Interactive motorsports broadcasting in a virtual reality environment

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Abstract

Interactive TV in motorsport, specifically Formula 1, is an established service that has been developed over the last 20 years. Market research reveals trends in broadcasting pointing towards, in the future, sports, in general, will be consumed via VR. Broadcasting interactive TV with VR acting as the medium, however, is an unfamiliar territory where a gap in research exists in interaction design.

The purpose of this thesis is to research the viewing habits of inexperienced and experienced viewers of F1 through empirical work that includes literature review, observation and interviews. The insights gathered are then conceptualized through workshops and sketching. These, in turn, helps produce a set of iterated prototypes that are usability tested to extract insights which reveal design recommendations for ergonomics and interface and elements for augmenting the viewing experience the designer should keep in mind when developing for VR broadcasted interactive motorsport TV.

Keywords: Virtual reality; Interactive TV; Immersion; User interface; Design recommendations;
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Acronyms

FOM  = Formula One Group
FOV  = Field of view
F1   = Formula 1
UCD  = User-Centered Design
UI   = User interface
VR   = Virtual Reality
2D   = Two dimensional
3D   = Three dimensional
1 Introduction

As there have been numerous interactive TV services throughout the years in F1, and the technology to broadcast new perspectives within sports is getting better each year, the possibilities to incorporate these into a TV broadcast has grown (Dransfeld, Jacobs, & Dowsland, 1999; Performance Communication, 2018). VR as a medium to broadcast sports is not new. Companies like Oculus and NextVR has created ways of experiencing new perspectives of sports focusing on the social aspect of it (Bashara, 2018; Nelson, 2017). But there is a gap in research in how to spectate interactive motorsport broadcast in a virtual environment.

This paper will outline F1 viewers spectating habits, opinions and needs through qualitative empirical work, and utilize literature surrounding VR on how to the design for the medium in order to develop for the target group’s needs. Through an iterative state, following Chu’s (2014) philosophy of prototype, experiment, and test, as VR is a relatively unfamiliar field to design for, a set of recommendations on ergonomics, interface and interactions when designing for interactive TV in motorsport arises. What this thesis aims to contribute towards is the field of interaction design when designing interfaces and interactions for interactive TV using VR as a medium.

1.1 Purpose

This thesis explores interactive television within the world of motorsports, and how virtual reality can be used as a medium to serve the content. It uses F1 as a testing ground as it has a history being experienced using interactive TV, as explained by Dransfeld, Jacobs, & Dowsland (1999). It focuses on what interaction designers should consider when designing interfaces and interactions for interactive TV in a VR environment. There is substantial research that has been done going into how interaction designers can design for media such as VR, but there is a gap in research on how users might want to engage and interact with elements within motorsports broadcasting, such as how a user might want to watch a replay or look up data about the drivers directly in the broadcasting feed. This gap is investigated using qualitative research methods commonly used within the field of interaction design to identify problems and design opportunities. The subject is also investigated by using established theory and market research in order to inform the design decisions. This data generates a set of interactive prototypes that test elements that the empirical work has revealed the viewer wants to have the ability to interact with and is tested with the target group set for this thesis.

1.2 Delimitations

While this project explores how to use interactive TV for motorsports, it does not explore the impact it might have on the sport itself. It also does not
explore new technology within interactive TV or VR. The project uses existing VR technology and does not explore the aspect of actually implementing the prototypes into production.

The cognitive aspect of tracking raw data during testing, such as eye-tracking, is not utilized. The project relies on what the users feel and experience during usability testing for its insights.

1.3 Target group
The target group for this thesis are both experienced and inexperienced, meaning frequent and occasional, viewers of F1 in order to generate data on how these viewers spectate F1, and what their opinions are on the current state of broadcasting of F1. These viewers are used throughout the thesis, incorporating them into the many different stages of the design process.

1.4 Ethical conduct
In accordance with *The General Data Protection Regulation*, any data that refers to personal information will be handled according to its guidelines. The thesis also follows the Swedish council guidelines (2017) for its ethical conduct. Prior to any tests that involve users testing VR will, therefore, be informed of the risk of motion sickness that VR has a potential of inducing. Symptoms of this can be general discomfort, nausea, dizziness, headaches, disorientation, vertigo, drowsiness, pallor, sweating and in extreme cases, vomiting. It can be caused by the visually induced motion, whereas physical induced motion sickness occurs due to the motion. Visually induced sickness can be stopped by simply closing the eyes, while physical induced sickness cannot. It is triggered in most cases by latency of feedback from the system. When the portrayed world is not acting or moving how the user expects it to, due to latency in the feedback, it is called “swimming” (Jerald, 2015).

1.5 Research question
*How might we design interfaces and interactions for a virtual reality environment that acts as a medium for interactive motorsport broadcasting?*
2 Interactive TV & Formula 1

The world of Formula 1 is fasted paced and contains a rich history of pushing the envelope of what is possible within technology and engineering. This chapter will briefly introduce F1, and also how broadcasting of the sport has been developed during the years with the rise of interactive TV.

2.1 An intro to the world of Formula 1

Formula 1 (F1) is the highest single-seater class within the Fédération Internationale de l’Automobile (FIA) and is owned by the Formula One Group. Dating back to 1950 as its inaugural season. The name “Formula” is based on the fact that every season there is a set of regulations and rules that the cars has to align accordingly. A season of F1 consists of multiple Grand Prix taking place around the world on both purpose-built circuits and on public roads which are transformed to street circuits for the weekend. A Grand Prix consists of practice, qualification and race sessions between Friday to Sunday. During the season, the drivers and teams collect points in the Grand Prix and the goal is to collect the maximum amount of points to win the two different titles which are Drivers Championship and Constructors Championship. The teams and drivers are awarded points if they place between positions 1 to 10 in the race on the Grand Prix Sunday. Each team must have, according to the regulations, two drivers and it is the two driver’s points over a season that accumulates to the Constructors Championship. This puts F1 in a unique position as a sport where the teammates have to fight against and alongside each other in order to win both championships. As of the 2019 season there are 10 different teams resulting in 20 drivers on the grid (Benson, 2019; Fédération Internationale de l’Automobile, 2010).

2.2 Media & Coverage

The first known F1 race to have been broadcasted was back in 1953 airing the British Grand Prix on BBC. Between 1953 and 1979 races were rarely shown live, with ITV and BBC showing highlights at best. BBC started exclusively showing races live from the 1979 season. The coverage grew and by 1990s BBC broadcasted a majority of the races live. Around this time Eurosport also started broadcasting races, including the qualifying sessions which BBC did not air. When BBC went to renegotiate the rights in 1995, it was announced that ITV had the exclusive rights resulting in BBC and Eurosport losing the right to screen F1 in the UK. ITV continued to air F1 for 12 years until the end of 2009 until it was announced that the sport was coming back to BBC. The show stayed on the channel for a couple of years until BBC made a deal with Sky, resulting in Sky taking over the air time.
As of 2018, coverage and ratings for F1 grew significantly. In terms of unique viewers, the sport grew 10% in viewership amounting to 490.2m. Significantly, the ratings in China grew 14% because of the return of free-to-air TV coverage from CCTV. Other markets that grew significantly were Indian sub content of +87%, France at +51% and Russia at +27%. The total cumulative number of viewers reached via TV from the top 20 markets amounted to 1.758bn. The Grand Prix with the most amounts of viewers were the Monaco Grand Prix with its cumulative audience of 110m, and six events during the season had more than 90m viewers each (Sylt, 2019).

