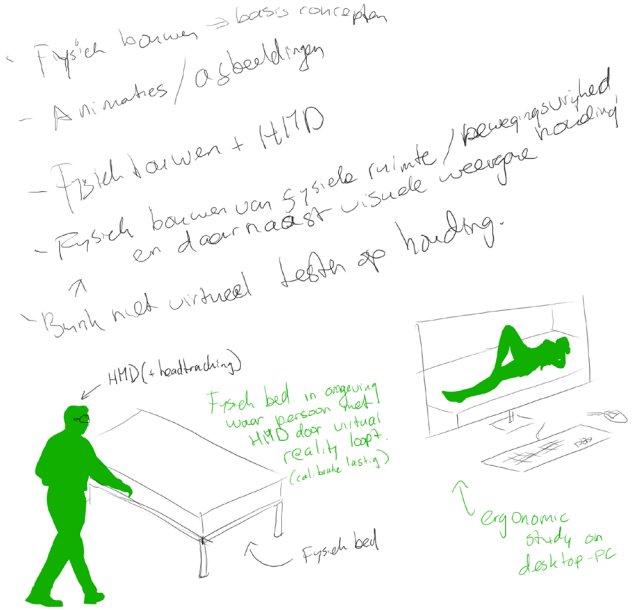
2. Hoe kun je weinig bewegingsvrijheid ervaren met behulp van VR?

figure 4.



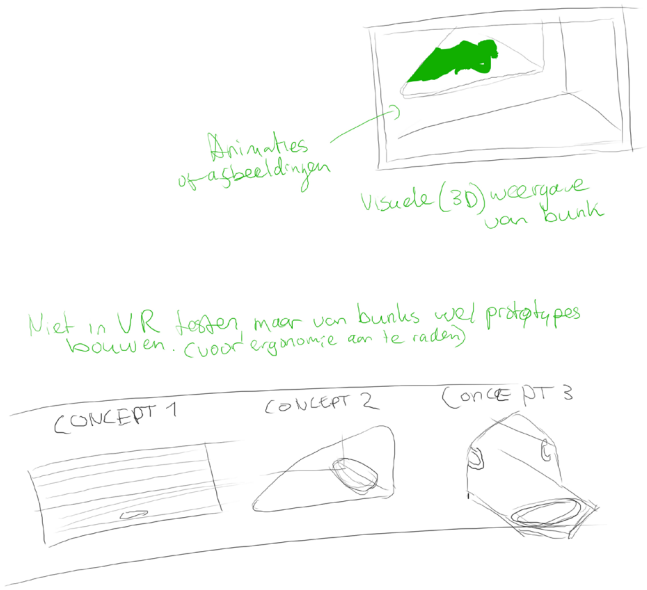
2. Hoe kun je weinig bewegingsvrijheid ervaren met behulp van VR?

figure 5.



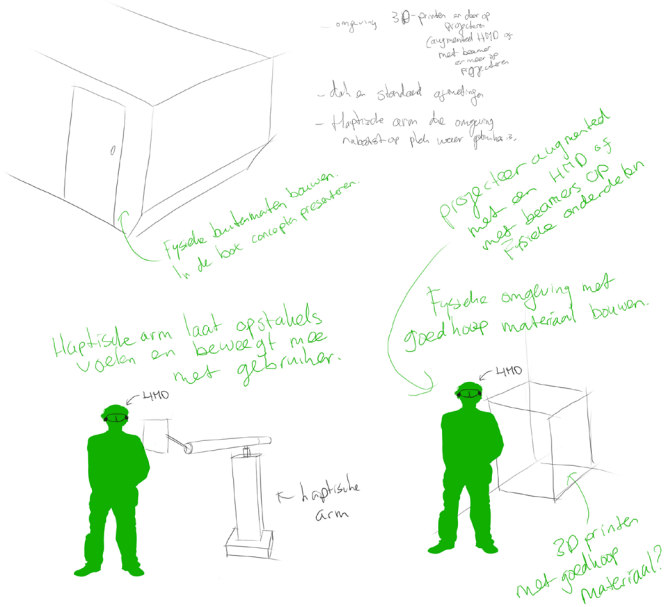
3. Hoe wordt de ervaring van de bunk overgebracht met behulp van VR?

figure 6.



