MASTER THESIS

Designing an Infotainment System for Electric Motorcycles

Enhancing User Experience for Urban Commuting without Compromising Safety

Master's Thesis in Industrial Design Engineering

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CHALMERS UNIVERSITY OF TECHNOLOGY
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Preface

This master's thesis presents a project covering 30 ECTS credits, which was conducted between January 2019 and June 2019. The project was conducted by two students at the Industrial Design Engineering program at the division of Design and Human Factors, department of Product and Production Development, at Chalmers University of Technology.

Many people have helped us during this project. First, we would like to thank all the experienced motorcycle tutors that has helped us with providing very valuable insights with regards to safety aspects and factors that we would have to consider when developing our concept. We would also like to thank all people who showed interest and responded to the questionnaire and showed interest in participating in our user research. Of course, a big thank you to those that also eventually participated in interviews and the usability tests which were vital to our design process. Your input has been invaluable.

A special thanks to Nils Berg who was our supervisor and experienced UX Designer that helped us structure the design process and providing us with valuable knowledge as to how to apply UX design practically. Big thank you to Jonathan Åström, the CEO of Regent Motorcycles who gave us the opportunity to be a part of such an exciting project and always provided us with necessary tools to perform the project. Also, thank you everyone at Annevo, you provided us with a stimulating workplace where we could bounce ideas with everyone.

Lastly, we want to direct our deepest thanks to the researchers at the division of Design and Human Factors at Chalmers. Thank you Fjolle Novakazi, Mikael Johanson for discussing with us and helping us structure our work. Special thanks to our supervisor, Fredrick Ekman, for guiding us through each step of the way and for always providing timely and vital feedback. Furthermore, we want to thank Pontus Wallgren, the examiner for the project who also was a veteran MC rider and participated in the user research and contributed with essential input.

Getoar Kumnova & Adis Imširovic

Abstract

The Master thesis was done in collaboration with Regent Motorcycles which is a company started within ANNEVO's innovation studio, situated in Gothenburg. The thesis was conducted to concretize what difficulties, requirements and needs motorcyclists have when driving, more specifically in urban areas concerning an electric motorcycle. This would be done by compiling a list consisting of requirements and user stories (which essentially are desired features). This list would be compiled based on the gathered information and knowledge throughout the project. The list would also become the underlying basis for a second project goal, which was to produce an infotainment system concept that would essentially embody the defined product requirements and user needs.

The master thesis resulted in an infotainment concept which called MotoRide Infotainment and can be interacted through a keypad at the left handlebar, eight-inch touch display or a Bluetooth connected headset. Having the display gives possibility to visually display various information and entertainment features. The information and entertainment consist of a music player, navigation, GPS and phone communication. By wirelessly connecting a smartphone through Bluetooth, it is possible access the smartphone's music and communication capabilities. What functionality is accessible depends if the motorcycle is in drive- or neutral mode to prevent the rider from exceeding mental workload. The infotainment system is designed to simplify riding in urban areas by offering real time information about present traffic situation and giving suggestions on alternative routes to avoid traffic jams based on destination set in the navigation. The infotainment system has the option of always being connected to the internet as well, independently from a connected smartphone.

The Motoride concept fulfilled the project goals which was to provide guidelines for how an infotainment system should be designed for an electric motorcycle that is meant for urban commuting. The concept aims to provide the functionalities that the modern motorcyclist expects and remove the need of using a smartphone while riding. Finding the balance between the safety aspect is essential. The number of features should not infringe on the rider's ability to maintain awareness of their surroundings and should be complemented with a user interface that enables the rider to stay in full control. Even if the MotoRide concept was designed for the target group of Regent's retro-designed motorcycle in terms of user experience and needs, they are still based on the needs of motorcycle riders which means that the infotainment design guidelines, together with the concept, still provides a suggestion for how to keep riders satisfied and safe at the same time.

Table of Content

1

INTRODUCTION

The introduction presents the context, background, project aim, project goals, demarcations and the societal, ethical and ecological considerations.

1.1 Context

Motorcycles are motor vehicles that has two or three wheels (Nationalencyklopedin, 2019). The Swedish Transport Administration (Trafikverket, 2018) has divided motorcycles in the three sizes: A1 - light motorcycle, A2 - medium sized motorcycle and A - heavy motorcycle. The difference between the classes of motorcycles depends on stroke volume and engine power. Motorcycles can further be categorized in subcategories that are used for different purposes and each have their own stereotypical riders and identity. The most commonly known categories of motorcycles are identified as custom, off road, touring, supersport and scooter (Nationalencyklopedin, 2019).

Electric vehicles have been identified to be suitable for urban commuting compared to vehicles using a combustion engine due to decreased emissions, decreased sound pollution, low maintenance costs and low cost of electric charging compared to refueling (CNBC, 2018). With decreasing battery prices, increased battery capacities and increased awareness of the side effects associated with emissions and low noise pollution, the electric motorcycle industry is expected to grow nearly 42 percent by 2021 from 2018.

This project considers Regent's electric motorcycle (see figure 1). It is categorized as a light- custom motorcycle which according to swedish legislation could be ridden by people that are at least 16 years old and that had obtained at least an A1 license.

Figure 1. Regent`s Electric Motorcycle

Regent's electric motorcycle is designed to be perceived as a cafe racer which is traditionally characterized by having the expression of being lightweight as it is stripped down to its bare essential components to give it a sporty appearance (Bikebrewers, 2015). The style and shape of the café racer emerged initially from the motorcycle styles from the 50´s and 60´s with inspiration coming from the motorcycles that participated in the Isle of Man tourist trophy racing events. The motorcycles at these events were regularly seen at meeting venues such as the Ace Café and Busy bee, racing from café to café which gave the bikes their name. Regent's electric motorcycle was primarily intended to be used in urban areas which is in coherence with its café racer design.

1.2 Background

The Master thesis is done in collaboration with Regent Motorcycles which is a company started within ANNEVO's innovation studio situated in Gothenburg. The idea for Regent Motorcycles was birthed by the vision of creating an electric motorcycle that was adapted for urban riding. The vision was to provide a range of cleanly designed electric motorcycles which created a bridge between retro- and modern design standards.

Their prototype called *Model NO.1* is under development and Regent have the ambition of making 100 commercial models available for the market from spring 2020.

Ultimately, they want to encourage more people to convert to electric transportation by offering a complete user experience that entails everything a user would expect from a modern vehicle being developed today. This means offering an infotainment system that is adjusted to the needs of motorcycle riders within the city which also fulfills the rules and regulations for riding in traffic. However, they do not know what this implementation would look like nor how it should function. An infotainment system is identified as a multi-functional interactive software and hardware system that provides entertainment-, communication- and information services. (A. V. Vasilakos, M. Parashar, S. Karnouskos, & W. Pedrycz, 2009). Historically, entertainment services included video/audio and radio, while communication services have included phone calling and connection by Bluetooth. Finally, information services have provided vehicle related information such as the overall distance the vehicle can cover with the fuel level, traffic information and weather forecasts.

Since Regent lacks the resources to develop this infotainment system, they firstly want help with defining requirements and what needs users have. Secondly, they want a concept that provides guidelines for how they should design a final infotainment system. Safety is a priority and driving guidelines should be followed to ensure that the rider is never put in danger when using the extra functionality that an infotainment system could provide. The purpose of having an infotainment system is to ultimately enhance the riding experience without compromising safety.

1.3 Project Aim

Firstly, the aim is to understand what requirements and user needs exists for the modern motorcyclist in the context of driving in urban areas. Secondly, the aim was to identify how an infotainment system should be designed to heighten the user experience while enabling safe use. To accomplish this, the following research questions would be addressed:

RQ1 - *What are the requirements and user needs for an infotainment system being designed for an electric motorcycle that would mainly be used in urban areas?*

RQ2 - *How should an infotainment system be designed for an electric motorcycle so that the identified requirements and user needs can be fulfilled, and in turn also heighten the user experience without compromising safety?*

1.4 Project Goals

The first project goal is to concretize what difficulties, requirements and needs motorcyclists have when riding, more specifically in urban areas. This is done by compiling a list consisting of product requirements and user stories (which essentially are contextualized user needs in terms of desired features). The list is compiled based on the gathered information and knowledge throughout the project. The list also becomes the underlying basis for the second project goal, which is to produce an infotainment system concept that essentially embodies the defined requirements and user stories. The final infotainment concept also aims to fit well into the brand and complement the design, feeling and overall experience of driving a retro-designed electric motorcycle. Ultimately, by fulfilling the two project goals, guidelines are provided for how an infotainment system should be designed for an electric motorcycle that is meant for urban commuting.

1.5 Demarcations

The priority is to design a prototype that prioritizes features that enables safe interaction between the user and an infotainment system. Features or functionality that heightens user experience but are in some cases deemed unsafe in consideration with the requirements or in need of a lot of development to implement safely, are not prioritized in the final concept. Since time is a limitation for the project, prioritizations on the user stories are set to steer the development process so that the project goals of designing a holistic infotainment concept can be fulfilled.

Therefore, prerequisites for a minimal viable product (MVP) are set. An MVP can be described as a product with just enough features to satisfy early users with a secondary purpose of providing feedback which can guide the further development. The MVP for the project is defined as an interactive prototype of an infotainment system which provides guidelines for how to fulfill the most important identified user needs. In turn, also heightening users' experience without compromising their safety. However, the final prototype does not necessarily need to be ready for a final implementation on a motorcycle.

The final prototype focuses on the aspect of how it functions while users are riding since is the most critical aspect of using an infotainment system. Since focus lies on user experience and safety, aesthetic- and/or graphic design of the components that the final prototype consists of, were only prioritized to the extent where it affected understanding and usability.
All participants in the interviews and usability tests were done with people that had responded in the questionnaire, excluding the driving tutors which were contacted individually. All user research was done in Sweden.

1.6 Societal, Ethical and Ecological Considerations

By conducting the master thesis, we are promoting electric consumption which has both positive and negative consequences. According to Green (2018), it is considered good since electrical consumption is more environmentally friendly than consumption of fossil fuels that causes air pollution and contributes to increased global warming and is hazardous to public health. It can also be negative in the way that users that otherwise would ride ordinary bikes or walk, are encouraged to start riding electric motorcycles which could increase the overall energy consumption and contribute to worsen well-being in society. However, by convincing road users that cannot consider riding a bike or walk to instead start driving electric motorcycles, would make a smaller environmental impact compared if they would continue to use fossil fuel vehicles.

In the scenario where people ride motorcycles instead of cars, the traffic would most probably not be as crowded since motorcycles in general take less space than cars. The best scenario would be if all users would use public transportation, walk or ride bikes since that would leave more space for people in the cities. However, there exists users that dislike or are afraid of using public transport since they want to be in control, have problems with social anxiety or simply want to drive themselves. If people need to travel longer distances, a motorcycle might be perceived as a more comfortable choice since riding a bike is generally more physically straining.

1.7 Project Process

The project is done by using the double diamond process which is a design process created to address problems and needs by exploring various options and making intentional design decisions (Design Council, 2019). The reason for choosing the double diamond process is because the process is similar to the "traditional" waterfall product development process. Österlin (2011) says that the traditional waterfall process for product development consists of the phase's pre
-study, concept generation, evaluation and manufacturing. In comparison, the double diamond process is considered to leave more room for iterations (see figure 2).

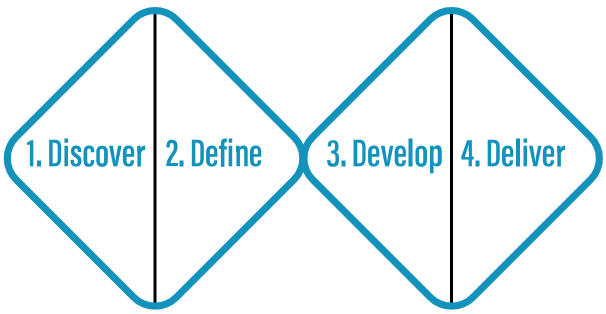

Figure 2. The Double diamond process

The development process is initiated in the *Discover Phase* by stating the problem and answering questions regarding what the current status is, what the desired future status is and what is necessary to reach it. Answering these questions implies exactly what research needs to be conducted and what knowledge needs to be acquired before moving to the *Define Phase*. This phase focuses on concluding and contextualizing all information and knowledge into requirements and user stories. Thereafter, the *Develop Phase is* initiated and marks the start of the ideation, UX design and concept development which are structured around the "5 elements of UX". What guides the development process are the requirements and user needs that have been defined from the earlier phase. By evaluating the generated ideas and narrowing them down, the final phase can be initiated, the *Deliver Phase*. This is where the final concept is finalized through an iterative design process. This entails usability testing which is a vital aspect of designing in iterations.

2

FRAMEWORK

This chapter presents the framework that was created through the literature review with the aim of creating guidelines for what needs to be taken into consideration for the rest of the project, specifically what to consider when designing an infotainment system for a motorcycle. It would aid in understanding gathered empirical data and the design decisions made in the concept development. The framework also aims to provide the reader with knowledge in relevant areas to increase the understanding of the project. Presented in this chapter are factors in four different levels that have been identified to have an impact the process of using an infotainment system while riding a motorcycle.

2.1 Considerations for Designing an MC Infotainment System

This section presents theory regarding what factors may have an impact on how a motorcycle rider interacts with an infotainment system while riding in traffic. The identified factors have been categorized and divided within four different levels. *Level 1* through *Level 3* presents mainly aspects regarding human factors and cognitive ergonomics (see figure 3). All aspects within these levels have been identified to influence a user's ability to understand and operate a system. A system can be described as a set of things working together as parts of a mechanism or an interconnecting network; a complex whole.

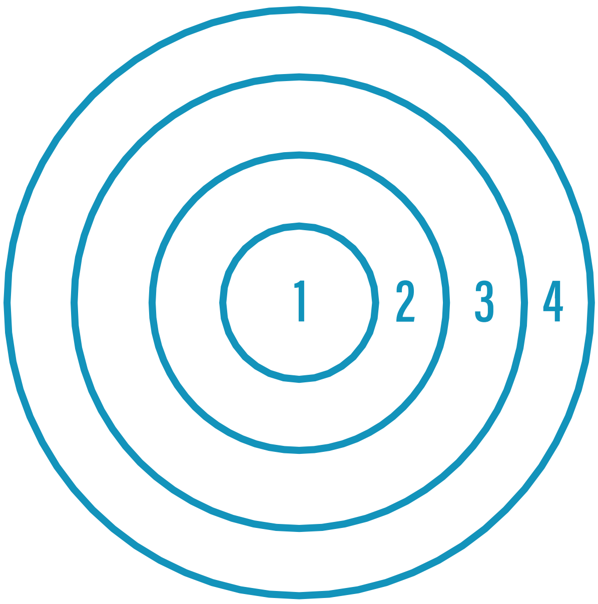

Figure 3. The four levels of factors affecting the operation of a system while riding a motorcycle.

Level three revolves around a concept called *situation awareness*. Endsley (1995) says that amongst several factors, situation awareness is crucial for e.g. driving in heavy traffic. Endsley (1995) defines situation awareness as: "*Situational awareness is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status*". The importance of situation awareness comes with the development of technology which has contributed to more complex and dynamic systems. These systems can in turn limit users to act effectively and make timely decision when using them. Situation awareness is presented as a crucial construct which users' decision making and performance depends on (which will be described more thoroughly in level three).

The final forth level refers to driving culture which entails factors outside of cognitive ergonomics and have also been identified to affect the use of an infotainment system while riding a MC in traffic. These include official driving guidelines, driving behavior and traffic safety culture.

Level One - Individual Factors

The first level is referred to as individual factors which presents individual factors that may influence the user's ability to interact with an infotainment system while riding a motorcycle. What has been defined as being individual factors are covered by a broader term called Human factors which is defined as the application of psychological and physiological principles to the design of products, processes, and systems (Wickens et al., 2004). The goal of human factors is to reduce human error, increase productivity, and enhance safety and comfort with a specific focus on the interaction between the human and the system. Cognitive processing, attention, perception, memory, automaticity and user goals are the individual factors which are taken into consideration for level one.