2.2.1 Interactive TV

According to the company Performance Communication’s (2018) market research rapport that looks into the future of sports fan, viewers will no longer be passive spectators. The rapport states that fans are going to be presented with an array of controls which is going to give them the ability to augment their viewing experience. Dransfeld, Jacobs, & Dowsland (1999) argues that a national TV director for F1 will no longer be needed when interactive TV will come with full force, further stating that even voice commentary will no longer be necessary for the sport as the ability to select your own cameras will be far more important to committed fans of F1.

2.2.1.1 First interactivity

The notion of interactive TV within the sport came as early as in 1996 where a limited number of viewers, a total of 100 German households, could during the Germany Grand Prix select various camera angles along the track. This allowed the German fans to follow their favourite driver, Michael Schumacher, fight in the field and finish in 3rd place. In 1997, Canal Satellite Numérique tried the same concept offering their viewers six sets of selectable cameras, 40 cameras in total, resulting in offering a very flexible coverage to their viewers (Dransfeld et al., 1999).

2.2.1.2 BBC Red Button

In 2009, when the sport came back to BBC, interactive TV was once again introduced to F1 via the BBC Red Button, which was a service where viewers had access to extra content when pressing the red button found on most remote controls. This allowed viewers having access to every practice session of a Grand Prix, as these were not aired on regularly scheduled TV broadcasting (Dransfeld et al., 1999).

2.2.1.3 F1TV Pro

For the 2018 season, F1 introduced fans to their new streaming service F1TV. It offers viewers the ability to follow any driver they would like, while also offering commentaries in multiple different languages. This is the platform that F1 is continuing to build and improve upon, giving viewers access to the same data offered to the team’s pit wall. Another feature the service provides is the ability to spectate on-board footage of all the drivers (Formula 1, 2018).
3 Theory

As this thesis looks at how VR can be used as a broadcasting platform for interactive TV, VR as a medium and tool will be introduced and explained, and how we might design for the future interactions and interfaces following established research and guidelines.

3.1 Virtual reality

VR as a medium and tool is nothing new when it comes to gaming and consuming media. A great number of developers and companies are focusing and investing in the technology, resulting in an array of commercially developed devices that has found its way into households. However, it is something that was not always the case. Like every new technology, VR has been an expensive piece of technology and has only existed in research labs most of its lifespan. The trend of making it more available gives it a larger platform to be developed on in order to unpack its potential, thus making it cheaper and more accessible (Jerald, 2015; Sherman & Craig, 2003).

Optical technologies that precede VR dates back to 1832 when Sir Charles Wheatstone invented the first stereoscope. It used mirrors angled at 45° degrees to reflect images into the eyes. After that, multiple devices were developed throughout the years. The first patent filing for the technology occurred in 1916, of which Albert B. Pratt was responsible for. It was developed as a head-worn gun pointing device that did not need any interactions with the hands. The device indicated that tech was moving into a new territory of not just simply showing static visual images. The concept made its way a decade later into the first flight simulator developed by Edwin Link. The first concept that we resemble as modern VR today was presented in the science fiction story Pygmalion’s Spectacles which was released in 1935. It tells the story of a set of eyeglasses along with other equipment replacing real-world stimuli with artificial stimuli with the help of vision, sound, taste, smell and touch. The first actual head-tracking VR device arrived in 1961 built by the Philco Corporation. It worked in the way that as the user moved his head, a camera in a different room moved accordingly (Jerald, 2015; Sherman & Craig, 2003). However, the term virtual reality was not established until 1982, of which Jaron Lanier was responsible. Jaron Lanier is recognized in the world of VR because of the Dataglove, which is a glove with sensors measuring finger bending featuring vibrating tactile feedback working together with a VR headset as an input device. In the 1990s there was a large expansion within the world of VR where companies experimented with the technology. Media started noticing it and spawned movies and literature featuring the technology. However, the equipment supporting VR systems were not sufficient, resulting in the industry started contracting by the end of the 90s. Between 2000 to 2012, VR research was
still ongoing within corporate, government, academic and military laboratories, however with little to none media attention. It was not until 2012 when Oculus VR was established and brought into the spotlight to the media by introducing a Kickstarter for their VR headset Oculus Rift, resulting in corporations started to see the value of VR again and commercially developed kits started to be produced by various companies, giving households access to it (Jerald, 2015).

3.1.1 User interface

Because of the household access to VR, there is a paradigm shift happening where interaction designers that come from a traditional 2D interface background and wants to start designing for VR must start to think about designing for 3D surfaces (Chu, 2014). Chu (2014) states that VR changes the relationship a user has to the content delivered, that through a traditional 2D flat surface such as a monitor or a phone the user perceives it as outside-in. With VR, the experience is quite the opposite where the user perceives it inside-out. It is a spatial experience where the content is around the user (Chu, 2014). Jerald (2015) argues that well-designed VR experiences are thought of a collaboration between human and machine where it all works, software and hardware, harmoniously together. Well-designed VR needs to communicate how the virtual world works to the user, which is when immersion comes into the picture. Sherman & Craig (2003) explains immersion can be used in two different ways: mental and physical immersion, further stating that it refers to a mental state of a feeling of being involved with the experience. According to Witmer & Singer (1998), immersion is connected to the effectiveness of a virtual environment, resulting in giving a sense of presence. Presence, in this case, means a subjective experience of being in one place mentally, but the physical body is in another. The pair states that presence seems to be a matter of focus where the user directs attention towards something and is promoted by the use of “...continuities, connectedness and coherence of the stimulus flow” (Witmer & Singer, 1998, p.226). As stated, immersion is necessary to experience presence, and so is involvement. Involvement is a state experienced as a consequence of focusing the attention on a selected stimulated flow. It depends on the importance the user attributes to the activity, meaning the more the user focuses on a VR experience, they become more involved with the experience, thus resulting in a greater sense of presence. It can work in the opposite way as well. If the virtual world is not responding as the way it should be, or a general discomfort occurs the experience and involvement will decrease drastically (Witmer & Singer, 1998).