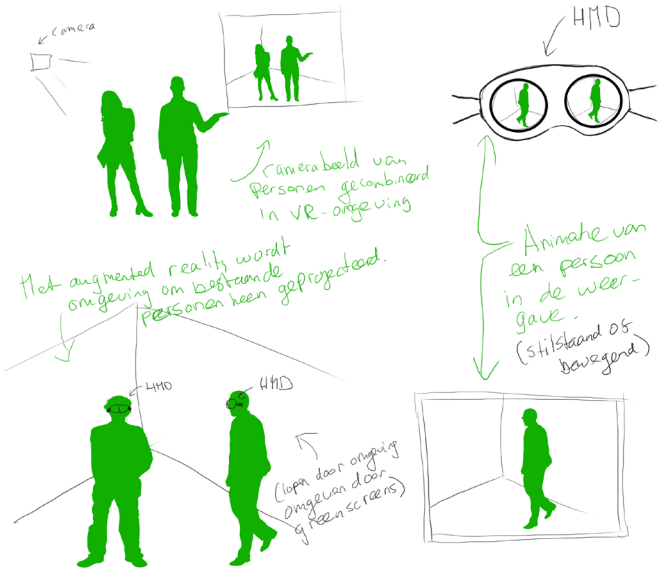
3. Hoe wordt de ervaring van de bunk overgebracht met behulp van VR?

figure 7.



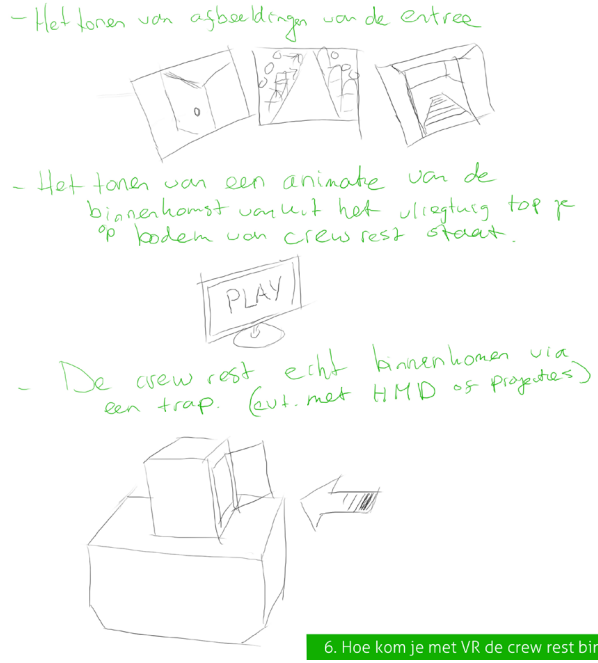
4. Wat voor fysiek interactie vindt plaats met obstakels in de crew rest?

figure 8.



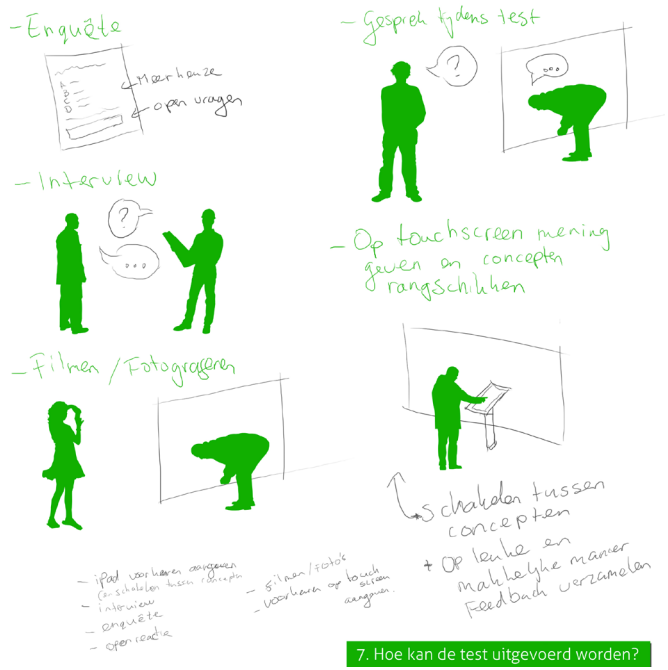
5. Hoe worden andere personen weergeven in de crew rest?

figure 9.



6. Hoe kom je met VR de crew rest binnen?

figure 10.



7. Hoe kan de test uitgevoerd worden?

figure 11.