Cognitive Processing

The processing of information is done with an interplay between three different cognitive processes: analogical-, analytical- and affective processing (Jenkins, et al., 2015). Analogical processing refers to usage of solutions from previous problems to create procedures or rules that correlate or solves existing problems from the system. Analytical processing is associated with reasoning that is based on existing information and knowledge to handle the system. Affective processing is identified as processing of information that depends on feelings and impressions. Based on the existing environment and situation, the user will have different levels of cognitive resources available that influences which cognitive processes are to be used. It is desirable that the system is designed to enable good conditions for analogical- and analytical processing to achieve a safe user experience since many decisions might need to be taken within narrow space of time while other tasks are dependent and ongoing. The information processing a user has is influenced by their inherit abilities, experience and training (Endsley, 1995). It is also possible that the user may occupy certain objectives and preconceptions which affect their interpretation of the environment.

Attention

Attention is presented as the user's ability to precisely perceive multiple sources of information, in the same time, without limiting their situational awareness (Endsley, 1995). In dynamic and complex environments, it is possible to get overloaded with information because of complex decision making and handling of multiple tasks that put high demands in attention which rapidly can exceed a user`s restrained attention capacity. The ability of handling multiple sources of information at once, is a skill that some users have easy for, but it is a skill that is possible to develop. By automating some aspects of the system, it can be possible to reduce some degrees of required attention.

Perception and Expectations

Perception focuses on the relation between occurrences in the environment and how the user becomes aware (Runeson, 2019). The user’s perception about specific information affects the accuracy and speed of handling that information (Jones, 1977). Repeated experience in an environment gives possibility for the user to develop expectations of forthcoming events. With time, the user will process information faster if it is in agreement with expectations and do wrong if it is not. Knowledge of form, characteristics, and location of information can significantly help aid the perception of information (Endsley, 1995). Therefore, when designing the system, it is important to take into consideration existing design patterns that exist among similar systems to increase the probability of the user making associations with previous experiences.

Mental Model

Mental models are created by users as “pictures” of complex interactions between system, user and environment to try understanding a specific situation (Stanton & Young, 2000). Mental models can help the user explain and predict the interaction with the system, but they are only an approximate representation which could be “unstable, incomplete, unscientific and even superstitious”. The specifics of a situation affect the adoption of an appropriate mental model which is used as strategy for managing the system (Endsley, 1995). Since mental models are subjective and it is hard to know which mental model a user has, it is important to take into consideration how interaction with the system can impact the user's mental model when developing a system (Stanton & Young, 2000). Because of this, it is important that the design team has a coherent perspective of the desired mental model to have increase the probability of designing a system that attains the desired mental model. If the user manages achieve the desired mental model when interacting with the system, there will be lower probability of the user interacting with the system in a unwanted way.

Memory

In combination, the structure of short-term memory, working memory, perception and long-term memory form the basic structure of which situational awareness is based (Endsley, 1995). Short term memory is defined in the terms of remembering certain information during a limited period of time (Risberg and Nilsson, 2019). According to the studies of different researchers, the information is accessed for maximally 10- or 18 seconds based on what research is studied. Working memory is associated with information that is temporary stored in the consciousness focus. The working memory is operating when, for example, the user is reading a book or listens to a lecture and in the same time develops a thought by themselves. The long-term memory is divided in an experienced (episodic memory)- and a knowledge (semantic memory) based component. The main function of the long-term memory is to permanently store information which might be usable in another occasion much later. Perception of memory is directed by the essence of both long-term memory as well as working memory (Endsley, 1995). By developing structured memory stores, it is possible to have great categorizations. A novice user does usually not have a level of classification of categories and does thereby generally absorb less information from same data input. Users that possess higher levels of expertise appear to develop knowledge of critical cues in environments that grant them to make good classifications in their memory.

When designing a system, it is important to take into consideration the limitations in memory which human beings possess. Information presented to the user should be adapted according to what kind of information is relevant with regards to that human beings can store information in short-, working- and long-term memory. It can also be good to take into consideration that users, depending on their level of expertise, have different feasibility of categorizing information which implicates that the system should be designed to meet the level of expertise which the intended users possess.

Automaticity

Automatic processes are defined as actions which occur without requiring attention (Benoni, 2018). The automatic processes tend to be autonomous, effortless and unavailable to conscious awareness (Logan, 1988). Automaticity can thus significantly benefit situational awareness by providing a mechanism for surmounting the limitations in capacity that exist in attention. Most users appear to be conscious of the situational elements that triggers the automatic retrieval of information (Endsley, 1995). However, many users are not aware of the mechanisms that are used for the resultant collection of actions when interacting with the information. The essential threats which are created by automatic processing is an increased risk of being less receptive to changing and new stimuli since automatic processes operate with limited usage of feedback. When designing a system, it could be desirable to take benefit of automaticity by partly or entirely automate actions and information which require unnecessary attention.

User Goals

A designer can only facilitate and not guarantee a certain goal through user experience (Kaasinen, et al., 2015). Measuring user goals are concerned with how well users, when interacting with systems, can reach their intended goals from a subjective perspective. This is different to usability goals that define how useful or productive a system is from its own perspective. It is desirable that the goals of the user can be solved or assisted by the system (Verberne, et al., 2012). The system could e.g. propose certain objectives that help the user reach their goals which the user could then decline or accept (Davidsson & Alm, 2009). It is also possible that the system might offer different driving styles which could benefit both the user and the system. For example, the user might choose to drive in an eco-mode where they get worse performance, but they consume less energy. The system would benefit from this by being able to adapt its regulations to maximize performance based on the need of the driving style which could help minimize deterioration of the system. Since users may have specific goals, some interaction elements may vary in their relevance over time.

Level Two - System Design and User Interface

Level two is structured around the interaction between the user and the system. The different aspects are separate constructs from situational awareness even though they are affected by it. Focus lies firstly on the system itself including aspects system complexity and system automation. What is also presented are aspects of the interface through which the user interacts with the system and guidelines as to how to design a good user interface. Secondly what is presented is the impact that using a system through an interface might have on the user in terms of cognitive workload and stress.

System Design

This subsection refers to the complexity and automation which are aspects of a system's design.

System Complexity

GwangKi M et al (2016) interprets the essence of complex systems as parts which are interrelated in some way. The system is composed of different parts or projects, which is characterized by its own dependencies. The various parts work together, and the system must conduct more than only some subset if its parts. The identified factor of increased complexity in many systems is creating a challenge for users that are trying to achieve situational awareness (Endsley, 1995). System complexity is considered to negatively affect situational awareness and mental workload because of the amount of system elements, degree of interactions between these elements and the rate of change or the dynamics of the elements. Moreover, the complexity of the user's tasks may change or increase through the number of tasks, goals and decisions which need to be made when interacting with the system. The complexity can be decreased by the degree of which the users has a well-developed internal representation of the system to help aid integrating data, directing attention and developing higher levels of situational awareness.

System Automation

Automation focuses on the automaticity of the system to help reduce the workload of the user while automaticity (see chapter 2.1) focuses on actions that are "programmed" to the user's backbone. Lacking levels of situational awareness has been identified to contribute to worsen performance that can follow automation (Endsley, 1995). Users who are working with automation have been identified with impaired ability to detect system errors and afterwards execute tasks manually. Moreover, users that have lost their situational awareness are identified to be slower with detecting occurring problems and will often require more time to reorient themselves to suitable system parameters to continue with diagnosis of problems and assumption of manual performance when automation of the system fails. There is a conjunction between declining situational awareness and automation of a cognitive task which was larger during various levels of limited automation. It is also identified that lower levels of situational awareness in automated conditions are in coherence with decrementing performance of the user. In contrast, situational awareness can be improved by systems that contain integrated information through automation. Automation that decreases irrelevant manual work and data integration which is needed to achieve situational awareness may provide asset to both situational awareness and mental workload.

User Interface

User interface is interpreted as *the way in which information is presented to the user* (Endsley, 1995). The design of the interface and how it impacts the user is also hypothesized to influence an individual's ability to achieve situational awareness. Figure 4 shows the sequence by which the user acquires information from the environment. In some cases, information is directly perceived by the user without the system, however, in other cases an intervening system senses information and presents it to the user. In the process of presenting information, some information is lost between each transition which is called transmission error.

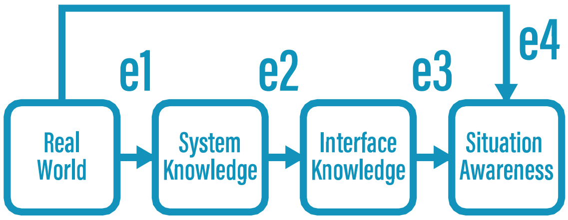

Figure 4. Information Processing

It is generally not possible for the system to acquire all needed information which is desirable for the user (Endsley, 1995). Most systems present information which the designer considers to be most necessary for the intended user with regards to limitation in what the designer can develop based on what knowledge and perquisites the designer possess (see e1 in Figure 4). Of the information which is collected by the system, not all of it can be shown to the user (see e2 in Figure 4). This could be due to limitations in how much information can be shown simultaneously or that the interface is not set up for displaying certain information. Of the information which is presented to the user (see e3 in Figure 4) and is directly acquirable from the environment (see e4 in Figure 4 there may be inaccurate or incomplete transmission to the use because of constraints in attention, perception and working memory. There are two primary externals issues which influence the situational awareness of the user, the degree of which the system acquires the needed information from the environment and how successfully the information is presented to the user through the interface.

Interface Usability

Usability is defined as a quality attribute which assesses *how easy user interfaces are to use* (Nielsen, 1993). User interfaces should contextual help and provide end users with necessary support for understanding how to use a system.

(P. A. Akiki, 2019). Endsley (1995) argues that the way information is presented to a user will largely influence the situational awareness by (1) *how much information can be acquired*, (2) *how accurately it can be acquired* and (3) *to what degree it is compatible with the user's situation awareness*. What is further argued is that a successful user interface offers a design that can transmit the necessary information without requiring needless cognitive effort.

Interface Design Guidelines

According to the alliance of automobile manufacturers (AAM), the total glance time necessary to complete a task, should not exceed 12 seconds (NHTSA, 2012). Furthermore, the time for a specific glance on the screen should not exceed 2 seconds. Creating great usability and user interface when designing systems are necessary to offer a good user experience and make the user feel that they have control (Kossiakoff et al, 2011). This can be hard to accomplish since potential users of a new system do generally not know how they most efficiently can interact with the system before they first try it out. Thus, it can be desirable to create prototype models of displays, consoles, and controls in an early stage of the process to enable the user to examine diverse responses of system inputs and iteratively experiment with alternative interface designs.

Presented are user interface recommendations by Jakob Nielsen that are known as "heuristics", to correct or prevent usage failures (Nielsen, 1995):

1. Visibility of system status - The user should always, in time and by appropriate feedback, be informed about the present status of the system.

2. Match between system and the real world - The system should contribute with information to the user according to present-world conventions, in a logical order and in the user's own language.

3. User control and freedom - If a functionality is accessed by a misstep, the system should give a possibility to exit from the unwanted state in a simple manner.

4. Consistency and standards - The system should be consistent in its use of actions, words and situations to reduce the probability of confusion.

5. Error prevention - The system should eliminate the possibility to make errors or at least mediate error related messages when necessary.

6. Recognition rather than recall - Easily understood actions, objects and options should always be visible and retrievable to prevent memory overload

7. Flexibility and efficiency of use - The system should give possibility to customize actions to promote efficiency that is associated with expert user interaction.

8. Aesthetic and minimalist design - The system should only mediate proper information and avoid usage of rarely needed information that might overload the user's attentional resources.

9. Help users recognize, diagnose, and recover from errors - If or when error

messages are presented, they should contain clear descriptions of the problems as well as a suggested solutions to the errors.

10. Help and documentation - The system should provide the possibility to search for task-related aid which have instructions regarding how to solve potential problems, if necessary.

Impact on User

The impact on the user interacting with the system results in increased or decreased cognitive workload and stress, which is presented in the subsections below.

Cognitive Workload

Workload is identified as the relation between the available resources of the user and mental work it takes to do a specific task (Parasuraman & Manzey, 2010) There are different solutions that can help minimize problems related to workload, for example, by designing the interface in a manner where the user is able to receive the right information, in the right time, gives possibility for the user to thoroughly evaluate information which is presented by the system.

In many dynamic systems, high cognitive workload is a inconvenience which is of importance since information- and workload features helps measure situational awareness (Endsley, 1995). The following combinations of workload and situational awareness exist:

(1) *Low situational awareness with low workload*
The user has little understanding of current activities and is not putting in much effort to find out because of low motivation, low attention or problems with alertness.

(2) *Low situational awareness with high workload*
The number of tasks and information are too great which result in possible deterioration in situational awareness because the user can focus on only a subset of information or may be actively engaged to attain situational awareness. This has to do with incomplete or inaccurate integration of information and perception which the user possess.

(3) *High situational awareness with low workload*
The information which is considered to be required, is presented in a manner which is easy to process for the user. This is considered to be the desired state.

(4) *High situational awareness with high workload*
The user is working with high intensity and is successful in achieving an complete and accurate picture of the situation.

Stress

Stress has been defined as a condition by users who are put in a position which they experience to be harmful, challenging or threatening (Stanton & Young, 2000). Stressful events can be occurrences that happen from time to time (acute stress) but it can also have lifestyle changes which are instigated by the individual (chronic stress). One common topic of all stressful occasions is that they evoke some adaption or confront response.

It is evident that driving in areas with high traffic increases stress levels and it can evoke different struggling behaviors (Stanton & Young, 2000). Furthermore, stress has been associated with aggressive road traffic behaviour which may be due to stress coming from driving or other aspects of life. Stanton and Young found that stress levels are affected by what time of day it is as well as driving conditions, where elevated stress levels were primarily noticed in the evening and in midweek. Matthews et al (1998) reported that stress related to driving in traffic, decreases perceived control and increases task-related interference. Their report highlighted that the combination of fatigue and stress can disarray the action of intention so that that the user's negative effects are heighten in low workload conditions.

Level Three - Contextualization of Dynamic Environments

A person's perception of the relevant elements in their environment that are presented through a user interface e.g. a system displays or even directly via senses, forms the basis for a person's situation awareness (Endsley 1995). Decision making and performance are presented as proceeding from acquiring situation awareness in separate stages that are also explicitly recognized as separate constructs. What this means is that even an expert decision maker can make the wrong decisions if they have incomplete or inaccurate situation awareness. Contrarily, someone who has perfect situation awareness can also make the wrong decision due to e.g. lack of training, experience or show low performance due to inability to carry out the necessary actions. Therefore, it is important to recognize situation awareness, decision making and performance as separate constructs since they are all inherently affected by different factors.

Situation Awareness

Sarter and Woods (1991) says that developing a definitive theory on situation awareness is futile and not constructive. However, Endsley (1995) argues that a clear definition is necessary since the term becomes victim of loose usage where it is defined differently by individuals at a whim. Besides providing future directions for research on situation awareness, Endsley's model is used to generate design implications for enhancing user situation awareness. Situation awareness is stated as a predominant concern in system operation which is why the first three levels in the framework covering *cognitive ergonomics* revolves around it.

Wirstad (1988) says "*In their tasks, users must observe the state of numerous system parameters and any patterns among them that might reveal clues as to the functioning of the system and future process changes*." Human control could not be effective if there is no understanding and future prediction based on it. With this said, situation awareness involves more than just becoming aware of components in the environment (Endsley 1995). To achieve true situation awareness, the user must also on an advanced level understand the situation and have the ability to project the future status in the light of their objectives. It goes beyond the description of how "traditional" information processing *(see section 2.1)* affects human behaviour in operating complex systems. According to Endsley, situation awareness occurs in three hierarchical phases (see figure 5).