3.1.1.1 Design guidelines & Ergonomics

To ensure a higher level of immersion and presence, general guidelines can be followed that has been researched and established. During Chu (2014) and his team’s work with VR, multiple insights were discovered when designing
interfaces for a 3D environment. Chu states that looking around is an inherent part of VR where the user naturally looks and move around to explore the virtual world. When they looked closer at ergonomics within VR, conducting a comfort range test they discovered angles that were generally comfortable and maximum, realizing that turning the head left and right had a range of 30° degrees to each side with a maximum of 55°. Looking up has a comfortable margin of 20° and a maximum of 60° while looking down only had a margin of 12° with a maximum of 40°. These angles formed the structure for their VR design utilizing horizontal movement for content, while vertical interface below and above the content was reserved for navigational interface such as menus and settings. McKenzie & Glazier (2017) corroborates Chu’s ergonomic guidelines and continues on this direction during their Google IO ‘17 talk by introducing more guidelines for a designer to follow when designing screen interfaces in VR. In their tests, curved screens on the sides of the field of view make text and items more legible and puts less stress on the user’s eyes and neck. By introducing established design principles by Don Norman into VR, Jerald (2015) adds upon this framework and how we can use these methods while designing for VR. He argues that discoverability is very important in order to deliver a fully immersive experience to the user, in the sense of psychologically being in a different place than the physical location (Jerald, 2015). Putting key content right in front of the viewer and secondary content on the sides while they are still in the users FOV promotes discoverability which in turn promotes immersion (Chu, 2014; McKenzie & Glazier, 2017). Jerald (2015) introduces six characteristics that determine the level of immersion, two of which this thesis focuses on: Extensiveness and Interactability. Extensiveness describes the sensory modalities, which can be audible or visual, that is presented to the user. Interactability describes the user’s ability to make changes to the virtual world and the response from entities within the virtual world.

3.1.2 Interactions

Sherman & Craig (2003) describe interaction as a key ingredient to the virtual world, explaining that if the virtual world is not responding to the user’s physical movements or inputs it can no longer be considered virtual reality. Well-designed interactions within VR enables a high level of performance while taking away the limiting factor of human and hardware limitations (Jerald, 2015). It can be hard to design natural real-world interfaces for VR as some of these are not the most optimal ways for users to interact with, e.g. searching for a book is easier and more efficient to do in a traditional UI than looking it up physically in a library. Sherman & Craig (2003) states that the use of metaphors can be very important in order for the user to learn techniques within the virtual world. Providing with a set of familiar affordances and signifiers, the user can draw on their experience in order to interact with the world more efficiently.
3.1.2.1 Feedback & Feedforward

Feedback from user interaction in a virtual world is vital according to Sherman & Craig (2003). For the user to form a correct mental model of the world, correct feedback and feedforward needs to be worked into the interactions (Jerald, 2015). Sherman & Craig (2003) states that it can be problematic to generate feedback in the virtual world, further explaining that the feeling of touching something can be replaced by a haptic feedback in some way, but must most often rely on aural or visual cues that confirms feedback to the user. The interactions has to be well-planned and thought out prior to designing it. When designing interactions, Norman (2013) introduces the cycle of interaction while presenting the terms Gulf of evaluation and Gulf of execution. The gulf represents how much effort the user must go through to complete a task. Bridging the gap of the gulf can be done with the help of Bridge of Execution and Bridge of Evaluation, which means providing good feedback and conceptual model to the user. The cycle of interaction can be broken down to three parts: forming the goal, executing the actions and evaluating the results and can be seen in figure one. It is an iterative process that the user goes through every time interacting with the world, its properties and objects.

Jerald (2015) further adds to Norman’s model:

![Figure 1. Jerald’s cycle of interaction](image)

**Execution** – Execution is a feedforward action and is completed using appropriate use of signifiers, constraints, mapping and the user’s mental model. It works via the user going through three stages: plan, specify and perform.

**Evaluation** – The feedback from evaluation lets the user analyse and reflect on the action of achieving the goal, and make adjustments accordingly or
create a set of new goals. It is also broken down into three stages which are: perceive, interpret and compare.

In order to design for a good mental model, principles introduced by Norman (2013) can be used to ensure a good experience, which Jerald (2015) corroborates and adds to:

**Affordances** – Affordances is defined as the relationship between a user and the properties of an object. It shows what actions are possible and how the user might interact with it.

**Signifiers** – A signifier is an indicator that communicates correct purpose, structure, operation and behavior of an object to a user. A good signifier communicates to the user of what is possible before interacting with the related affordance.

**Constraints** – Constraints are the limitations of actions and behaviors. These constraints are designed to guide actions and help promote interpretation. Within VR design the constraints focuses on the physical and mathematical constraints. What objects the user physically can’t move or touch means that they are placed there with a purpose in order to guide the user.

**Mappings** – Mapping is about the relationship between two or more things, e.g. a control and its results. In an VR environment, Jerald (2015) explains that devices often have a good natural mapping for certain techniques, e.g. hand-tracked devices works well for virtual hand technique but poorly for a driving simulator, as a physical steering wheel would be more appropriate.

### 3.1.3 Prototyping and sketching for VR

Chu (2014) mentions that VR is still a very much an unfamiliar field where experiments and tests are vital in order to deliver a good experience within VR. Chu’s team adopted a process of being agile, meaning doing more and planning less, relying on that testing the prototypes would yield important insights. McKenzie’s & Glazier’s (2017) approach differs from this though, wanting to inform about how the field of interaction design needs to introduce new sets of standards when designing for VR such as new units and guidelines in order to prototype and develop at a more consistent rate for VR, generating a more consistent experience.

### 4 Methods

This chapter will outline the base of the design process for this thesis. It presents and explains the methods used throughout the project. Prior to each session involving users, they were informed for ethical conduct about the aim of the project.
4.1 Design process model

The approach and model of this thesis have been in the sense of User-Centered design (UCD). It involves bringing in users to any stage of the design process (Abras, Maloney-Krichmar, & Preece, 2004). According to Abras et al. (2004), the users have to be carefully selected and how to involve them, as there are three types of users: primary, secondary and tertiary. The primary users are the ones that are going to use the product regularly. The secondary users are the ones using the product on occasion and tertiary are the ones who will be affected by it. This thesis involves the primary and secondary users as it involves a target group of both experienced and inexperienced viewers of F1. Abras et al. explain that once the stakeholders have been identified, a thorough analysis of their needs is done through empirical work, this work is then translated into prototypes which are again tested by the users. For this project, the empirical work includes observations, interviews, and workshops. When these needs have been established, prototypes are created in order to be usability tested and evaluated by the stakeholders. One tertiary user has been interviewed for the thesis, which is an F1 team representative, for the sake of informing this project of how the F1 team work with F1 broadcasting, and what kind of research themselves has done in the field of VR.

4.2 Literature review

Review of literature is the process of studying theoretical perspectives within the field of interest (Muratovski, 2015). It helps the designer to get to know the subject with the help of previous research that may be of relevance. By doing literature review, the designer must study the literature carefully and recognize areas where further research must be implemented, as the data has been researched and collected by someone else. In order to do this, the designer must read and analyse related journal articles, books etc. Writing down reflections on the material helps the designer to make reasonable claims and arguments for their own work. The most important aspect of literature review is to inform the reader, and the designer, about the state of knowledge within the area. When all the data has been gathered, it must be organized and classified into patterns.