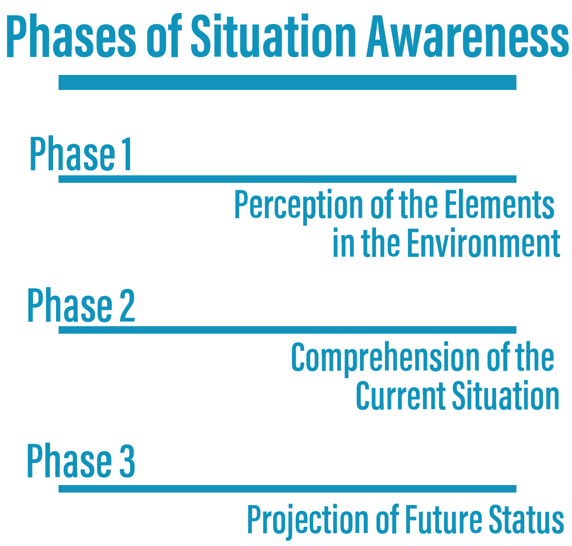

Figure 5. Illustration of the phases of situation awareness (Endsley 1995).

Phase 1 (Perception of the Elements in the Environment)

To obtain situation awareness, the first thing that needs to happen is that the user perceives attributes, status and dynamics of relevant elements in the environment. A motorcyclist would e.g. perceive elements such as the road, other vehicles, pedestrians, traffic lights and road signs. The relevant characteristics of these elements would also be perceived such as e.g. size, color, speed and location.

Phase 2 (Comprehension of the Current Situation)

Beyond just perceiving and being aware of the isolated elements in the environment, the second phase is where a synthesis of the disjointed elements in *phase 1* occurs. What happens in the second phase is that in the light of the user's goals, an understanding is actualized regarding the significance of each element. The user forms a holistic picture of the environment by forming patterns between each individual element and comprehends how they are related to occurring events. A motorcyclist could e.g. see a vehicle driving towards a stop sign or see a pedestrian walking towards pedestrian crossing.

Phase 3 (Projection of Future Status)

The last phase of situation awareness is where the user creates a projection of what the future (short term) actions of each element in their environment will be. This projection is achieved by using the gathered information of each element in the environment and comprehending how they affect one another. Based on the circumstances which the motorcyclists perceive, they project a future scenario which most probably would occur. A driver driving a vehicle towards a stop sign would project that they would stop in front of the stop sign and that potential pedestrians would have precedence.

As stated before, true situation awareness is much more that simply being aware and perceiving the environment (Endsley, 1995). The user must also comprehend the significance of each element and in the light of their goal and i.e. project what the probable future outcome would be. The user's projection of the near future is what becomes the underlying basis for their decision making and action selection, which is what users directly proceed to after classifying and understanding the situation.

Dynamic Decision Making

Situation awareness does not only serve the purpose of providing the basis for decision making as the significant input, it also impacts the decision-making process itself (Endsley, 1995). Experienced users that are considered to be expert decision makers will first act to understand and classify a specific situation and then immediately proceed to action selection. Manktelow and Jones (1987) says that the situation context and parameters of a specific problem will largely determine the ability of individuals ability to adopt a sufficient problem-solving strategy.

Before a user determines what the best course of action is, they must have asserted all the critical features within a spectrum of probable outcomes (Endsley 1995). Furthermore, a dynamic situation might require that the user takes many decisions during a narrow space of time which are continuously dependent on up-to-date analysis of their environment. Having incomplete or inaccurate situation awareness in these environments can result in devastating consequences depending on the context. As presented, a prerequisite for the user being able to make good decisions is that they obtain and then maintain good situation awareness since the environment might be constantly changing in complex ways. This effort can range from being trivial or one of the major contributors to either poor- or good performance.

Performance

Something that can (however not always) be predicted is the relationship between situation awareness and the performance of the action that a dynamic decision lead to (Endsley, 1995). A general correlation is that a user often has poor performance when they have had inaccurate or incomplete situation awareness. Other reasons for poor performance could be that insufficient time has been a limiting factor or that the user does not recognize situation and cannot efficiently calculate the outcome. It is also noted that poor situational awareness does not necessarily mean poor performance, since the user might realize their lack of situational awareness and modify their behaviour to reduce the possibility of poor performance. Venturino, Hamilton and Dvorchak (1989) argue that performance is predicted by a combination of decision making and situational awareness. Their conclusion urges that good situational awareness can be viewed as a factor that will boost the feasibility of good performance, but it cannot be guaranteed.

Level Four - Driving Culture

This section firstly presents the level four factors which includes official driving guidelines which are taught when taking a Swedish motorcycle license. Lastly what will be presented is theory on driving behaviour and risk perception among motorcyclists, and how traffic safety culture also affects behaviour.

Official Guidelines for Motorcycle Riding and Safety

The recent increase in the use of powered two-wheelers (which includes mopeds, scooters and motorcycles, here on after referred to as PTW) in urban areas has led to an increasing involvement in road accidents which indicates that there is a need to get a better insight into the mechanisms of said accidents (Maestracci, et al., 2012). With a better understanding of how e.g. driving behaviour and risk perception plays a role in an accidents, appropriate safety intervention policies can be developed. One way of doing this is promoting safe driving on a national level and making sure that motorcyclists maintain the theoretical knowledge regarding how a motorcycle should be ridden safely. Another aspect is that non-motorcyclists can also reach an understanding of what is critical for motorcyclists and what situations they find stressful so that drivers of other vehicles are more considerate and accommodating in traffic. Since the development of Regent’s Motorcycle is done in Sweden, the Swedish traffic educators’ national union (STR) motorcycle driving manual, is presented as an example of how safe driving is promoted on a national level. STR (2018) has compiled a list of moments that a motorcyclist needs to manage to handle urban driving:

- Have good attention on other traffic, forward, backward and sideways
- Able to adapt velocity to other traffic, view, routing and more
- Practice your ability to see and identify various road signs and road markings
- Able to interpret and rank various instructions that occur in traffic
- Able to place the motorcycle on the right position when driving at intersections and roundabouts
- Able to apply different rules that concerns intersections and roundabouts and clearly show your intention of following them
- Able to apply the rules for crossing pedestrian crossing and bicycle crossing
- Train the interaction with other road users and be able to interpret their signs, signals placement, driving style and behavior
- Able to in time show other road users your intentions with help of turn signals and stop lights
- Able to apply rules for stopping, parking and turning around in urban environments
- Be risk conscious of e.g. hidden dangers parked vehicles and exposed weather

Similar to car driving in dense urban areas, it is vital that the motorcycle rider is comfortable with planning their route by following road signs and road markings (STR, 2018). The ability to in advance plan how to solve a situation is characteristic of a skilled motorcycle rider which is an important aspect since e.g. the majority of accidents in urban areas take place at intersections. STR (2018) has also compiled a list of four checkpoints that riders should take into consideration when driving through urban areas (see figure 6).

Figure 6. Four recommended checkpoints

Since motorcycles are in general smaller than cars, there is a risk of car drivers sharing the traffic lane which can become tight with space and hazardous (STR, 2018). To prevent that other drivers share your traffic lane, the motorcycle rider should try to place themselves in the middle of the traffic lane. The rider should keep distance sideways when passing parked cars to avoid the risk of getting hit by a door that suddenly opens. Parking motorcycles in cities is usually very profitable since many cities offer free parking in central and crowded places.

Riding Behavior

Data shows that during the period 1997-1999 in the UK, it was about eight times more likely for motorcycles to be involved in fatal accidents compared to cars (Horswill & Helman 2001). This was with consideration for the same distance traveled during the same time period. Five key behaviors have been identified that differs between drivers that was involved in accidents and those who have not experienced an accident independent of what vehicle they are driving: 1) *Speed choice* 2) *Car following distance* 3) *Overtaking propensity* 4) *Ability to perceive hazardous situations in the road ahead* 5) *Self-reported driving violations*. Something to note is that that young male motorcyclists are at a higher risk of being involved in an accident compared to any other motorcyclist. This is however also true for young male car drivers compared to other categories of car drivers. According to the Transport Analysis, there were in total 54 deceased persons due to fatal moped and motorcycle accidents in Sweden during the year 2018 (Trafik Analys, 2019). Out of the 54 deceased persons, 8 were younger than 18 years old and the average age of the deceased motorcyclist was 45 years old. During the decade 2008 - 2018 was 94% of the deceased persons from fatal motorcycle accidents drivers and a big majority were men.

Horswill & Helman (2001) have drawn the following conclusions regarding how motorcyclists behave in comparison to car drivers:

- Motorcyclists choose faster speeds than car drivers, overtake more and they pull into smaller gaps in traffic. Regarding the vehicle following distance, it is quite similar.
- The behavior of taking higher risks on a motorcycle was only likely to account for a small amount of the accidents that differed from motorcycle accidents and car accidents
- When driving a car, people with a motorcycle license do not differ in behavior when compared to non-motorcycling car drivers with regards to the amount of risk-taking. (The interesting aspects were that motorcyclists were better at hazard perception when they were in the context of driving a car, which translated from them having to be more aware of their surroundings when driving a motorcycle)

Maestracci, Prochasson, Geffroy & Peccoud (2012) states that the use of PTW:s has increased on a large scale in French cities, especially in Paris and its outskirts. The safety of people riding PTW:s is a growing vital issue on a national level and not only in correlation to public opinion. Statistics show that there has been an increasing amount of PTW:s in traffic, especially within urban areas. Maestracci, et al., (2012) says that in France, those riders represent about 1.5% of all traffic within the road network. But in developed urban areas, this percentage of overall transport means is much higher. There has been an increase in percentage of accidents involving at least a PTW (with consideration to the total number of Parisian road accidents) in urban Paris. However, the number of accidents is not proportionate to the increase of the amount of PTW:s in traffic, the number of PTW related accidents are higher and they are more implicated.

Risk Perception

Horswill & Helman (2001) says that aside from higher risk perception when motorcyclists drive a car there are not any differences regarding sensation seeking, mild social deviance, and attitude. The increased risk perception comes from riding a motorcycle since it is more critical due to being more vulnerable compared to other vehicles if they are involved in accidents. Maestracci, et al., (2012) states that people riding a PTW "*rather fear the situations during which a car driver is changing lanes, while accidents involving them occur more often when a car driver turns (right, left or U)*". Knowledge regarding e.g. this type of discord in terms of awareness in traffic can provide guidelines for heightening safety for all road users, extending to cyclists and elderly pedestrians.

Maestracci, et al., (2012) states that within ergonomic terminology, "*an accident is seen as resulting from a fault in the system. Given a road is a systemic whole, the difference between perceived risk and real risk can be seen as an aggravating factor in accident-occurrence*". Regarding the topic of road risks, there are several models attempting to draw parallels between objective risk (real risk measured from collected data where situation and cognition are characterized) and subjective risk (perceived risk). This corresponds to how a person evaluates an operation within an occurring situation and precedingly move to choice of behavior (Saad 1998). This theory is comparable to Endsley's (1995) description of how action selection and performance are directly preceding from a person forming and maintaining situation awareness (*presented earlier in level 3 factors*).

Traffic Safety Culture

The current use of the term *traffic safety culture* is quite ambiguous and widely used in different contexts (Ward, Keller, Linkenbach, Otto, 2010). However, there is enough evidence that a variable such as traffic safety culture can have a major influence on risk behaviors and crash rates of drivers. A definition for the construct of traffic safety culture could be used for developing effective traffic safety interventions. Ward, et al., (2010) argues however that for a definition to be applicable, it needs to specify the elements of risk behaviour and boundaries for which the constructs operates in.

Culture is important and that it is the considered to be the mechanism through which people come to understand themselves and their relationship to the world (Moeckli & Lee, 2007). Vehicles and driving are intimately connected to a person's individuality and their collective sense of self i.e. who they are as a person, what they believe, value, aspire to achieve and how they interact with others. Culture is inherently material which accounts for how groups identify themselves and interact with their environment through artifacts. A vehicle's design is as much of an answer to the need of utilitarian travel as it is to the drivers' imagination of speed, control and power. Moeckli and Lee (2007) further states *"the choice to drive is affected by people's beliefs and values regarding appropriate uses of vehicles and the resources required to operate them. And driving itself changes how people understand time and space, altering their perception and experience of distance"*. The vehicles are the material objects and driving are the embodied experience that reflect and reinforces cultural identity.

Ward, et al., (2010) says that cognition, artifacts and behaviors are parts of any culture. Cognition is however one of the most vital aspects of a culture that impacts the cultural-based behaviors. The cognitions ultimately motivate and dictates deliberate reflections of the specific culture.

An argument for risky behavior is that the belief structure in the prevailing culture have a convincing impact on a person's decision-making process, their tendencies for risky behavior and acceptance for safety interventions. Particularly, attitudes towards behaviors where a person can expect high benefits with low cost might encourage person to make the decision to engage in that behavior.

3

DISCOVER

Discover is the first phase of the double diamond project process which aims to provide theoretical knowledge regarding what it means to use an infotainment system while riding. Furthermore, the other purpose of conducting the discovery phase is to research the market and get to know the users by identifying their needs and expectations.

Firstly, what is presented in this chapter is a description of the process and methods used during the discovery phase. Secondly what is presented are the results which the process and methods produced.

3.1 Method & Process

This section presents the process and methods used for the discover phase which includes problem definition, literature review, market research, benchmarking and user research.

Problem Definition

Problem definition is a method used to give an overview of the work that needs to be done to reach a desired situation with the project (Johannesson, et al., 2013). This is done by determining what the status of the project is, what the desired outcome is and finally compare the two situations to identify what divergence exist between the two situations. Activities for reaching the desired situation must be successively conducted to lay out the path for a proper advancement. The following questions should be acknowledged:

1. What is the current situation today?
2. What is the desired situation?
3. What are the divergence between the two situations?

Problem definition was used to determine the status before initiating the project, what is the desired outcome how it would be achieved. Conducting the problem definition helped structure and plan how to conduct the project. Defining the problem was accomplished through a project brief that was held between the project group and Regent's stakeholders at their office in Gothenburg. What this method ultimately enabled was to set a high-level outline for the project goals by determining what the desired result was and defining what criterions were required to reach an MVP.

Literature Review

Literature reviews are done with the purpose of collecting and synthesizing research on a specific subject (Hanington & Martin, 2012). The purpose of conducting the literature review is to extract information from published sources that might benefit the product development process. The gathered information from the literature review should centralize the identified information in a constructed way, where the connections are linked between references while preserving focus on the present project.

The primary purpose of conducting the literature review was to gain theoretical knowledge on what it means to ride a motorcycle, what affects the rider's ability to ride a motorcycle and what operating a system entail. Based on the findings from the literature review, a framework was created to structure and contextualize all factors that were identified to be relevant for the project. The framework helped guide the project work and help the project group take consideration to all different aspects that can affect the use of an infotainment system while riding a motorcycle. The framework was specifically useful when analyzing the empirical data that was gathered during the interviews and usability tests. In this way, it was possible to analyze and understand the results on a deeper level which aided the project members to take reasonable design decisions during the concept development.

Market Research

The market research aimed to investigate trends and growth within the market of infotainment systems. By reviewing the market and identifying trends, a broad insight into what users within the market wants, needs and expects, was accumulated.

Benchmarking

Benchmarking is done to gather knowledge of the current market situation, identify competitors and their product selection (Bergman & Klefsjö, 2010). The benchmarking can provide inspiration and ideas from competitors that is beneficial for the concept development in a way where positive aspects of other products could be extracted and applied to the infotainment concept. Bergman and Klefsjö (2010) have identified three different ways of conducting benchmarking:

Generic Benchmarking

A generic benchmarking is a general comparison between of the company's objects/values and other companies in any area or industry. The generic benchmarking was done by attending the motorcycle fair "MC Mässan 2019" in Stockholm. The motorcycle fair had motorcycle manufacturers Harley Davidson, BMW motorrad, Ducati, Suzuki, KTM, Yamaha motors, Honda and other brands present (MC Mässan 2019, 2019). Regent Motorcycles did also attend the fair by exhibiting their motorcycle prototype. A practical evaluation to identify the target group was conducted by asking passers close to Regent's stand what their first impression and attitude was towards electric motorcycles with infotainment system in it.

Competitor Benchmarking

A competitor benchmarking is a direct comparison between the company's objects/values and competitor´s objects/values. The competitor benchmarking focused on the present motorcycle market by researching how user interaction, user interface and user experience for infotainment systems are designed by competitors. The competitors were identified to be motorcycle brands which had implemented and utilized infotainment system or at least aspects of what could be a part of one, even if they did compete for the same market shares in terms of target group. Since the market for motorcycle infotainment systems was rather limited, this would serve the purpose of investigating how other motorcycle brands had designed their infotainment systems. The benchmarked motorcycles were *Yamaha Star Eluder Transcontinental Touring 2018*, *Harley Davidson Livewire 2019* and *BMW R 1200 GS 2018*. The motorcycles were interesting to compare because they all had infotainment systems that were among the best in the market (Brasfield, 2018).

Functional Benchmarking

A functional benchmarking is a comparison of the company's objects/values and other companies' objects/values that share the same functionality and are comparable in areas or activities. The benchmarking focused on the car industry due to it being the industry where the market for infotainment systems was argued to be the most relevant to benchmark against for the project due to two reasons: The first reason for mainly looking towards the car industry was since the infotainment system is a vital aspect of the car riding experience. Secondly, infotainment systems have been developed in the context of car driving for roughly fifteen years (Polestar, 2019). The perception of a seamless driving experience has evolved and two of the most prominent electric car models *Tesla Model 3* & *Polestar 2* were benchmarked.

Ultimately, the benchmarking had the purpose of identifying trends, functions, user interfaces and user interactions from both motorcycle competitors and companies in other industries. More specifically, the infotainment systems and user interfaces were benchmarked to identify how they affected the drivers' overall user experience and safety. The findings from the benchmarking affected the conclusion of the requirement list and helped guide the concept development process since the analysis of the different infotainment solutions would conclude the benefits and drawbacks of different implementations. The benchmarking also had the purpose avoiding bad design decisions and utilize identified benefits from others while also providing a distinctive and unique experience.

User Research

User research is a systematic way of investigating users, their needs and requirements to provide insights and context to the development process (Interaction Design Foundation, 2019). User research aims to provide information to draw conclusions by uncovering problems and determining relevant facts. Information on users can be gathered through both qualitative and quantitative methods as interviews and questionnaires which were used in the user research. The results from the interviews and a questionnaire was compiled with the information that was gathered through creating the framework and prior activities in the discover phase to give a wider picture of the situation.

Questionnaire

Questionnaire is a method user for collecting self-reported information from users about their thoughts, characteristics, perceptions, feelings, attitudes or behaviors (Hanington & Martin, 2012). Questionnaires are typically used for collecting quantitative information from large sampling of respondents that can be used for creating statistics which can then be analyzed. Since surveys are self-reported, they should not be interpreted as an accurate reflection of true feelings, thoughts, behaviors or perceptions.

A survey was done by creating a questionnaire which was shared in social media and Regent Motorcycles website with the purpose of compiling a database of users who signed up and could consider participating in interviews and usability tests. The ideal respondents were users who had experience of riding PTW: s (powered two-wheelers) within urban areas. Moreover, the questionnaire served the purpose of getting a better understanding of who the interested buyers are i.e. the target group. Some questions in the questionnaire served the purpose of collecting data about e.g. age, riding experience and interest in electric vehicles.

There was a total of 80 respondents from the questionnaire and the age varied from 20 to 62 years old. The majority of respondents were in the age span of 20-40 and there was also a clear distinction of the rest of the respondents, where they were not spread out but there was a secondary group which consisted of mostly people over the age of 50.

Interviews

Doing interviews is a fundamental method for research and enabling direct contact with users (Hanington & Martin, 2012). By conducting interviews, it is possible to capture firsthand personal experiences, attitudes and perceptions.

Interviews were conducted to identify needs and problems from interviewees that had experience of using PTW: s and infotainment systems in urban areas. The interviewees consisted of professionals, also called experts, worked as MC tutors and regular riders that had various riding experience. The interviews were semi-structured with capacity for outspoken ideas, spontaneous- and follow-up questions. The interviews were done through in-person meetings, phone calls or video conferences. The two group of interviewees had different interview templates, were questions for the expert interviewees focused on safety, general problems and needs. Whereas, interviews with regular riders focused on specific difficulties and needs they have when riding (see appendix A and B for interview templates).

Experts

There were in total five expert interviewees that had on average 15+ years' experience of working as MC tutors. Two of the expert interviewees had impactful roles, working as responsible for MC operations in the Swedish traffic educator's national union and MC national traffic coordinator for the transport administration. The interviews gave insights on regular mistakes MC riders make and recommendations on what riders should know to become aware of their surroundings. They also shared their opinions and thoughts of what is suitable to be included in an infotainment system designed for electric motorcycles.

PTW Riders

Interviews was done with ten regular riders that were 20- to 35 years old. All interviewees were also respondents from the questionnaire that had signed up to participate in the interviews and usability tests. The purpose of these interviews was to compare and evaluate their answers with the answers from the experts to provide insight to how riders behave how they perceive motorcycle riding. Furthermore, it was desirable to identify what needs and expectations riders have from an infotainment system on an electric motorcycle.

3.2 Results

This section presents the results from the methods and process used during the discover phase.

Balance Between User Experience & Safety

In the initial status of the project, Regent Motorcycle had developed a new electric motorcycle and they wanted to implement an infotainment system, but they did not know what it should contain and how it should be designed

The desired situation was to create a holistic concept for an infotainment system that considered the most important user needs and desired features in terms of enhancing user experience without compromising safety.

To reach the desired outcome, it was necessary to conduct user- and market research in the context of riding in urban areas. By defining the research questions and project goals, a project plan was set to fulfill the research questions and project goals. The knowledge necessary to achieve this would be gained by firstly acquiring theoretical knowledge and creating a framework. Secondly, empirical data would also be gathered through a discover phase. Utilizing the gained knowledge together with acknowledged design methodologies and conducting the underlying project plan, would make it possible to answer the research questions and reach the project goals.

Trends and Market Development

Before initiating the benchmarking process, a trend analysis was conducted that indicated an increasing trend of implementing infotainment systems for motorcycles. In 2016, Bosch released an infotainment system that replaced traditional instrument clusters with modern displays that enabled riders to connect and use functions as music and taking calls (Bosch, 2016).

This was made possible by pairing a smartphone and headphones or integrated helmet through Bluetooth. Using these functions during a ride were made safe and intuitive by integrating a keypad which enabled the riders to navigate functions without removing their hands from the handlebar. Bosch claimed to enhance rider safety by making the digital screen adaptable to any weather conditions which means e.g it is visible in direct sunlight and is eligible during rain. Only necessary information was shown in critical moments which reduced distraction. For example, the number of informative elements gradually decreased when the motorcycle drove at higher speeds. Vital elements as speed indicator and warning notifications did never become excluded.

Bosch SoftTec (2016) states that there will be a 7.4% annual growth in the motorcycle market within the next years which means that more than 123 million two-wheelers are assumed to be sold by 2020 (see figure 7). Among the 123 million newly produced motorcycles, it is assumed that 19 million of them will be mounted with an infotainment system.

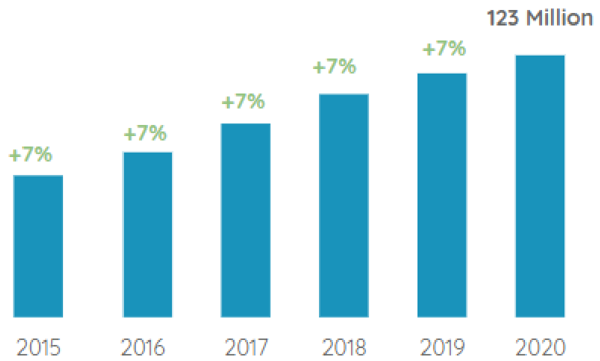

Figure 7. Expected Annual Growth in Motorcycle Market from 2015 to 2020.

Smartphone Usage while Riding a PTW

Research showed that there was a need for additional features by the modern rider compared to what it was before. Bosch SoftTec (2016) presented statistics from an online survey that is based on computer-aided web interviews which was done with 2601 participants from USA, Germany and Canada.

Figure 8. Showing statistics from Bosch SoftTe (2016) regarding how MC riders use smartphones in their travels.

The participants ranged from the ages of 16 and 69 years old and consisted of both men and women that were riders and owners of a motorcycle. 16,8% of the riders owned a motorcycle that was electrically driven. All participants from the online survey owned a smartphone which they used to care for aspects of their travels. The participants engaged with their smartphone when preparing for a ride, during stops/breaks or when following up a ride afterwards (see figure 8). 44% of the participants used their smartphone while riding in traffic which indicated that their motorcycles lack alternatives for smartphone functionalities. 80% of the of the participants expressed that they wanted to have access to the same functionality that is present in their smartphone on their motorcycle without endangering their own lives or others. This implies that almost 50% of the participants made a conscious choice to engage with their smartphone while riding, even if they were aware of the dangers and risks associated with it.

A smartphone is not designed nor optimized to be used during motorcycle travel since it can negatively affect a rider's performance and situation awareness (see 2.1 *Level 3 - Contextualization of Dynamic Environments).* For example, if a rider wants to change song on their smartphone while riding, it would require unsafe behavior which can be broken down into four parts. 1) Look away from the road and their dynamic environment to look down at the smartphone 2) The rider would first have to remove their hands from the handlebar which disables the rider to have good control of the motorcycle 3) Locate the specific interactive element necessary to achieve their goal. A display that in turn it is not optimized to be used in an environment where weather and light are factors than can heavily affect the interaction negatively 4) The rider would have to have very high motor skills to be able to successfully press the correct and relatively small touch element to achieve their goal with good performance. Combined with the fact that riders commonly use gloves, it is a very hard and risky action. This sequence would need to happen within a very small frame of time.

This can be viewed from the perspective of driving culture (see 2.1 Level 4 - Driving Culture*)* as it might be connected to different attitudes towards safety interventions and driving guidelines and their tendencies of engaging in higher risk behavior. Even if motorcyclists have increased risk perception due to being more vulnerable compared to other vehicles if they are involved in accidents, they still engage in risky behavior. This might be connected to the prevailing traffic safety culture which says that the culture can have a significant impact on a person's decision-making process. Attitudes towards behaviors where a person can expect "high benefits with low cost", as riding fast or using a smartphone while riding, can encourage the rider to engage in dangerous behavior. Therefore, it is important to provide safe alternatives, as compensating behavior will occur if riders' needs are not being met, as the survey has shown.

Nearly half of the participants in the survey (from the developed western countries) only used their two-wheeler during their spare time which meant they wanted to maximize their enjoyment and experience during the limited time which they ride their MC. This correlates to the statistics of that 50% of the riders using their smartphones (while riding), use it for navigation, music, driver assistance or communication apps.

The Baseline Infotainment System

Initial insight into infotainment systems were gained by visiting motorcycle fair in Stockholm which indicated that the big majority of motorcycles that were present at the fair, did not have any kind of infotainment system.

Figure 9. Motorcycle Fair

However, there were some exceptions with motorcycle brands that exhibited motorcycles with infotainment systems. BMW Motorrad exhibited the adventure touring motorcycle *2019 BMW R 1200 GS* (1), Harley Davidson exhibited the *HD Street Glide Special 2019* (2) and KTM exhibited the *2019 KTM Duke 390 with TFT Screen Console* (3) (see figure 10). The motorcycles were primarily designed to be used for long distances where the infotainment system could be interacted by a touch display, a keypad or voice command. The infotainment system filled the purpose of providing information services as telltales (warning signals), speedometer and fuel quantity while also providing entertainment services as listening to music. The *HD Street Glide Special 2019* offered the possibility of displaying navigation in the accompanying display which was not possible in the other motorcycles. To have access to navigation in the other motorcycles, it was necessary to mount an additional display to the motorcycle.

Figure 10. Motorcycles Present on the Motorcycle Fair

The electrical scooters *M1 Pro* created by Niu had infotainment systems which were present at the fair (See figure 11). The project group considered them to be good for commuting because they offered a 70 km range and required low maintenance. However, the M1 Pro provided lacking user experience because the project group considered the display to be outdated with regards to limited functions were available.

Figure 11. Niu M1 Pro

Most attendees that visited the Regent stand, liked the concept of a modern electric motorcycle with an infotainment system. Some users expressed that they could see themselves driving in the city and utilizing the benefits of an infotainment system that provides information and entertainment services to enhance the user experience. However, there were some attendees who expressed a dissatisfaction, knowing that there will be an exclusion of engine noise which was considered to an important element of the motorcycle experience. Other attendees expressed distrust towards having an infotainment system in the motorcycle because of the fear associated with losing control and not paying attention the road and traffic. This can be connected to the design prerequisites of the interface of such an infotainment system (see 2.1 *Level 2 - System Design and User Interface*). The distrust of having an infotainment system could be connected to the attendees thinking of the same functionality that is correlated with infotainment systems in cars which also often provides interaction through a touch display. This indicated that the user interface must provide an intuitive and safe way of interacting with the system and not include unnecessary information or features that can affect the user negatively in terms of increased stress and high cognitive workload. Altogether, to provide value for users and trust towards the system, it is important to develop an infotainment system that offers the most desirable functions without compromising safety.

Infotainment Systems in the Motorcycle Market

The results from the competitor benchmarking indicated that the primary way of interacting with an infotainment system on a motorcycle was through touch displays that were between 7-8 inches and through physical buttons from a keypad. It was also important to provide a user interface that is easy to navigate without compromising user experience and safety. The benchmarking also indicated that the market for infotainment systems was very limited for motorcycles in comparison to how developed it was in the car industry.

Interaction between user and System

Interaction with the infotainment systems was primarily done through a keypad or touch display. Some infotainment systems provided the possibility of interacting through voice command, but it was never the primary method of interacting for any competitor. Voice command was primarily used for phone communication and functioned as a complement to keypad and touch display. When the rider would interact with keypad or touch display, they would get feedback through vibration, tactile resistance or sound to clarify that the intended action had successfully been conducted. The keypad which interacted with the system, was always positioned on the left handle and was designed to be ergonomically interactable with the left thumb. Positioning the keypad on the left side has also to do with the fact that the throttle is standardly positioned on the right side for motorcycles. Another standard among fuel powered motorcycles is that the clutch is positioned on the left side of the motorcycle. The buttons of the keypad were designed to give possibility to rest the thumb on any button so that the user could prepare themselves for a specific action which was conducted only when the user intended it.

Figure 12. BMW Joystick

User Interface and Navigation

The identified user interfaces had the conjunction of providing large and clear elements that were easy to identify and read. Time, momentary speed and telltales (outward signs used for indicating something) was always displayed to the rider on a static part of the interface while the rider was driving. The navigation in the interface was in general responsive and logical, no matter if the keypad or touch display was used. That was possible because the displayed information was structured to intuitively correspond to the user's intentions when navigating. For example, pressing up on the resulted in a vertical movement on the display which was in coherence with the user's intentions.

Figure 13. BMW R 1200 Interface Cluster

User Experience

The results from benchmarking user experience in the motorcycles market, indicated that available functionality through an infotainment system was outdated in comparison with what was available in e.g the car industry. However, there were some motorcycles which were considered to offer an overall good user experience and the motorcycle *2018 BMW R 1200 GS* with a TFT Color Display (see figure 10) was considered by the project members to be one of the them.