4.2.1 Types of literature review

Muratovski (2015) explains that there are six types of literature review that are used in research. Out of these six, methodological and thematic has been applied to this thesis.

Thematic – Thematic review helps the designer to examine multiple perspectives that are connected to the field in question. It presents themes or topics that are common across the literature and helps the designer to become well-informed about the subject in hand. The technique has helped
analyse and present common traits and themes within the future of sport broadcasting, and also about VR and its properties.

Methodological – Methodological reviews analyses methodologies. Muratovski (2015, p.33) informs that it “look at processes of, procedures in, or approaches to conducting studies in relation to the topic of interest“. This technique has informed this thesis about methods such as prototyping and creation for VR, and also how to write and structure the thesis-writing process.

4.3 Observation

The thesis utilizes observation sessions at the beginning of the project. Preece, Rogers and Sharp (2015) state that observation sessions can be used at any stage during development. Further explaining that early on in the process it helps the designer understand users’ context, tasks and goals, while observation later on in the design process, as in usability testing, helps inform the designer how well the prototypes developed supports the tasks and goals. Muratovski (2015) explains that it is a way to conduct visual research and there are two domains a designer should look at when constructing observation sessions: structures and settings, and behaviours and interactions. The first thing to look at is the place the observation session is taking place at, as it can have an influence on how people are behaving. The next thing to look at is the human setting within this place and how the designer might interpret activity. Taking notes during the session is encouraged, however, these shall not be intrusive.

4.4 Interviews

Throughout this thesis project, interviews were used extensively as a way to conduct qualitative research, finding out about people’s opinions, ideas and behaviour. Kahn and Cannell (1957) describe interviewing as conversation with a purpose. There are many forms of interviewing techniques that vary in formality and structure, which can be crucial depending on what setting the interview is taking place in. In some cultures, direct questions can be considered rude, and in other cultures, a not-so-direct question can result in an answer that might be too vague. Interviewing is a balancing act that the designer needs to be aware of and to keep a constant watch over what direction the interview is headed. Most often the designer needs to ask open-ended question and request clarification, being too open-ended with questions, however, can lead the conversation to being sidetracked, which also can reveal certain information about the subject but can take away focus from the subject (Muratovski, 2015).

For this project, semi-structured interviews were used as it uses a mix of both closed and open questions. Preece et al. (2015) explain that the interviewer has a basic script to stick to so the same topics are covered with each
interviewee. It starts with planned questions and encourages the interviewee to say more until no more relevant data is revealed.

All of the interviews were conducted face-to-face except when interviewees were at remote location which required phone call.

### 4.5 Workshop

A workshop with a focus on participatory design was held during the project. Muller & Druin (2007) explains that workshops are usually held to diversify stakeholders and interested parties to promote communication and commitment to shared goals. Workshops are most commonly held at sites that are neutral to all parties. It can be used to aid creativity and create design opportunities the designers might not have thought about. The workshop held for this thesis can be described by Sanders (2000) as a Strategic Design Workshop, with a strategy following say-do-make. It combines market research *what people say*, ethnography *what people do* and participatory design *what people make*. Activities can be of constructing and mapping material such as sketching an interface out collectively on a piece of paper.

### 4.6 Sketching

Buxton (2015) states that both while sketches and prototypes are representing the design concept, they serve different purposes. Further explaining that sketching dominates early stages of ideation while prototypes serve a purpose later in the stages. It has to do with the aspect of cost, time, quantity and disposability.

What qualifies as a sketch are some attributes. It has to be quick, timely, disposable and plenty, among others. It does not just only have to be on paper, it can take on any form as long as it has these underlying properties. Buxton (2015) explains that sketching has more to do with exercising the imagination and understanding, than about the material used. It should inform the design decisions taken for the prototypes as it helps to suggest, explore, question and propose because of its nature.

### 4.7 Prototyping

Preece et al. (2015) state that users often cannot tell what they want, but as soon as they see something and get to use it, they soon know what they do not want. A prototype helps a user to understand and give feedback on concepts. A prototype is a tangible object and a manifestation of a design that affords to be interacted with to explore its suitability. It is a great tool when discussing or evaluating ideas with stakeholders and serves as a communication tool among designers (Preece et al., 2015). A prototype can be a great number of things ranging between a paper-based outline of a display to a 3D mock-up (Preece et al., 2015). What determines what kind of prototype to create depends on the role it is supposed to have. Houde & Hill
(1997) presents a three-dimensional space model that represents aspects of an interactive artefact. The three dimensions are: Look and feel, Role and Implementation. The look and feel aspect refers to the sensory experience of using the artefact. Implementation refers to question the techniques and component the artefact needs to have in order to properly work. Role means to question what kind of function the artefact serves in a user’s life.

According to Buxton (2007), a prototype should dictate, refine, answer, test and resolve specific issues, and is used in latter stages of a design process when things converge. Low and high-fidelity are terms commonly used within the field of interaction design. It refers to the degree the prototype is meant to look and behave like. A low-fidelity prototype most commonly does not look much like the final product and does not provide the same functionality. It can use material such as paper or cardboard. They do offer aspects such as simplicity, cheap and quick to produce. High-fidelity, on the other hand, most often looks like the final product and provides more functionality than low-fidelity prototypes. They are more costly to produce and heavily time-invested but more efficient in communicating ideas and testing technical issues than low-fidelity prototypes (Preece et al., 2015).

This project has utilized prototyping at its core in order to fill the gap of research within interactive TV in VR. The prototypes help to inform further design decision through an iterative state with usability testing the prototypes and further developing. Through the empirical work, the prototypes explore elements that viewers would like to interact with during a broadcast, and it helps to explore how to build an actual artefact that has been user tested. As Chu (2014) mentions, the field of VR design is still relatively unfamiliar where tests and experiments are vital in order to push the field forward. With the help of prototyping, it has helped inform this thesis of what to think about when designing for interactive broadcasting interfaces for motorsports.

*Figure 2. Houde’s & Hill’s model of what prototypes prototype*
4.8 Usability testing

In order to test the prototypes produced for this thesis, usability testing has been conducted in order to extract insights from each iteration of prototypes. The goal of usability testing is to test if the product that has been developed is usable by the intended target group (Preece et al., 2015). Abras et al. (2004) explains that usability testing aims to fulfil five goals, which are: improve the product’s usability, involve real users in the testing, give the users real task to complete, enable testers to observe and record actions of the user and enable testers to analyse the data and make appropriate changes. Preece et al. (2015) state that structured or semi-structured interviews can also be conducted in order to collect additional information.

5 Design Process

This chapter describes and refers the design process to the methods and theory presented in this thesis. It will explain the process of empirical work leading up to the creation of prototypes which is then usability tested. Connections of the outcome of each iteration of prototypes to the theory explained in chapter three will be presented.