The motorcycle is categorized as an adventure touring motorcycle which is designed to endure long routes in tough environments. The infotainment system can be navigated by utilizing a unique joystick (see figure 12) which offers great functionality when the user becomes comfortable with the configuration. However, the pins (see figure 12) which were designed to help the thumb to rotate the joystick were a little too small which decreased the trust to perform when interacting with the joystick. Having the possibility to interact with the infotainment system by voice interaction was considered to work smoothly and the user did even have the possibility of set their own phrases. A black frame that encloses the display gives space for telltales (see figure 13) which provides information about engine problems, lighting, parking and other usable information. The tail lights helped reduce the cognitive workload and enabled the display to show less information in a clear way. Finally, the infotainment system offered the possibility of connecting devices through Bluetooth which enabled the user to e.g answer and make calls and listen to music wirelessly.

The *2018 BMW R 1200 GS* had some problems which were considered to impair the overall user experience. The infotainment system did not offer GPS functionality on the available display which was considered odd by the project group. If the user wants to have access to navigation, the user had to acquire an additional screen which displays the information (see figure 10). This was considered to be annoying since the extra screen impairs the overall visibility and increases the mental workload which is not desired. The *BMW R 1200 GS* offered other infotainment functionalities as phone pairing, phone communication, music player, adjustment of settings, information and statistics of motorcycle, customizable dashboard, and traffic related information as present speed limit (BMW Motorrad, 2019).

Infotainment Systems in the Car Industry

Tesla Model 3 redefined what a dashboard is by having a minimalistic approach and implementing a larger display between the windshield and armrest that is available in the middle of the car (Tesla, 2019). The display replaces most physical buttons and removes the need for traditional gauges that usually are present behind the steering wheel in traditional cars.

Figure 14. Interior Tesla model 3

All information and functionality that the driver needs to obtain a safe and great user experience is presented through the display which allows for interaction through touch and voice-command. The reason for having everything presented on one display is to boost a minimalistic and futuristic feel that works well with an autopilot mode which Tesla provides. The placement and size of the display enables easy functionality that is reachable from the armrest in the middle of the car. The driver also has access to smartphone connectability which gives possibility to functions such as keyless starting of vehicle and pairing of contacts and music. The vision when developing the user interface for Tesla model 3, was to create a user interface that offers efficient usage with as little effort and distraction as possible (FWA, 2019).

Figure 15. Interior Polestar 2

Polestar 2 has gone in the same direction and aims to provide a seamless experience, however not as drastic compared with Tesla model 3 since they include traditional gauges (Polestar 2, 2019). Polestar 2 further simplified aspects such as key-less smartphone connect ability through available sensors that respond when the driver is close to the car. The available sensors are smart and starts the car immediately when the user sits down on the front seat, without having to use any car keys. Polestar 2 has focused on providing intuitive navigation and structured menus in the digital interface. They have also implemented android operating system which is integrated with *Google Maps* and *Google Assistant*. Google has one of the best voice assistants in the market which is probable the reason for Polestar for choosing to implement it. Developing an own voice command system, is a very hard task that traditionally has not been a positive experience when vehicle manufacturers have tried to it themselves in the past. Certain aspects of infotainment systems in cars must be interpreted and translated for the motorcycle context due to the difference in conditions.

The Urban MC Rider and Their Needs

Among the users that responded on the questionnaire, 95% of them had experience of riding a PTW in traffic which indicated that the interest for the regent's electric motorcycle came primarily from experienced riders (see figure 16). With consideration to the channels that the questionnaire was shared through, it indicated that there could be a potential broad target group overall. Since people found the questionnaire organically, it became apparent that the retro electric motorcycle was appealing for an elderly group of users as well.

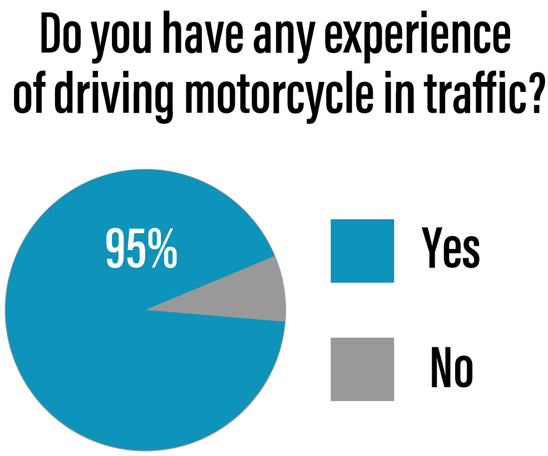

Figure 16. Experience of driving motorcycle

Among the users that had experience of riding a PTW, the majority had over 10 years of experience (see figure 17). This implied that the respondents who chose to participate in the interviews and upcoming usability testing would most probably provide credible information. The participants would provide information and experiences regarding e.g. what was difficult exist when riding motorcycles. The findings would be considered in the concept development process.

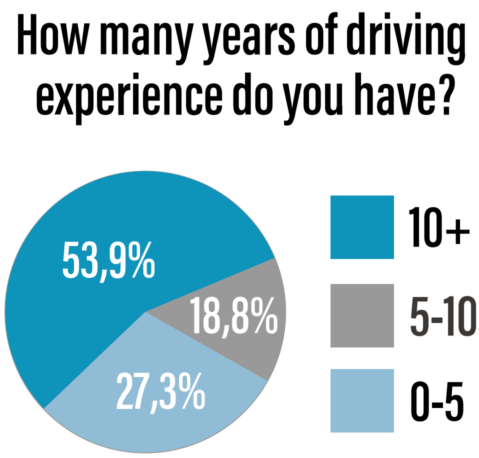

Figure 17. Pie Chart of Experience

The questionnaire showed that most respondents rode their PTW for the purpose of joy riding, it being a smooth commuting alternative, it suited their lifestyle, or it was a part of their identity (see figure 18).

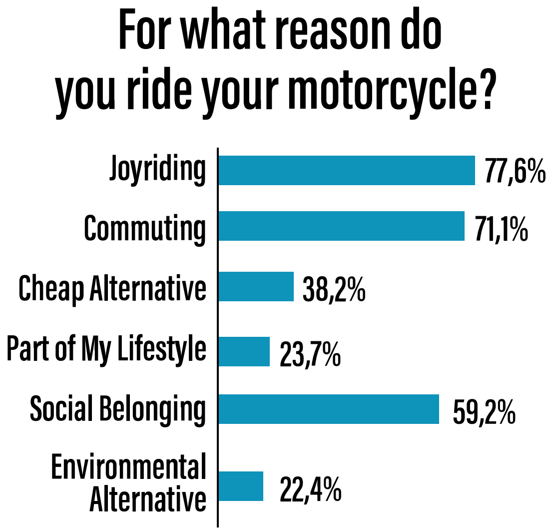

Figure 18. Reasons for Riding Motorcycle

Regarding the context of using their PTW, most respondents rode their PTW on either rural roads or urban city roads which was essential for gathering information on specific difficulties and needs that are correlated to that context. The questionnaire indicated that most respondents could easily understand and use new technology.

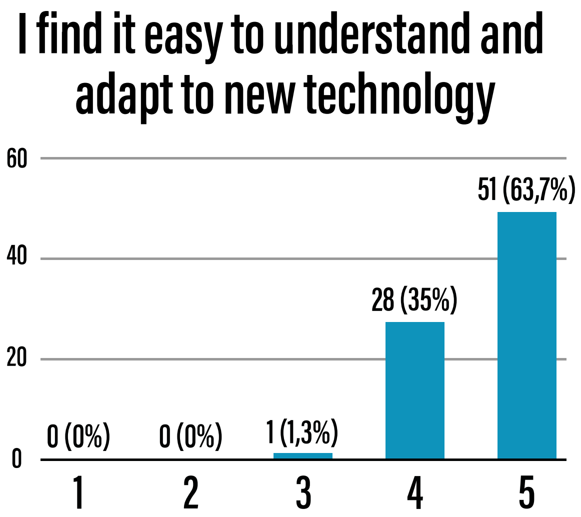

Figure 19. Understanding New Technology

The results hinted that there would not be a need for compensating for an older user group in terms of usability and it could be assumed that everyone is used to using modern interfaces.

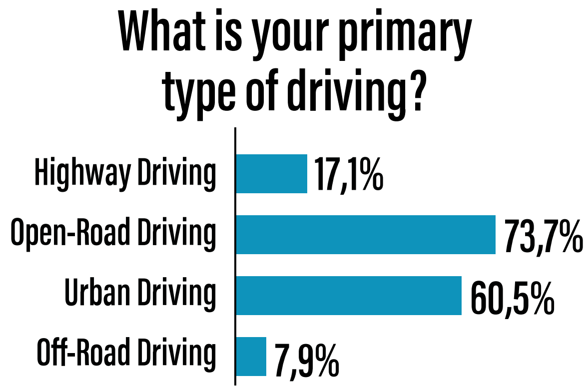

Figure 20. Primary Type of Driving

The Expert Perspective

According to the expert interviewees, something common among new motorcycle riders is that they tend to ride fast and engage risky behavior as they are searching for an adrenaline rush. The risky behavior exists among experienced riders as well, they are however more capable riders. Another dangerous behavior is to not plan one's riding ahead which can lead to undesirable consequences as going too fast towards an intersection or curve without being able to slow down in a proper manner. Inexperienced riders have the common characteristic of not being aware of risks and hidden dangers that exist in traffic. Among some riders, there exists overconfidence where the rider might believe that they are a good rider that can ride in a risky manner. This can often be connected to them not ever being in an accident or at least experienced a near-accident situation. This is dangerous since these riders are prone to stretch the boundaries which might put themselves and others in danger. Adding an infotainment system needs to take into consideration the different aspects and not worsen the rider's capability to ride safely.

It is important to acknowledge that a motorcyclist is generally more exposed to suffer severe damage in case of a traffic accident than a car driver. Thereby, it is important to be aware of the blind spot when driving since are in general smaller than other cars, busses or trucks. Furthermore, it is important that the rider fills their lane and shows other vehicles and pedestrians that they exist. When riding towards an intersection or roundabout, it is important to know that pedestrians and cyclists can sometimes act in an unpredictable manner where it is important to be ready to act if they would act unexpectedly. In similar cases, an infotainment system should require too much focus and encourage riders to engage in risky behavior. Therefore, the infotainment system should only include the most essential features as riders could be placed in dangerous scenarios where they pay too little attention to the road and environment.

Choosing when to drive a motorcycle is strongly linked with the weather since a big majority of motorcycles do not provide any shelter against critical weather conditions. Snow and rain can create slippery surfaces and deteriorate visibility which can put the rider in danger. Other aspects as gravelly roads, tired asphalt, potholes, tram tracks and leaves need to be taken into consideration when riding to prevent risk of losing control and be exposed to an accident. Actively choosing when to drive a motorcycle has also to do with comfort were it generally is more enjoyable to drive motorcycle during a warm summer compared than during a cold winter. Riding conditions encourage most riders to wear gloves due to wind conditions which can make it very cold no matter the time of the year. Not wearing gloves when the conditions are rather cold can result in hands becoming numb which can lead to worse performance of handling e.g. the throttle, brakes and buttons. Therefore, it is important to consider how the interface for the infotainment system should be compatible with gloves since it is not desirable to force the user to remove their gloves to interact with the infotainment system.

The Rider Perspective

Some PTW rider interviewees expressed that they had a bad habit of using their phone while riding which can expose them to traffic accidents since riding motorcycles require plenty of attention (see 2.1 Level 1 Individual Factors*)*. It is also connected with other individual factors e.g. perception and level of automaticity which are factors that are evolved through experience of riding. The PTW interviewees expressed that interacting with a smartphone while riding in an urban area is complex since it requires high levels of attention due to pedestrians, vehicles and multiple lanes which require quick decision-taking.

It became apparent that the younger interviewees had grown up with constant access to internet and they regularly used GPS from their smartphones to reach specific locations. The possibility of always being connected and reachable by phone, even when you are riding a motorcycle, was a necessity for a majority of the interviewed PTW riders. It was desirable to have the ability to connect their smartphone and headsets wirelessly since cables can be entangled which might put the rider in uncomfortable riding positions.

When asked about what they associate infotainment systems with, the interviewees expressed that interactive touch displays should be included to show information and offer entertainment services. By having an infotainment system, it was assumed that it should be possible to have access to traffic related information, music player and communication possibilities accessed from pairing their smartphone. Some users expressed a desire to interact with the infotainment system through a HUD (Head-up display) in the helmet visor, similarly how HUD displays are configured on the windshields in cars. However, the idea of implementing HUDs in cars was relatively new. There had been attempts to design motorcycle helmets with HUD installed in the vizor, but it had not been standardized for the motorcycle industry. Which in turn would make it hard to consider for this project.

When asked about what a suitable screen size for an eventual display would be, the interviewees expressed that a screen size similarly to what size Nintendo Switch consoles have. They did not want a small display which could affect the ability to easily interpret information. However, they would not want it to be to big either as it would not be appreciated from a design point of view as it would look like a tablet on two wheels. The display should complement the design and feeling of the motorcycle and not take away too much from the joy of just riding. The size of the screen should display all the necessary information while not taking too much focus from the road. Regarding the topic about having a display with touch-functionality as a user interface for the infotainment system, mixed opinions were expressed regarding an eventual display being interactable through touch or not. Some users expressed that they would most likely feel irritation if they are not able to interact with the display when riding while others expressed that they understand the risks that are associated with riding and using a touch-display. If, however they had access to it, they expressed that they would probably engage with the touch-display anyways.

Interacting through voice command was something desirable since it seemed to be an intuitive way of controlling the infotainment system with. However, some interviewees expressed distrust towards voice command as they had bad prior experiences by infotainment systems in cars or smartphones. They were doubtful if voice command would work on motorcycles as wind conditions makes might disturb the functionality. In situations where attention is more vital than normally, it is important to provide an interface that users can trust and will perform the intended commands effortlessly. Most interviewees expressed that they would like to interact with the infotainment system through physical buttons placed on the handlebar while riding as they would not have to remove their hands. It would require the same type of maneuvering as they were used to such as interacting with buttons for blinkers, headlights and horn. Voice command was expressed to be a desirable complement to a touch display and physical keypad, with the presumption that the infotainment system would respond correctly.

Design Considerations

A theme that was recurring through the interviews was a fear of looking on the screen to interact with features and functionates, more than what is suitable for safe riding. It can be compared to the statistics and correlation to the framework that was presented earlier (see 3.2 *Trends and Market Development*) where many respondents in Bosch's survey admitted to using the smartphone while riding. Even with the assumption of an infotainment system being safer than a smartphone, it beats its' own purpose if the infotainment system contains information and features that are excessive. As the results from the user research indicates, users are more likely to interact with excessive features even if they are not essential to their travel.

By utilizing a display and having the possibility of providing navigation, it is important to offer information in a more optimal way than using a smartphone. This would entail using a display that is in an optimal size which provides clear contrast, is adaptive to lighting environment and different weather conditions. There would also be a possibility of providing the option of mediating traffic information which in extension could be utilized to provide real-time recommendations for shortcuts and alternative routes to avoid traffic peak and long queues. With the ongoing digitalization in progressively more markets, it is obvious that there exists a need to be able to pair a smartphone or headset to the infotainment system wirelessly. It is important to take into consideration that lag, bad connection and slow navigation would rapidly destroy the user experience which could result in dissatisfied users. If an infotainment is implemented, the interaction between the system and user must work seamlessly as the user experience would otherwise worsen and the user would

Thereby, the system should be designed with a suitable amount of information and provide safe and intuitive ways of navigating through the system to reduce the probability of users looking excessively on the display to validate their actions. It is also important to take into consideration that when a motorcycle is in movement, vibrations occur, and the screen might be harder to interpret and therefore should icons and text be designed to be distinguishable and legible. Like all other systems, there is a learning curve to fully understand and learn a system. Therefore, the learning curve should be decreased as much as possible to enable the user to become proficient and gain the ability to use the system effectively and safely. The results of the interviews also concluded that the most vital features an infotainment system for an urban motorcycle should have are: phone communication, music player, navigation and GPS.