5.1 Conceptual exploration

Research is the first phase in the research phase, as depicted in figure three, and has been done in order to analyse what has been done within the field of augmenting the viewer experience with the help of newer technologies such as AR and VR. With these technologies, multiple products have been launched that is trying to immerse the viewer into the viewing experience in new ways and has helped inform this thesis of what research already been done and what potential gaps might exist. Research that looks at how interactive TV has been utilized over the years in the world of F1 has also been conducted and can be found in chapter two.

![Figure 3. First part in research process out of three](image)
5.1.1 Existing VR products in sports

Oculus introduced its platform *Venues* where the focus lies on the social aspect of bringing viewers together in a room to watch events live. It is designed to let users interact with others in a virtual space. 252 people can be in the same room together, all synchronized watching the same event (Bashara, 2018).

Other platforms such as NextVR are trying to bring the viewer closer to the action, offering perspectives that look like the user is in the actual stadium and giving them access to angles that are not aired on regular scheduled TV (Nelson, 2017). A product similar to NextVR, DreamVR announced a partnership with F1 delivering behind the scenes VR footage that viewers can take part of that shows perspectives in VIP areas at various Grand Prix. The footage does not, however, include any footage of live races of any sort (Fourtané, 2019).

5.2 Design criteria

To inform this project about user's needs, as explained in chapter four, empirical work has been conducted which has helped pave the way to creating prototypes that users later test and evaluate.

5.2.1 Observations

Before each session, the participants were informed about the project’s scope of augmenting the TV experience. Because of this, they were given pen and paper to write down any notes or ideas they had when spectating a race. After circa two hours that it takes to watch a race, semi-structured interviews were conducted in order to have the participant to reflect on the experience. The session was conducted in my home and at some of the participant’s houses. It was done in order to let the participant be as comfortable as possible and act as they would naturally during races. Their behaviour during the races was observed and recorded.

*Figure 4. Second part out of three in research process*
5.2.1.1 *Inexperienced viewers observation*

While observing the less experienced viewers, the races watched was pre-recorded as some pre-determined questions were made about certain scenarios in the race.

The less experienced viewer participants had similar notes and reflections after watching a race. Elements such as differentiating which driver is which and general confusion surrounding rules were expressed. When asked about this afterwards, the participants stated that it was confusing at times when following a specific car on-screen and relating to the graphic showed on-screen during the feed. When following a car that just had went for a pit-stop for a set of new tires, and was chasing the said driver’s rival, which often creates intense moments in the race, one participant stated:

“I don’t really know why we are following this driver now, or why the commentator is excited over following him. Why is this more important than anything else in the race?”

Certain essentials became clear during the observation session. Even though the commentator was explaining the situation, the participants felt overloaded with information as timing screens and other graphics were cluttering the screen. They expressed that it was hard at times to put on-screen action into context to what the graphics were showing, even though the on-screen graphics showed that the driver just put on a set of new tires, resulting in going much faster on-track and another graphic showing how much time he gained on the rival. At times the participants stated they found difficulty in differentiating between drivers and knowing which was which. Each of the participants stated it was easy to remember the face of the drivers and knowing what team they belong to, but that it was hard during the race knowing who was who because of the fast-paced nature of F1. They expressed that graphics showing the drivers face would ease their confusion during the race, or an indication that shows which driver is on the screen. Multiple times the participants would ask “Who was that?” or talk about a certain scenario during the race but naming the wrong driver.

5.2.1.2 *Experienced viewer observation*

As the sessions with inexperienced viewers were pre-recorded races, the sessions with experienced viewers were live races. This was done in order to record the experienced viewer’s habits while spectating. The participants were free to have complete control of the TV and free to use their phone and computer however they wanted. Two separate observations were recorded.

As the F1 show started, both participants opened up their laptop and logged into their F1TV account. From there they started up the data feed. When asked about this afterwards why this was done, both stated that they used to only do this with their phone as it was not possible until the F1TV service was
launched. The participants explained that during the starts they wanted a full data view of leaderboard, timing screens and tires.

“The tires in the beginning phase of the race are important, as these are often what decides the order of the grid when the race starts. The softer tire is always the better tire to start on but wear off quickly, which decides who needs to do a pit-stop, which in turn dictates the rhythm of the race”

When asked if the TV feed is not sufficient when broadcasting the starts, both participants stated they did not trust, at times, the TV director showing the bits that are important to them. Having the live feed of data ensured that they would not miss any action.

During the more static parts of a race, the participants would switch from the data view into following on-board with specific drivers. They explained that they have multiple favourite drivers on the grid which they cheered on for different reasons.

“I would love for Sebastian Vettel to win the drivers championship as he is someone I have cheered on for years. I would also love to see Kevin Magnussen do well as he is from Denmark and I would like to see him go to a bigger team and be giving the chance to drive a better car. Alex Albon is someone who was my favourite driver in F2 and would like to see him do well in F1 as well.”

The two participants both shared the attitude that the TV feed sometimes misses out on the more important action in their opinion, stating that following the midfield battle is more fun than the battle for the first position. They both stated that the midfield battle is more even between the cars and more fun to watch because of it.

5.2.2 Interviews

To follow up on the insights gathered from the observation sessions, interviews were conducted with experienced fans with a more narrow scope on augmented TV, as well as focus on the technical side of augmentation with an interview with a Formula 1 team representative.
5.2.2.1 Formula 1 team representative

Early on in the thesis process, e-mails were sent out to all of the F1 teams and to F1 as well. It explained the purpose of the thesis, and if any of them would agree to an interview. It resulted with one of the teams reaching back agreeing to talk about the project. The person that reached out to me was a team representative. We agreed upon meeting each other in Barcelona on the second week of F1 pre-testing between the 26th-28th of February. However, because of the team’s hectic schedule during the tests, there was no possibility for a meetup. We agreed that a phone call would be sufficient.

During the interview, the project’s progress was explained and that augmentation of the viewing experience was being explored. The team representative explained while the team was not working with F1 broadcasting, he knew that VR as a broadcasting medium was being explored by FOM. He explained, however, that the team were exploring Virtual Reality with other goals in mind. They were looking at VR in order to mediate to visitors at their factory what the experience is like when being at a Grand Prix. Further explaining that giving the visitor the sense of the intensity in the paddock, and also what the drivers experience during a race is important in order to give the visitor a realistic view of how a race weekend unfolds when being on-site.

5.2.2.2 Summary of interviews with primary users

After the multiple observation sessions and the interview with the team representative, more interviews were conducted focusing on the subject of augmenting the TV experience and how viewers would like to engage with the broadcast material.