4

DEFINE

This chapter presents the *Define Phase* which is the second phase of the double diamond process. This phase aimed to conclude all information that was gathered throughout the earlier discover phase and contextualize it by creating defining the target group and creating the infotainment design guidelines. These would in turn serve as an underlying basis for developing the final concept.

Firstly, what is presented in this chapter is a description of the process and methods used during the define phase. Secondly what is presented are the results which the process and methods produced.

4.1 Method and Process

This section presents the process and methods used for the define phase.

Brand Analysis

A customer's perception of a company can be considered as the brand and identity of that company (Warell & Nåbo, 2001). With that said, brand and identity are important parts in product design as well and influences the development of e.g. product and services. Whenever a product is being developed, it is important that it fits in to the narrative to form a cohesive and complete story. An essential aspect in today's competitive market is working to increase customer value, since it is the factor that differentiates brands from each other.

Therefore, it was important to define what Regent's brand stood for and who the target group was before initiating a concept development process to produce a concept that fits into the narrative and fulfills needs that users from the target group has.

Persona

Persona is described as archetypical descriptions of user behavior patterns into representative portraits to create a user centered design focus, test scenarios and enhance the communication (Hanington & Martin, 2012). To successfully conduct project with emphasis on user-centered design, it is important to understand people since pursuing to design for everyone does usually result in incoherent or unfocused solutions. Personas can help with the development of an ideal solution by capturing common behaviors in relatable and meaningful profiles which is based on information from real users.

The persona created for this project, was used to form a mutual perspective on who the average person in the target group is what kind of behavior patterns the user would have. Moreover, the persona was useful when creating the product requirements but mainly had a big impact on the defining the user stories and the overall concept development process. The persona was used as a reference and a reminder to evaluate if the design process was going in the right direction and fulfilling the needs of the target group.

KJ Technique

KJ Technique is a method used to help teams organize complex and complicated amounts of information and ideas (Hanington & Martin, 2012). The KJ technique is a method used for conveying information that exist among team members to prioritize and organize the data.

The KJ Technique was used for analyzing and categorizing the identified patterns and their implications from the framework, market research and user research. The results from the KJ Technique was used to create the requirement list and user stories which in turn became the underlying basis for creating the infotainment system concept.

Requirement List & User Stories

To achieve a favorable result from a product development project, it is important to create a requirement list that fully describes the product (Johannesson, Persson and Pettersson, 2013). The requirements should explain which requirements must be realized and which requirements are only desirable. Both the product requirements and user stories described below were created based on the findings from the *Discover Phase* which entailed the framework, market research and user research. The requirements and user stories were primarily set during the discovery and define phase but has been updated throughout the iterative concept development process due to some design implications from the usability tests.

Requirement List

A requirement list was created to compile identified requirements from the *Develop Phase* to a list of requirements that were categorized within the areas *Law & Safety*, *User Experience* and *User Interface*. The purpose of defining product requirements was to create a list of requirements which provided guidelines for how a MC infotainment system should be designed which could be applicable for any type of motorcycle. However, these product requirements were based on requirements and needs that users had when commuting in an urban city. The requirements were divided into two types: *quantifiable* requirements that are concrete and a set target can be achieved and *un-quantifiable* requirements which are abstract and desirable. Another purpose was to use the requirement list as a framework for developing the infotainment concept, answer the research questions and fulfill project goals. Requirements that were defined as desired features in the infotainment system were excluded from the requirement list since they were more applicable to be contextualized as user stories. Whereas the requirement list set the boundaries that the features can be developed within which then considers aspects such as safety, user experience and concrete requirements for related hardware. Requirements related to features for the infotainment system were excluded from the requirement list since they were instead presented as user stories.

User stories

User Stories is a method of representing small occurrences in users' lives (Interaction Design Foundation, 2019). They can be viewed as a different format of scenarios which can be used as an underlying basis for the design process to enable the designer to empathize with the user and to generate ideas that fit their needs. User stories are essentially a high-level definition of a requirement (at a conceptual level) which contextualizes user's needs.

For this project, user stories were used to contextualize relevant user needs that regarded desired infotainment features that were identified throughout the *Discover Phase*. The concluded list of user stories would serve as a list of possible features that was described from the perspective of the users. The user stories are formulated by acting as the "voice" of the users and answering the questions: *Who*, *What* and *Why*. All user stories could be potential features that could be implemented in the final concept of the infotainment system and would help guide the ideation in the *Develop Phase*. The product requirements that was earlier defined, would then serve as the boundary for how and if the user stories could be fulfilled. In contrast to the product requirements that were more general and applicable to other types of motorcycles, the user stories were more oriented around the needs and desired features for an electric motorcycle that mediates all necessary information through a digital display. The user stories are characterized with the words *Must*, *Nice* or *Need* due to the importance each user story has. *Must* describes user stories which are elementary and can't be excluded from the infotainment concept. *Need* represents user stories that are considered important to implement in the infotainment concept because of the significant value it contributes with, but it still possible to develop an infotainment concept without it. Finally, *Nice* characterizes user stories that would increase the total value of the infotainment concept, but it is still possible to have a complete infotainment concept without it. The persona would help guide the creation of the user stories as a reminder who the target group was.

With consideration to the project goals and project demarcations, the user stories needed to be prioritized to reach the project goal of designing a holistic infotainment concept that followed the defined product requirements. Prioritizations were set to define what user stories would need to be fulfilled and i.e. what features needed to be included in the final infotainment concept to offer the most desired features. To reach a conclusion regarding what features were most important, the method *Card Sorting* was performed with users to let them mediate what they found most vital. By conducting stakeholder interviews, it was possible evaluate what user stories were to be implemented in the final concept.

4.2 Results

This section presents the results from the methods used the define phase which included.

The Modern but Classic Motorcycle

The analysis and interpretation of Regent Motorcycles' brand indicated that had the ambition of providing sustainable, elegant and easily maintained motorcycles that suited the lifestyle of young and urban commuters. They wanted to evoke a sustainable and modern feeling while providing a design which was heavily influenced by retro rebellious cafe racers from the 60's and 70's. By offering an infotainment system with modern standards found in cars, they wanted to disrupt the otherwise conservative motorcycle industry by providing something new and innovative.

Based on the content from Regent's web page and social media, it was apparent that Regent aimed their marketing towards men and women living in urban areas and were 20 to 35 years old (see figure 21).

Figure 21. Picture Used in Regent's Marketing

This generation would be the ones that generally cared more for sustainability and an electric motorcycle would be more applicable to their values and expectations of modern transportation. This generation cared more about lifestyle and prioritized low maintenance and convenience over owning a fast fossil-fueled motorcycle with the best performance.

The Urban Commuter

Traditionally speaking however, a big aspect of riding a motorcycle is the feeling of freedom that comes with it and the ability to just hop on the motorcycle for a joy ride and enjoy the engine sound without having a specific destination.

Buying a motorcycle simply due to utilitarian reasons is not the norm and the people who do, usually lean towards buying cheap alternatives such as mopeds, scooters or the electric options of the earlier mentioned. The urban commuter would however see the lack of emissions and sound pollution as a benefit in contrast to the traditional motorcycle riders, where sound and performance generally was a big aspect of the riding experience.

Motorcycles have traditionally been a statement product that was strongly connected to one's identity where different types of motorcycles had different stereotypes of the users that owned them. With this new retro-modern electric motorcycle, the user research made it apparent that there was a clear and broader target group that Regent intended. The target group revolves more around people that fit into the context of use, which is urban commuting, irrelevant of age or prior riding experience. The preference for Regent's electric motorcycle would ultimately be based on the utilitarian aspect, sustainability aspect or design preference. Other electric motorcycle brands usually had very futuristic designs which required a specific taste.

Magnus Larsson - The Persona

Magnus Larsson is a 28 years old, single man that lives in Gothenburg. Magnus works at a warehouse as a forklift driver and plays tennis in his spare time. He is an easy-going person that likes to spend his friends and family. Since Magnus lives in a populated urban area where there often is a lot of traffic, he does not need prioritize having a vehicle and has for a long time used public transportation to get around the city. However, after many years of commuting with public transportation, he is tired of having to adapt to time tables and always needing to plan his travels to get around and would like more freedom. Magnus had never owned a vehicle since he sold his moped when he was 16 years old. With the development of electric transportation, he wanted his first purchase to be an electric vehicle. Magnus always stays updated about the latest technology and innovations and regularly reads different technology articles. However, he also has an affection for vintage products that can be found in secondhand shops since they appeal to him from an aesthetic perspective as well from an environmental perspective. If he would describe himself, he would say that he is a minimalist that rather have few things that brings value to his life rather than many insignificant things that just end up on a shelf.

Figure 22. Illustration of the Persona

With the release of Regent's electric motorcycle with retro aesthetics that would also have an innovative infotainment system, Magnus has found the vehicle that he has been waiting for. He would no longer have to wait for the tram and could now freely move around the city on a clear conscience.

Infotainment Design Guidelines

This chapter presents the main synthesis of theory and user tests, visualized by tables that contain infotainment design guidelines in the form of requirements and user stories. The results from the discovery phase concluded that the user interface for infotainment system should consist of physical buttons on the handlebar, a touch display and a possible headset that is paired through Bluetooth. Another conclusion was that all necessary information that the user needs when interacting with the infotainment system, should be mediated through the display (with touch capability). The display would also replace the traditional information clusters and would mediate all information that is required according to law. The list of chosen features is presented in the develop phase (see 5.1 Strategy – Prioritizing User Stories) while the extended list of possible features is available in appendix C.

Requirement List - Holistic Guidelines

The requirements which were included in the mockup are presented below. Requirements that are quantifiable have the designation (*Q*) while requirements that are considered to be unquantifiable have the designation (*UQ*).

Requirement List		
Requirement	**Explanation of requirement**	**Type**
Law & Safety		
Provide (according to law) all the required information to the rider.	This entails providing information about telltales including warning notifications, speedometer, battery level,	Q
Enable the rider to ride safely and maximize their ability to pay attention to the road	Not subject the rider to information overload and provide necessary information efficiently (have logical priority of information and functionality)	UQ
Offer balance between safety and functionality	Find the balance of limiting functionality without having too big of a negative aspect on user experience.	UQ
Provide functionality that eliminates the need to use a smartphone while riding	Provide the most essential features so that the rider would not need to use their phone. It does not however mean that all the smartphone's features should be translated.	Q
Enable the rider interaction without needing to remove hands from handlebar	The rider should be able to fully interact with the infotainment system without having to remove their hands from the handlebars while riding.	Q
Strive to fulfill identified user interface guidelines from the second level in the framework.	The second level in the framework *System Design and User Interface* which presents guidelines for user interface should be used as guidelines.	UQ

Minimize glance time necessary for interpreting information on the display and amount of interactions required for achieving their goals.	Minimize the amount of time and interactions necessary by designing an intuitive system that enables the rider to quickly achieve their goals.	UQ
The physical keypad interaction should not hinder the rider to easily access and use other necessary functions necessary for navigating the MC in traffic.	The rider should easily understand and use the keypad infotainment buttons in relation to other functions that need to be used and easily accessed by the handles which are: - Turn Signals - Headlights - Horn - Handbrakes - Throttle - Kill switch (for killing engine/generator quickly if necessary)	Q
User Experience		
The rider should be able to enjoy the freedom/rebellious feeling of riding a MC	Riding a motorcycle gives the user experience related to freedom that cannot be experienced in e.g. cars. The implementation of an infotainment system should not infringe too much on that experience.	UQ
Enhance the approval aspects of riding a café racer (cool factor).	Riding a motorcycle attracts attention which is considered a positive aspect of riding a motorcycle. Aim to complement this aspect of the experience.	UQ
Provide feeling of that motorcycle and its infotainment system is tailored for the user	As a user I want to get the feeling, that the development team has taken into consideration who I am as a user to enhance my experience as a motorcycle rider	UQ
Provide a holistic and complete seamless interactive experience for the user	Users want to have a seamless experience from the moment when they decide to ride the motorcycle until they are finished. (Everything from starting the MC, it being electrical and having an infotainment system etc.)	UQ
Enable user to have a true traditional MC riding experience	The things that come with driving a MC is to not have a specific purpose/destination for driving and should be enhanced	UQ
Encourage and enable users to use the infotainment safely in relation to the features that are available	Having an infotainment system should not feel like a "burden" and should be there to heighten users experience without them having to feel as it affects their safety negatively. There must be a balance between number of features and safety which feels natural and acceptable by the users.	UQ

The infotainment system should feel like a natural extension of riding the motorcycle	The riding experience should be in focus and the infotainment should only be complementary to the riding experience based on the user's needs. It should not feel like there is a "tablet on two wheels."	UQ
User Interface		
The user needs to be able to use the motorcycle without pairing a device	The motorcycle needs to be usable for riding even if there are few functionalities available	Q
The infotainment system should be Intuitive and not have a steep learning curve to use	The design of the infotainment system should be easy to comprehend and navigate through	UQ
The rider needs to be able to interact with the infotainment system by using motorcycle gloves	The user interface needs to be compatible with gloves	Q
The infotainment system and its components must work fluently	The interaction with the infotainment system must work perfectly. Otherwise, if some interactions are not optimal and the user cannot achieve their intended goal, they will get disrupted which can affect their and others safety	Q
The display should be of optimal size	The information should be presented in a way that utilizes the available space of the display to provide an intuitive and safe user experience. Recommended screen size is between 7-8 inches	Q
The design of the infotainment system needs to correlate with the design language of the motorcycle	The infotainment system needs to be perceived to be a part of the motorcycle and not perceived as an addition	Q
The display should always be legible	The display needs to be legible regardless of weather conditions or other factors	Q
The display must not expose the rider for undesirable reflections that might worsen the sight	The display must have adaptive brightness and not become glossy so that the display never becomes a dangerous obstacle when driving	Q
Interactive elements should be placed in correlation to the mental model of Motorcycle Riders	Since the motorcycle does not have a clutch on the left handle, the left hand should be the primary hand used for interacting with the infotainment system. Since it leaves more room for handling more elements and in turn does not significantly contribute to a higher cognitive and physical workload.	UQ

Interactive elements should not contribute to an overall cluttered interface.	Few interactive elements should be placed on the right handle since it is intended to handle the throttle which is a vital function.	UQ
Offer feedback when interacting with the infotainment system	The user needs to get clear system response when interacting with infotainment system by tactile, sound and visual senses so that the user knows that their intended action has been conducted	Q
Offer interaction and functionality that is easy to maneuver, efficient and safe	The functionality of the infotainment system should be designed to minimize risk of using it incorrectly. It should also be intuitive to use	UQ
Buttons need to maintain functionality over time	The available buttons should be designed with high quality to manage mechanical aspects so that the user has small risk of making mistakes that might jeopardizing safety	UQ
Optimal viewing angle on display	The rider should have a suitable viewing angle on display, based on ergonomic principles	Q
Optimal Size of elements	The size of the elements should be designed to be eligible and big enough to enable a safe and good user experience	Q

Table 1. Requirement List

5

DEVELOP

This chapter presents the *Develop Phase* which is the third phase of the double diamond process. This phase aimed to prioritize what features (user stories) would be prioritized to fulfill the criterions for an MVP and fulfill the second project goal. After prioritizing features that were to be included in the final concept, the following step was to generate different ideas and lo-fi prototypes to identify possible ways of providing those features. After evaluating the ideas and lo-fi prototypes, the best concepts were moved into the last phase of the double diamond process, the *Deliver Phase*.

Firstly, what is presented in this chapter is a description of the process and methods used during the develop phase. The process was modeled around a design process called *5 Elements of UX* which consists of the stages *Strategy*, *Scope*, *Structure*, *Skeleton and Surface*. These would overlap with the last and final *Deliver Phase*. Secondly, what is presented are the results which the process and methods produced.