The interviewees were asked how they structured their viewing experience. Three out of four experienced F1 viewers stated that they use other media to look up data that was not offered via the TV, further explaining that they did not feel that the feed from the TV was sufficient for their spectating needs. Giving them the reason to resort to other mediums in order to be satisfied.
When asked what elements or data was missing from the main TV feed, the interviewees explained that the lack of control of following their favourite driver was one of them. Timing screens was also important and the ability to compare certain drivers lap times. The control of looking up replays of action-packed scenarios, such as overtakes, whenever they wanted was lacking. Two of the interviewees further explained that they had to resort to the F1 subreddit on the website Reddit in order to watch replays on-demand. When asked why they felt the need to do so immediately, the two of interviewees both said they felt the need to analyse situations, such as crashes, and form an opinion about it themselves. It also became clear that age was an important aspect to recognize. Two of the participants were older and gave different answers on how they watch replays. They said that they often just wait for the feed to provide the replays, and then trust the post-F1 shows on the TV networks they watch to provide the important replays that the live feed might have missed.

When asked about if they feel confused about which driver is which, all of the interviewees said no, stating that they have followed all of the current drivers in F1 in other series such as Formula 2 and even Formula 3. Because of watching drivers come up through other racing categories, the interviewees felt that they knew enough to differentiate between the drivers and which drivers were rivals. Stating that it was a fact that they often had in mind during races, explaining that they looked for fights between rival drivers and often thought it was more entertaining than watching the front of the field.

When the interviewees were asked what excites them about the sport in general, all of the interviewees responded with the same answer: development of the cars over the seasons is a driving force. The interviewees
described how excited they became when their favourite team introduced new parts to the car that might give them an advantage over the rest of the field. They all stated they love the technological war between teams and which of them gets the job done better.

5.3 Conceptualization

In order to generate and propose ideas for the prototype process, workshops and sketching was conducted. The workshop generated a visual direction for the *look and feel*, presented in chapter four, for the prototypes to be produced. While the sketching session created a more narrow set of guidelines for the *look and feel* of the interactions of the prototype.

5.3.1 Workshop

To generate ideas for the interface, a workshop was held with participants with mixed levels of experience within VR and F1. The focus of the workshop was to look for design opportunities for VR as a broadcasting medium and how to apply its aspects to an F1 viewing experience. The session started out by looking at what some of the F1 teams had done with VR from a marketing standpoint. This was done in order to bring everyone up to speed of how it could look like prior to sketching.

![Figure 7: Red Bull VR example video shown during workshop](image)

The participants was then introduced to scenarios which were pre-recorded videos. After each scenario they were given screenshots of the scenario that they could freely sketch on. The scenarios were: *overtakes, pit stops, starts, qualifying* and *general driving*. They were given elements that would be of importance to each scenario, e.g. such as time difference and speed compared to the other car when overtaking. The participants were also welcome to
sketch down ideas of their own. They were also asked to either sketch or keep in mind how they would interact and engage with elements.

![Workshop participants sketching ideas](image)

**Figure 8. Workshop participants sketching ideas**

5.3.1.1 *Summary of workshop*

During the overtake scenario, the participants expressed different priorities of what they wanted to be able to do. The less experienced F1 viewers wanted to be able to engage with the data and to show more information about the drivers. The more experienced F1 viewer felt the need to have complete control over the replay feed more than anything else, as he felt secure in able to identify drivers and what position they were in. He explained that the TV feed could sometimes cut to replays at the wrong time, and wished that he instead could control the timing of replays, being able to replay a scenario during the less intense parts of the race. When sketching out ideas for the UI, all of the participants made comments about how it should be just enough data and not too cluttered as when there was too much of it, they felt the sensation of being overloaded with information and graphics. As a solution to this, an interaction that could hide the UI was proposed.

All of the scenarios shared similar insights where the less experienced F1 viewers wanted more control over being able to tell the drivers apart, while the more experienced F1 viewer wanted the ability go through data that was important to his viewing habit. He explained that the data would be: comparing lap times between drivers, what tires the drivers were using to determine possible strategies, the speed they were travelling and the ability to compare to the driver in front or behind. All of the participants expressed a desire to be able to choose different camera angles and perspectives, such
as following along on-board with drivers and structure their own set of screens in the feed with multiple drivers on-board.

![Figure 9. Workshop sketches](image)

When analysing the sketches, they all shared a similar trait of having the UI worked into the environment of the feed, as well as having space around the feed to display data and leaderboard.

![Figure 10. Workshop sketches](image)

Other interesting insights that came out of the workshop was the possibility of connecting people and creating a collective TV directorship where people who followed their own favourite driver could have the possibility to notify others if important scenarios occurred and the others connected could have the possibility to quickly switch to the feed, which in turn could ensure that none of the action was missed out on.
5.3.2 Sketching

Prior to prototyping, sketches of the user interface were created. The workshop insights aided this process. The first step was to sketch out a flat 2D interface to explore different ways of structuring the viewing experience and the space around. Familiar elements to an F1 viewer that was discovered in the observation and interviewing section of this chapter was used in order for the user to get to know the virtual world faster. As described in chapter four, the sketches created were done in order to explore and suggest ways of prototyping the interface. The main objective when sketching was to create a tangible mental model of the navigation and affordances that the elements offered with the help of design guidelines explained in chapter three. The leaderboard was a vital part of the interface as most interactions would surround it. The reason for this was the fact that during observation with the experienced F1 viewers, it was revealed that they most often use the leaderboard to establish a mental model of the race with the help of positions of drivers, the time between drivers and what kind of tire they were on. When sketching out the navigation of the interface, different modes were introduced as ways to interact with the leaderboard. Onboard footage mode would let the viewer to augment the viewing experience by letting them control what footage goes on what screen. Replay mode would let the viewer choose replays to watch and on what screen, and data mode would let the viewer display data of any driver. They would all have to be activated from a navigation interface. When a mode was activated the viewer could then interact with the leaderboard.

![Figure 11. Flat 2D UI sketch](image-url)
When structure had been established, feedback in the interface from elements were also sketched out.

5.4 Prototyping

Based on prior empirical work and sketches, elements such as onboard footage, replays and driver information were extracted as important objects to be interactive within the interactive virtual environment. These were the elements that the observed and interviewed viewers felt was lacking from the provided TV feed. Taking inspiration from and following established principles to design for VR, prototypes of low-fidelity and high-fidelity were created in order to test ways of interacting with the elements in the virtual world.

For the prototypes and usability testing, the VR headset used was a Samsung Gear VR. It provides a stereoscopic vision which renders a left and right view, giving the user a 3D effect and a sense of depth. It can only use the orientation of the device, and not position tracking. It means that the position of the view is fixed, but the orientation is a full 360° degree view (Chu, 2014). When navigating the virtual world and interacting with it, the Gear VR can either use the gaze with the touchpad integrated on the headset itself or the Gear VR remote which allows the users to interact with the element with the remote in one of their hands.

5.4.1 Low-fidelity prototype

To explore the category of Look and feel that is presented in chapter four by Houde & Hill (1997). The first step in prototyping was to translate the UI from

![Figure 12. Displaying feedback from onboard footage mode](image-url)
a 2D surface to a 3D surface. There are multiple challenges to this as Chu (2014) in chapter three presents, such as viewing angles and feedback. As a way to tackle these challenges, 360°degree sketching paper grids were utilized. The reasoning behind this was to inform the prototypes of the scale of the UI and what was comfortable, keeping in mind that the viewers were most likely to be sitting in their sofas at home when spectating a race, resulting in limited head movement.

![Figure 13. 360° grid low-fidelity prototype on paper with comfortable and maximum FOV outlined around the interface](image)

When the UI had been sketched out on the 360° grids they were photographed and viewed at in a VR photo viewer.

![Figure 14. 360° degree low fidelity in VR mode](image)

When the viewing distance and angles were up to par according to Chu’s (2014) guidelines for ergonomics, the *look and feel* of the low-fidelity prototypes were translated into high-fidelity in order to develop further iterate on the category, but applying it to the interactivity for the virtual world.

5.4.2 First iteration of high-fidelity prototype

With the low-fidelity prototypes informing the high-fidelity prototyping process of viewing distance and angles, the first round of prototypes was ready to be produced. The prototypes utilise Mozilla’s A-Frame WebVR
engine (Mozilla, 2018), which is a code framework for VR that uses HTML and JavaScript to construct VR worlds.

The first step was to create the virtual world and the UI according to the appropriate 360° sketch grid. The aim with this prototype was to test out the look and feel of interactions between the different navigational modes which were onboard footage and driver information. When starting to develop the replay mode, it was quickly discovered that the interactions would be somewhat the same as the onboard footage interaction. Instead of putting in time towards creating a replay mode, it was decided that the interactions with the onboard footage mode would be focused upon, further refining it as they both would follow the same interaction patterns in this prototype.

![Image of virtual world and UI](image15.png)

*Figure 15. Selecting onboard mode*

Activating the first iteration of onboard footage mode, the view control buttons would slide out next to the leaderboard. Each button next to the driver would signify and control which screen the onboard footage would appear on when clicked.
When activating the *Data mode* the leaderboards affordance would look the same, but offer different feedback. When clicking on a driver’s name, the information and data about that driver would appear on the right side of the screens.

5.4.3 First round of usability testing

Two participants tested the prototype. They were given a set of assignments to do while testing. The first assignment was to set onboard footage of drivers *Sebastian Vettel* and *Charles Leclerc* on the two screens above the main screen. The second assignment was to find driver information about any of the drivers on the leaderboard. The third and final assignment was to watch a video and just reflect on the experience. During testing, the participants were free to reflect and speak out loud about how they navigated the interface. Post-testing they were asked to reflect on the experience.
5.4.3.1 Summary of first round of testing

Both of the participants liked the concept of continuously interact with the leaderboard, keeping it as an integral part of the viewing experience of F1. They appreciated the curved interface as they felt that they did not need to turn their head that much to read. One thing that both participants noted was that when choosing the onboard footage they both spent a lot of time looking away from the screens. Resulting in taking away too much focus from the race itself, thus breaking the immersive nature of VR. They noted that choosing which screen to show onboard footage was a very precise interaction which required them to be accurate with the controller, resulting in looking at the interface more than the screens.

Both participants felt that the view distance (see figure 18) was a bit too close to the screens when interacting with the interface. They did however like the view distance when they were just spectating the screens. One of the participants proposed that there should be a toggle or interaction to adjust the viewing angle to make it more comfortable, similar to what was proposed in the workshop found in section 5.3.1.

![Figure 18. Figure of what the FOV was with the darker area being 60˚ degrees and red curved lines being the interface](image)

Regarding feedback from the virtual world, both participants said that it was pretty good, but when looking up driver information it was hard to notice if they succeeded, as the leaderboard element and driver info element were on opposite sides. Both participants felt that a visual or audible cue would suffice. Feedback on which driver was which on the screens were requested as well so it was easier to bring up data on the driver who’s onboard footage was spectated.

5.4.4 Second iteration of prototype

Going into the second iteration, the insights and results of the first round of usability testing were analysed. It was clear that the interaction when choosing onboard footage needed to be easier to complete and not as accurate. Overall feedback from the virtual world was needed. The angles of
the interface needed to be adjusted and the idea to let the viewer control the viewing distance was interesting.

**Overall feedback** – To improve on the general feedback, audible cues were introduced to each element that was interactable. Affordances such as more visual and audible hover and confirm states were incorporated where appropriate. This was done in order to minimize the gap of the two feedback gulls as discussed in chapter three.

*Figure 19. Flow of second iteration of interaction choosing onboard footage*

**Onboard footage mode** – The interaction to control the screens were adjusted which can be observed in figure 19. Instead of pushing buttons to control the screens, the user now selects the driver they want to follow the onboard footage on, similar to the interaction of data mode, a small preview screen pops up next to the controller and all of the screens increase in size to show to the user that they are interactable, the user then clicks on the screen they want the footage on and the onboard feed starts on the selected screen. Interface with the team colour and name shows up above the screen to indicate which driver is on which screen, and the icon showing which screen is activated shows up next to the selected drivers on the leaderboard, indicating which screen is activated for the spectated driver.

*Figure 20. Flow of second iteration of interaction with driver data*
Data mode – The data mode interaction was refined and added upon. Audible cues were added to let the viewer know that they succeeded in selecting a driver. The added interaction was that the viewer can now click on the screens to show more information and a driver picture directly on top of the screen with a lowered opacity, allowing it to be transparent but enough to read the information and watch the onboard footage seen in figure 20. It acts as a toggleable element and disappears when the viewer either deselect the screen or turn off the data mode.

Viewing distance – The viewing distance was brought back quite a lot, allowing the user to have a greater FOV over the interface. An interaction to hide the interface and bring the FOV closer to the screens was added, as seen in figure 21.

5.4.5 Second round of usability testing

For this round of usability testing, there were a total of four participants. They were two previous usability testing participants as well as two more. They were given similar assignment of controlling onboard footage, revealing information about drivers and turning off the interface to spectate.

5.4.5.1 Summary of second round of usability testing

This time around, the two participants that tried the first iteration of the prototype were pleased with the adjustments. When trying out picking driver onboard footage, one of them stated the following:

“This interaction is a lot of fun and the feedback is very pleasant. Showing a preview window feels like I’m grabbing a hold of it and throwing it on the screen making the interaction very liberating, giving me a sense that I’m in control, and it feels like I’m more immersed than before.”

The participants also confirmed that the overall feedback from the virtual world was much better and that it helped improve the feeling of immersion. They liked the new viewing distance, stating that they felt that they were more in control of the virtual world than in the previous iteration. Each participant
thought that the toggle to control viewing distance was a good way to navigate between spectating and interacting with the interface. Multiple comments were made however about the leaderboard when hiding the interface, stating that it was needed when spectating.

![Illustration on the new FOV](image)

*Figure 22. Illustration on the new FOV, bringing back the view distance allowing more of the content into the FOV, with darker area being 60° degrees and red curved lines being the interface.*

All of the participants liked the new interaction to display information about the drivers by toggling the screens. They felt that the interactions were more aligned with each other and followed a pattern of putting focus on the screens more than the interface.