5.1 Method and Process

This section presents the process and methods used during the Develop phase.

Five Elements of UX

The 5 elements of UX refers to a design process that is oriented around the concept development and focuses on ensuring that all aspects of the user's experience happen according to the designer's conscious decisions (Elgabry, 2016). This implies taking into consideration every possible outcome that a user's interaction might lead to and understanding the users' expectations and how they generally behave throughout the process of using a product or service. The complexity of developing a MC infotainment concept would require structured ideation sessions, rapid prototyping and user testing within an iterative process with emphasis on UX. Since the project was focused on answering the research questions and fulfilling the project goals that had emphasis on UX, a deliberate choice was made to implement the five elements of UX to help guide the design process.

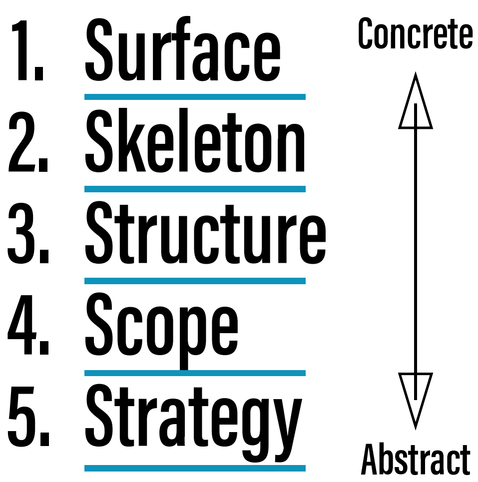

Figure 23. 5 Elements of UX

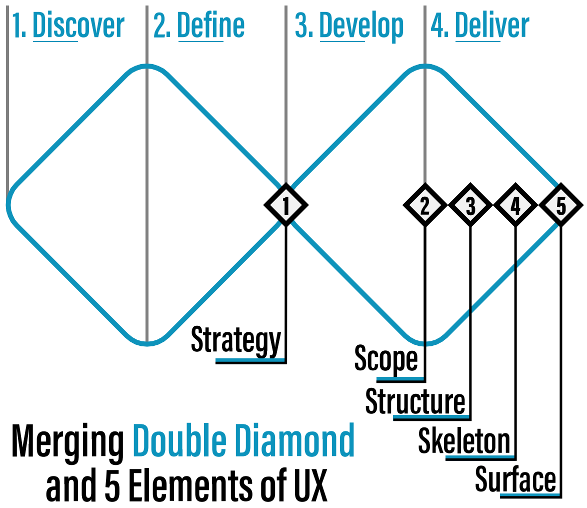

Figure 24. The 5 Elements of UX Used Within the Double Diamond Development Process

The Develop phase aimed to set up a strategy which entailed prioritizing what user stories should be fulfilled. This in turns provided guidelines for the ideation and set boundaries for the solution space to enable an efficient progress. Based on the ideas that were generated, trends started to be identified within the exploration of ideas that ultimately were treated as candidates for implementation in the *deliver phase*.

Strategy - Prioritizing User Stories

Deciding on a *strategy* describes the intersection between fulfilling user needs and project goals (Elgabry, 2016). What makes up the solution space is the balance of both sides which considers customer value, feasibility, and project constraints such as time and budget (see figure 25). To define the solution space, a prioritization of user stories was done to define what the MVP (minimal viable product) for the final infotainment concept was. This was accomplished together with users and by presenting the project group's final prioritizations of the user stories to company stakeholders.

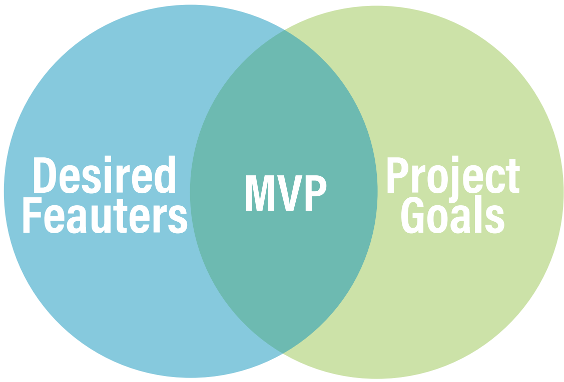

Figure 25. MVP is the Intersection of the Users' Desired Features and the Project Goals.

Card Sorting

Card sorting is used to comprehend user's opinion with meaningful categorizations (Hanington & Martin, 2012). Card sorting is a participatory design method aimed to explore how participants prioritizes and categorizes features in relation to one another. The features are presented by "cards" which can e.g. be post it notes that contain different features which the participants would sort based on specific categories.

Card sorting was mainly used to get the expectations, opinions and perspectives from motorcycle riders regarding the features that was associated with each user story. There were in total ten respondents from the questionnaire that were contacted to participate in the card sorting. They were within the identified target group, *the urban commuter*. Participants were presented with cards where all possible features from the created list of user stories. By letting participants prioritize the features from most important to least important, patterns could be identified regarding two things: 1) *Prioritization and desirability of features* and 2) *Information hierarchy* which included categorization of features and how they would like to have them presented. After this activity, the project group evaluated the results and prioritized what user stories should be included in the final concept.

Stakeholder Interviews

Stakeholder interviews are meetings that are held with key stakeholders: customers, bosses, subordinates or peers (Manandhan, 2017) This allows e.g. the product developers or UX designers to merge their perspectives together with the stakeholders and perform a holistic evaluation.

For this project, the stakeholder interviews were held with Regent stakeholders excluding the users since their opinions and prioritization of user stories were collected through the card sorting activity. With the card sorting as a basis, discussions were held together with the stakeholders regarding the user stories were prioritized after the card sorting activity. The purpose of the meeting was to evaluate if the criterions for the project goals and MVP would be fulfilled with the prioritizations that were set by the project group. After evaluating that the prioritized user stories would fulfill the project goals, the ideation of ideas was initiated.

Ideation

Generating ideas was the first step in the iterative development process generation which focused on producing a large amount of ideas and concepts regarding how the chosen user stories could be fulfilled. The concepts and ideas that were considered to have most potential, were chosen to be further developed in the upcoming deliver phase.

Brainstorming

Brainstorming is a method that traditionally has been used to trigger creativity with the intention of generating ideas and concepts of a specific problem or subject (Hanington & Martin, 2012). Some common norms for brainstorming are "withhold judgment and criticism", "Go for quantity over quality", "build on each other's ideas" and "welcome oddity". The purpose of the different rules is to create a safe forum for development of ideas and concepts which can help overcome any restraints that the team members might retain.

The brainstorming session was used to generate a large amount of ideas and concepts which would be evaluated and developed in the deliver phase if any value could be identified. The main starting point for the brainstorming session was to produce concepts of how the prioritized user stories could be solved. The market research, user research and literature review from the discover phase served as a source of inspiration for the brainstorming session. The brainstorming was initially conducted individually by sketching or writing down ideas on paper or post-its of how the different user stories could be solved. The ideas were then described and discussed between the project group members which lead to a second brainstorming session that was done collectively. Different approaches and combinations were merged to different systems of ideas that were modified in iterations which ultimately resulted in different low fidelity concepts being created.

Low-fidelity Prototyping

Low-fidelity Prototyping is an iterative method that is used for developing and testing ideas within design teams, users and clients (Hanington & Martin, 2012). Creation of physical models of a product or interface concept is an integral feature of the design process. This represents a transition of creative ideation into tangible form which is used for rapid testing of ideas and concepts. Low-fidelity prototyping can appear as concept sketches, storyboards, or sketch models which are common in early ideation processes. The prototype is seen as a concept created for iterative changes through constructive review and feedback. Low-fidelity prototyping is also used for interface and software design through the creation of paper prototypes which can e.g. represent interface screens.

Low-fidelity prototyping was primarily done with the purpose of creating rapid concepts of physical and digital interface models. By working with low-fidelity prototyping, it was possible to make rapid models which were evaluated. An important aspect of low-fidelity prototyping was to experiment with different dimensions and evaluate concepts from a user-centered perspective.

Scope - Selection of Ideas

Scope is defined as the phase where user needs and project objectives are rewritten into requirements for what functionality and content the concept will offer for the intended user (Elgabry, 2016). The requirements should aim to fulfill and align with users' needs and project goals. *Scope* for this project represents the finalization of the ideation phase where ideas and concepts are narrowed down by evaluating them and choosing the best ones.

Action Feasibility Matrix

Action priority matrix is a method used for prioritizing different activities, concepts or ideas to conduct projects more time efficiently (MindTools, 2019). The matrix consists of the four boxes (a) *Quick Wins*, (b) *Major Projects*, (c) *Fill Ins* and (d) Thankless Tasks. *Quick Wins*, refers to activities which are considered to be most attractive since they give good return with little effort ,*Major Projects*, refers to projects that give good return but are time consuming *Fill Ins*, refers to activities that are of low priority and should be taken away or delegated and *Thankless Tasks*, refers actions that should be avoided since they give little return and are time consuming.

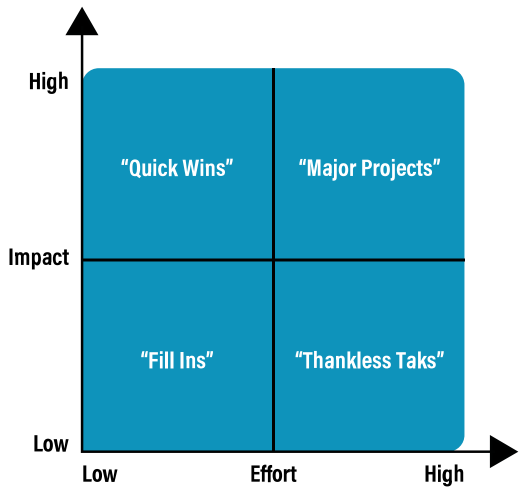

Figure 26. Action Feasibility Matrix

The ideation resulted in a big selection of different ideas and concepts. With help of the action priority matrix, it was possible to organize and evaluate the concepts to identify what is interesting and what should be further developed in the deliver phase. The method was useful for visualizing and categorizing activities in the different areas of the matrix (see figure 26) to utilize time and prioritize the most valuable features. After using the matrix, the different ideas and low-fidelity prototypes were narrowed down and selected to be further developed in the *deliver phase*. That is where the iterative process of developing one final infotainment prototype began which consisted of iterative design sessions and usability tests.

5.2 Results

This section presents the results from the develop phase which entails the prioritized user stories and a map of the user interface.

Prioritized Features (MVP)

The user stories which were considered to most efficiently fulfill the project goals and provide the most desirable features. These were the features which the final prototype would aim to provide (see page 52).

GPS	As a rider, I want to receive information regarding my current position so that I where I am currently.
Navigation	As a rider, I want to receive information regarding how I can get to my destination so that I navigate myself.
Time and Distance to Destination (Navigation)	As a rider, I want to receive information of how much distance and time is left to reach my intended destination (Navigation)
Turn by Turn (Navigation)	As a Rider, I want to receive turn by turn information so that I receive additional help for reaching my destination.
Mediate Telltales	As a rider I want to have access to information about all necessary telltales to maneuver the motorcycle in a safe manner.
Mediate Speed	As a rider I want to have access to information about the current speed to maneuver the motorcycle in a safe manner
Mediate Battery Level	As a rider I want to have access to information about the current battery level so that I can adjust my driving
Current Time	As a rider I want to see the present time so that I can relate to the time of day and plan thereafter
Bluetooth Connectability	As a rider, I want to pair my smartphone & headset to the infotainment system so that I have access to the functionalities they provide.
Voice Feedback	As a Rider, I want to receive voice feedback from the system so that I am can receive relevant information when I have paired a headset.
Communication Capabilities	As a rider I want to be able to access my phone’s communication capabilities so that I can communicate with others.
Music	As a rider, I want to be able to engage with a music player where I can manage my music so that can adjust what I am listening to.
Regulate Sound Volume	As a rider I want to be able to regulate the sound volume for the infotainment system so that I can adapt volume to my needs.
Traffic Information	As a Rider, I want to receive traffic information so that I can avoid ques and get to where I am going faster.
Location of Charging Stations	As a Rider, I want to know where I can charge my MC so that I do not run out of battery.
Information on Weather	As a Rider, I want to receive information regarding weather so that I can adjust my travels if necessary.

The User Interface

This section presents a map of the possible interactions that the user could have with the infotainment system based on the infotainment design guidelines. The different possible ways of interacting with an infotainment system are presented (see figure 27). Specific placement of keypads on the handlebar were assumed that they should be placed close to the handles based on what was found in the market research and user research. The exact positioning of each specific button was evaluated and refined in the deliver phase.

Haptics

Interacting through a keypad and the touch display would be the main way for the user to physically interact, navigate and input commands into the infotainment system. However, designing the physical buttons would be outside the scope of this project. The focus would lie on designing the buttons on a conceptual level and focusing on the method of navigating for the buttons and how they correlate to the infotainment system. The critical aspect would be to create coherence between the button input and the way that the user would navigate through the system.

Vision

By using their vision, the user would be able to look at the display to interpret visual information. They could also look at the keypad to reassure what button they can press (even if this is not desirable and would mean that the keypad is no intuitive, the possibility is there).

Audition

The user would be able to interact with the system through sound which enables the system to provide voice and sound feedback to e.g. provide information or reassure that interactions in the system has been made without them having to look down at the display for reassurance. However, as the figure suggests, an additional component would be necessary to provide this aspect of the user interface. This additional component would most likely be an integral helmet with built in headphones or regular headphones.

Based on the prioritization of desired features, the ability to talk with the infotainment system and navigate it through voice command would not be included in the final prototype. As it became clear through the discover phase and card sorting activity with users, the users would not trust voice command or use it to a great extent as they would rather rely on physical buttons and touch-functionality.

Indirect Interaction with Smartphone

By enabling the user to pair their smartphone with the infotainment system, the user would get access to some of their phone's compatible features. This would mean that while using those features in the infotainment system, they are interacting with the smartphone indirectly and the infotainment system would become an extension of the smartphone.

The prerequisites for the different aspects of the user interface would however be defined throughout the iterative process in the deliver phase, with regards to how they would provide the prioritized features and fulfill the criteria for the MVP.