When asked just to spectate video feed in the virtual environment, all of the participants made comments about immersion stating it was a very exciting way of spectating sports. All of the participants made comments that they would like to try to watch a whole race like this. The two new testing participants proposed the idea of placing it all in an environment such as on a racetrack to further increase the immersion and viewing experience.

# 6 Discussion

For this chapter the insights and their value for interactive motorsport TV in an VR environment will be discussed.

## 6.1 Insights & value

As this thesis focused on exploring VR as a medium for broadcasting interactive TV, it was important to recognize the patterns that appeared in the design process and draw parallels to the theory in hand in order to
advance and further develop the prototypes. As this is unfamiliar territory and gap in research for interaction design at the moment, it was important to prototype in order to generate and corroborate data, as stated in chapter three. It was important to notice that the users said that when the interactivity was focused on interacting with the screens themselves, and using the interface around the screens as tools as demonstrated in the second iteration of the high-fidelity prototype, the viewer felt more immersed. Also the more FOV over the interface there was, the better discoverability there was in the UI, in turn leaving the viewer feeling more immersed, confirming what was stated in chapter three. And although the thesis focuses on F1 as a sport, the insights discovered on what to incorporate into the broadcast should be applicable on other motorsports series as they contain similar elements.

It is also worth noting that simple feedback such as audible cues in the virtual world can make a lot of difference to the users mental model. As mentioned in chapter three, the user is cut out from the physical world and can only, with the VR technology used, rely on the visual and auditory senses. It was important in putting constraints to the viewing distance and feedback from the interface in order to not overloading the user with information. Mapping interactions into having similar patterns were also of importance, as the user felt that they could easier navigate the interface. A consistent flow of feedback and use of interaction with the leaderboard when using the different navigational modes confirmed that the user could more freely discover interactions while at the same time focus more on the spectating experience.

An interesting aspect of this thesis, the author has previously thought of VR as a phenomenon that has been too hyped up in the industry. However, when working with the technology intensely over a four-month period the opinion had changed, realizing that VR introduces a whole new dimension to immersion and presence, and has, in the author’s opinion, a lot of future potentials and use cases. Because of the nature of F1 and the desire to push the envelope of what is possible in engineering, this can be applied to broadcasting as well and is something VR has a use case for.

Going forward, it is important to keep the ergonomics in mind. The thesis never tested watching a full-length race in the way the prototypes were developed. Doing so can yield data that can change the prototypes drastically as it is a very important aspect of the project. As much as it is an interesting way of spectating the sport, it also has to be sustainable for the viewer. Testing new virtual scenes of the world can also be of value to the aspect of immersion and presence. In usability testing, participants stated that they would like to try the prototypes in other virtual environments such as on track, or with other F1 fans, which touches upon the social aspect that this thesis has not explored. Connecting F1 fans in this way could be of interest as there are other VR projects that focus on this, which are presented in chapter three. The project does not involve 360° degree videos which also can change the experience drastically. F1 have cameras on the cars that record in this way but
is never utilized in live broadcasting. The reason for not using it for this project was because there was no way during the project to gain access to it. Designing a VR interface for a 360° video might prove to be a different challenge, but an important aspect of VR to keep in mind going forward.

6.2 Critique of own work

Even though the low-fidelity prototypes yielded data on viewing distance, it could have been utilized more to inform the high-fidelity prototypes as these take a longer time to iterate on. Having a faster iterative low-fidelity prototyping process with usability testing would result in a more efficient way of developing, and multiple aspects could have been explored this way to faster produce higher quality high-fidelity prototypes.

The usability tests did not test a dynamic leaderboard that can change as the order of the F1 field changes over a race, which can, in turn, disturb the user experience while watching in the way prototyped. While this is a critique towards the prototypes, it can also be prototyped and used in usability testing going forwards.

The author recognizes that more users could be brought into the various stages of the design. However, reaching out to F1 fans in the south of Sweden, where the author was situated, proved to be a bit of a challenge. The sport itself has a great outreach globally, but not so very much here. A better job of recruiting could have been done in order to provide a richer nuance of data with a greater number of participants.

7 Conclusion

Much like an F1 championship, this thesis has acted like an F1 team entering each Grand Prix (stage in process) with a new evolution of its car. It has been a focus on driver (user) input resulting in making the car more efficient. At the end of the championship, the car is at its peak performance. However, when the new championship season starts again the car is at the lowest point of its evolution of the season. Much like the championship seasons, The work that has been conducted for this thesis has an intention to be a starting point for designers as what to consider when designing for interactive TV in VR as a medium, as the developed car is a starting point for a new season.

As set out to find out for this thesis was to explore interactive TV for motorsports in a VR environment, the study discovered a set of elements through empirical work that the designer should focus on when designing for the medium. The empirical research also revealed that viewers of different experiences cared deeply about augmenting their viewing habit because of the nature of F1 races. During static moments of the race, it was revealed that
users would spend their time looking up data and replays. The data was offered in this case through F1TV viewed either through the streaming service or a second medium such as the phone via the F1 app. The replays, however, were most often hosted on sites like Reddit resulting in taking away focus from the broadcast. During the races, the viewers would most often spectate different onboard footage of their favourite drivers. Viewers will less experience were at times confused over which driver was which, and had to resort to external media in order to find out more information about the said driver.

With the use of interactive TV and VR as a medium, it opened up the design space to incorporate these elements directly into the broadcast suiting the intended target group of inexperienced and experienced viewers of F1. The observations also revealed that the viewers use existing elements as fundamental parts to create a mental model of how a race might play out, using elements such as the leaderboard to determine strategies based on timing, tires and position, which were incorporated into the prototypes.

The theory supported sketches and prototypes through various design guidelines that have been established for VR. Ergonomics was an important aspect to consider when designing the interface of a virtual world. Placing the content strategically mattered because of the human physical limitations, and also because of the setting the target group would spectate sports would be from their sofas as revealed in chapter five. General VR design guidelines explained in chapter three were also incorporated into the prototypes in order to develop high-fidelity prototypes that focused on the look and feel of the interactions when navigating the virtual world. They were done in order to generate good usability test data that could be used to form a set of recommendations when designing interactivity for broadcasting interactive TV in VR.

What the thesis presents, at the end of the day, is design opportunities that the viewer can use to augment their spectating habits. Every viewer is on different levels of involvement with the sport, some has their favourite driver they want to feel a connection towards, and some are just spectating for the fun of it but it all boils down to the same conclusion – every viewing habit is different and there is a desire to augment it in different ways. Someday, when the live interactive broadcasting technology finds its way into VR, the project’s insights might act as design recommendations for future ways of interactive broadcasting in motorsports.
References


Appendix

VR prototype in action: https://vimeo.com/337780983
Github repo: https://github.com/trollcus/formula1-vr/tree/v2