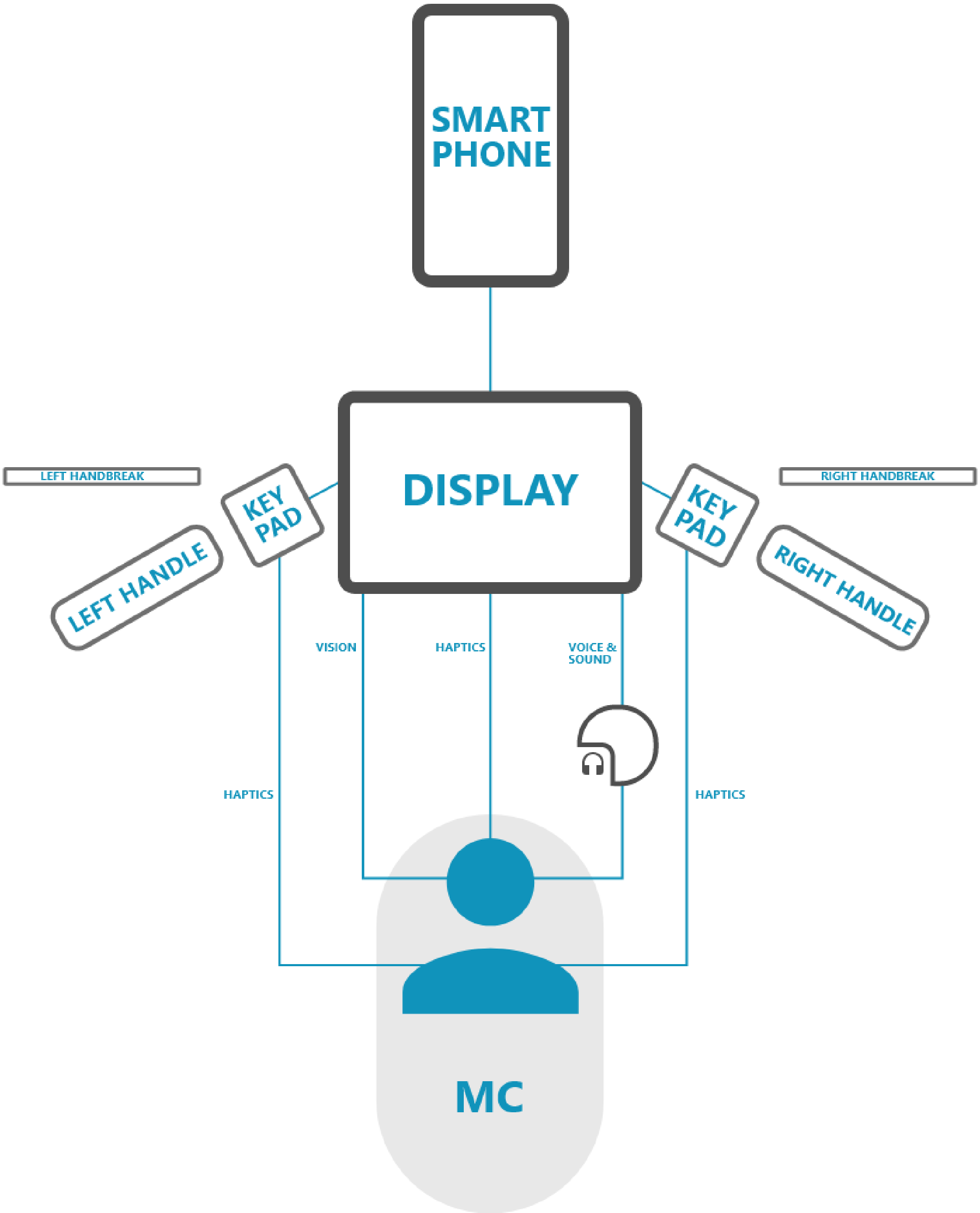

Figure 27. Map of the User Interface.

6

DELIVER

This chapter presents the *Deliver Phase* which was the fourth and final phase of the double diamond project process. This phase was an iterative process where time was spent on finalizing the ideas chosen for further development and in turn evaluating and verifying them by doing usability tests. The outcome of the iterative process would be the final concept.

Firstly, what is presented in this chapter is a description of the process and methods used during the deliver phase. The process for the deliver phase would also follow the design process for 5 elements of UX which overlapped from the earlier develop phase. Secondly what is presented are the results which the process and methods produced.

6.1 Method and Process

This section presents the process and methods used during the Deliver phase.

Structure - Defining the Concept

Structure defines how a user interacts with the product, how the system behaves when user interacts with it, how it is organized and how the content is prioritized (Elgabry, 2016). This is divided into two parts, *Information Architecture* and *Interaction Design*.

Interaction Design

Interaction design defines what steps are necessary for a user to achieve a goal using the features that have been defined in the *scope*. An approach for designing the interaction is to create *user flows* and thus focus on the user goals and how to enable them to achieve them in the most effective manner. Creating user flows should lead to a better user experience since it puts the user in the center of the design process.

User flows were done by mapping out all possible user goals and evaluating them against the MVP which makes it easy to create the user flows accordingly (Interaction Design Foundation, 2019). An important aspect is looking at the different possible entry points that a user might enter the service from. User flows were created to review how the interaction in the infotainment system would function in relation to the user stories that are set to be fulfilled and the features that allow them to achieve their goals.

Information Architecture

Defining the *Information architecture* essentially aims to set relationships and hierarchies between all types of data and features. This provides a better understanding by demonstrating what should be represented in an interface. A hierarchy for the features to be included in the infotainment system can be created by arranging content elements and their organization. This in turn facilitates the process of designing an interface which is ideally easy to understand and use.

The information architecture was defined by doing a *Hierarchical Task Analysis* (HTA Analysis). This method enables identification of tasks and subtasks which can then be categorized to get an understanding of what tasks users need to complete to accomplish specific goals (Hanington & Martin, 2012). Placing data, features and actions that correlate to a user story in a hierarchy, results in a familiar tree diagram or similar formats of flow charts that can be verified by evaluating how the user would move through the hierarchy. This made it possible to explore the several possible approaches that users can have for completing the same task.

Skeleton - Refining the Concept

Skeleton should help determine where the visual form on the screen is located, as well as presenting and arranging all elements which the user is interacting with on the user interface (Elgabry, 2016). Furthermore, the skeleton should describe how the user is moves through the information and how the information is presented to the user. A common method used when creating the skeleton, is wireframing which is used to display a visual format of the product that includes content, navigation and ways of interaction.

Wireframing

Wireframing is a method used primarily for user experience projects where a model of a user interface is developed without coding or designing it esthetically (Interaction Design Foundation, 2016). The concept is in general a low- to medium-fidelity model which is not as developed as the final product. Medium-fidelity models are characterized as concepts which has required medium effort and detail to conduct (Aquino, 2017). The medium constraint should encourage designers to make higher-level decisions and focus on the user interaction. According to Aquino (2017), (a) *interface-*, (b) *navigation-* and (c) *information design* are three elements which should be taken into consideration when designing wireframes. (a) *interface design*, refers to presenting and arranging interface elements (buttons, labels, inputs) to enable a functional interaction with the system, (b) *navigation design*, refers to designing the navigation which is to be used when interacting with the system and (c) *information design*, refers to defining the presentation of information so that it facilitates understanding for the user.

Wireframing was used with the purpose of creating user interface concepts on a medium-fidelity level, based on the results from the *HTA Analysis*. The wireframes would be used to describe the elemental interface, navigation and information of the different parts that are included in the HTA Analysis. The wireframes were then turned into an interactive prototype through Adobe XD which is a vector-based software tool developed and published by Adobe, used for designing and prototyping user experience for mobile and web applications (Adobe, 2019).

Surface - Finalizing the Concept

Surface is described as the sum of all conducted work where emphasis is put on the esthetics, final layout, typography and colors (Elgabry, 2016). The results should give a clue of what the user can do, and how the user can interact with the user interface. It should also make elements easier to understand and increase the cognitive ability to absorb information. Mockups are described as prototypes that puts emphasis on describing shape, surface properties and color (Johannesson, et al., 2013).

Since the project has the demarcation of not prioritizing aesthetic- and/or graphic design of the components (see section Demarcations 1.5), the delivery will be a hi-fidelity concept of a infotainment system that emphasis on providing a great user experience which is safe, but also has considerations to graphical elements that have an effect on experience, usability and safety.

Usability Testing

Usability testing aims to seek empirical evidence regarding how to further develop the usability of an interface (Hanington & Martin, 2012). It is an evaluation method that allow project teams to observe participants interaction and experience with an interface as they go through a specific task (or a set of tasks).

The tests were done by letting the users interact with a digital prototype in a room where the user had possibility to give feedback and share their experience of interacting with the prototype and navigating through it (see figure 28). The objective of the tests was do identify difficulties and frustrations participants had when navigating through the system. What was also evaluated and tested were the participants ability to understand the features and elements included in the concepts and their interpretations of them. This is so that these aspects can be prioritized and improved in an iterative process of reaching a final prototype. The tests were constructed around specific user tasks and scenarios which represented possible user goals. The tasks assigned to the participants was concrete and specific and reflect the relevant user-goals of the target group. These tasks were set in scenarios to contextualize them and provide users with necessary information for completing the tasks. See appendix D for a more detailed description of how the usability testing was conducted.

There were in total 12 tests performed with users that had signed up through the questionnaire. The experience of riding PTW:s among the participants varied from 2 years to 10+ years of experience. There were in total four planned design iterations which were executed according to plan. Each following design iteration was initiated after each set of three usability tests. The reason for having specifically three tests before modifying and updating the prototype was to compensate for subjective opinions and evaluate the patterns in the feedback provided from the different participants. Three was evaluated to be a reasonable number of tests for reaching an objective conclusion of each design iteration. With the concluding evaluation of the feedback received during one design iteration, it became the underlying basis for modifying the prototype or following iteration.

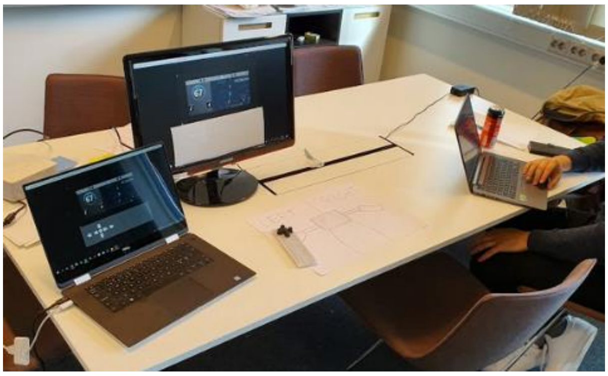

Figure 28. Picture of Preparing for a Usability Test

The three usability tests that were done after the final design iteration ultimately functioned as validation tests as they indicated that the concept had reached a desirable status. This meant a prototype which enabled the participants to interpret, understand and explain all visual elements without any guidance. Secondly, it also meant that the participant could navigate through the system and complete the user tasks given to them effectively and with minimal amount of errors.

6.2 Results

The following section presents the results from the deliver phase entailing the iterative design process and usability testing.

Design Implications from Usability Tests

This section presents the overall insights that were gained during the user tests that were made throughout the iterative concept development process. The feedback from the user tests implied the following design implications:

Display

The mockup that simulated an 8-inch sized display was experienced to be optimal as going smaller would lead to difficulties of interpreting the information and bigger would affect their experience and design perception of the motorcycle.

Visual Interface on Display

Provide high contrast and sufficient sizes on each element and that the "theme" should be adapted depending on the lighting environment.

Navigating Keypad and Design

The keypad should offer distinctive and clear buttons which feels intuitive to press and know what button will be pressed without having to look down to maximize intuitively and safety. The number of buttons should also be kept as low as possible to minimize the need of working memory and risk of pushing the worn buttons. The navigation possibilities that the keypad enables in the infotainment system should only be enabled in clear, intuitive and distinctive horizontal and vertical directions.

Intuitive Interaction

The interaction that is accessible when riding should be minimized and more complex interaction with the infotainment system should be limited with regards to the safety aspect (see figure 29). This was experienced to be acceptable and reassuring for most participants as they mediated that they would probably have abused excessive information, features and functionality if it was available.

This would not negatively impact user experience to just include the most important user stories that were included in the MVP (even if some thought there was room to put more visual content and features). More information would lead to a bigger need of filtering that information, which in turn would require more attention. However, it would be important to make the users experience as seamless as possible when they need to stop to perform certain actions.

Figure 29. Showing an early stage prototype where the speedometer would adjust to what was active. This was later stripped down and made simpler as it was realized that essential elements for riding should not move around.

The interaction possibilities that was in the mockup iterations were very limited since there were few elements that the user could interact with and navigate which was something they were not used to. In about half of the tests, the users managed to accomplish each user task correctly by guessing what each keypad interaction would lead to. However, after running through the user tasks (even after making the wrong assumptions in the beginning), they quickly understood the logic in the system and how the navigation was constructed. By turning off the screen and making them pretend as they were riding and having them go through the same user tasks without having visual feedback, they could navigate through all the user tasks quite easily, which implied that there was a quick learning curve.

Having too many elements that the user could navigate through and interact with would however encourage the user to look down at the screen and implies that there would be excessive features that would require the user to switch between several elements.

The iteration in (see figure 30) also provided better contrast between background and different elements which was found to be optimal during the earlier user tests. A darker "theme" would however be adjusted for darker surroundings and the theme and lighting would have to adjust if the environment was very bright.

To know which element is active and what would happen when they press a button, they would have to look down. This should be avoided. Usability testing implied that there should not be repositioning of important elements such as the telltales, speedometer and battery which are vital for the riding itself. It was realized that if the user either mistakenly interacts with the system or forgets what the status was before looking down, there might occur an incongruence regarding where to look and receive the information they are expecting.

Congruence Throughout the System

When the user needs to look down at the display for reassurance, provide visual cues for what keypad input should map to the visual navigation and elements of the screen to increase the intuitive interaction and interpretation. Create congruence between the keypad interaction and the display, which entails utilizing visual cues to help the user understand what keypad input leads to what action.

System Feedback and Reassurance

It was clear that users have a strong need of reassurance when they are interacting with the infotainment in terms of feedback, especially if

Figure 30. Iteration focusing more on contrast and experimenting with clear sectioning of the display.

they would interact with the system without looking at the display for reassurance that they have achieved their objective.

As stated before, even if the goal is to reduce the amount of time needed for looking at the display, the visual cues for what will happen, what is happening while they are interacting and what is active when the user interacts with the system is very important.

Sound and voice feedback are essential for the goal of enabling the riders to interact with the infotainment system without looking at the display. For receiving e.g. direction in the navigation or getting sound feedback for interactions made, they would anticipate some sort of feedback, otherwise they would feel compelled to look at the display to be assured that something has happened.

Tactile feedback from the keypad would be very important for the cases where sound and voice feedback were not available if the aim was to minimize the time that the user looks at the display for confirmation after an input. So, a clear and distinctive keypad which in combination provides very clear feedback regarding that something has happened will be very vital for a final implementation.

Minimize Time Necessary to Look Down at the Display

An important design implication was to design the infotainment in such a way that the amount of time that user spends looking down should be reduced as much as possible.

Intuitive Information- & Feature Priority

Think about the information priority and the different scenarios that can occur to make sure that each scenario would still require an intuitive reaction and interpretation from the user. In other words, consider what information and features be prioritized in different scenarios that can occur. Even if a clear design implication was to reduce the need of looking down, it would still be necessary for users to look down to interpret some visual information that only could be received by looking at the display. Therefore, enable the user to interpret desired information as quickly as possible.

Sometimes users wondered why not more information was included when riding and when asked what more they would need, it was nothing vital. However, they started thinking of features that they initially did not even anticipate, which further indicated that when more is available, they would abuse it. When asked if the available information would be acceptable if it was in a final implementation, they agreed. Most vital information should be visually prioritized and should contrast more in relation to the other features that are non-vital for riding a motorcycle safely.

With limiting the amount of complex navigation comes also the minimizing of the number of accessible features and functionality when riding. Since voice command was not an option, it would lead to either complex button combinations (when have fewer buttons on keypad) or the complexity of having to many buttons. Ideas regarding how more features could be provided when riders stopped at red lights and enabling touch functionality was tested as well. However, providing too much would mean that the rider might get to focused on those tasks and get "stuck" or frustrated that they do not manage to complete their objectives in time.

Figure 31. An iteration that experimented with offering a quick menu with quick acess to avarious features when stopping.

Providing a "quick menu" which was optimized both for touch and the keypad however only provided a very limited amount of functionality where they could choose between 3 favorites within each category (see figure. This was however also found frustrating as it felt very limited.

Therefore, the design implication led to removing that idea completely since it was notable that if a function does not function seamlessly and according to expectations, it would create more frustration than satisfaction. Therefore, it is better to in some cases to not create expectations regarding additional functionality at all even if the intention is to heighten user experience. It can backfire and even lowers the experience even more than the initial features, as it can create unnecessary frustration. The decision was made to only make more complex functionality to only be available when parked in neutral mode which was perceived acceptable from the users that it was tested with. What would however also be vital to user experience is optimizing what features they have access to when stopped and how seamlessly they are able to access and use desired features.

In the cases where even the small number of features available is still excessive for a user, the undesired features should not be intrusive and the user should still have free choice to not engage with undesired features.

System Architecture

This section presents the conclusion of the final system architecture that the iterative concept development process and usability testing resulted in. The presented final system architecture is what the final infotainment system concept was designed around (see figure 32).

SYSTEM ARCHITECTURE

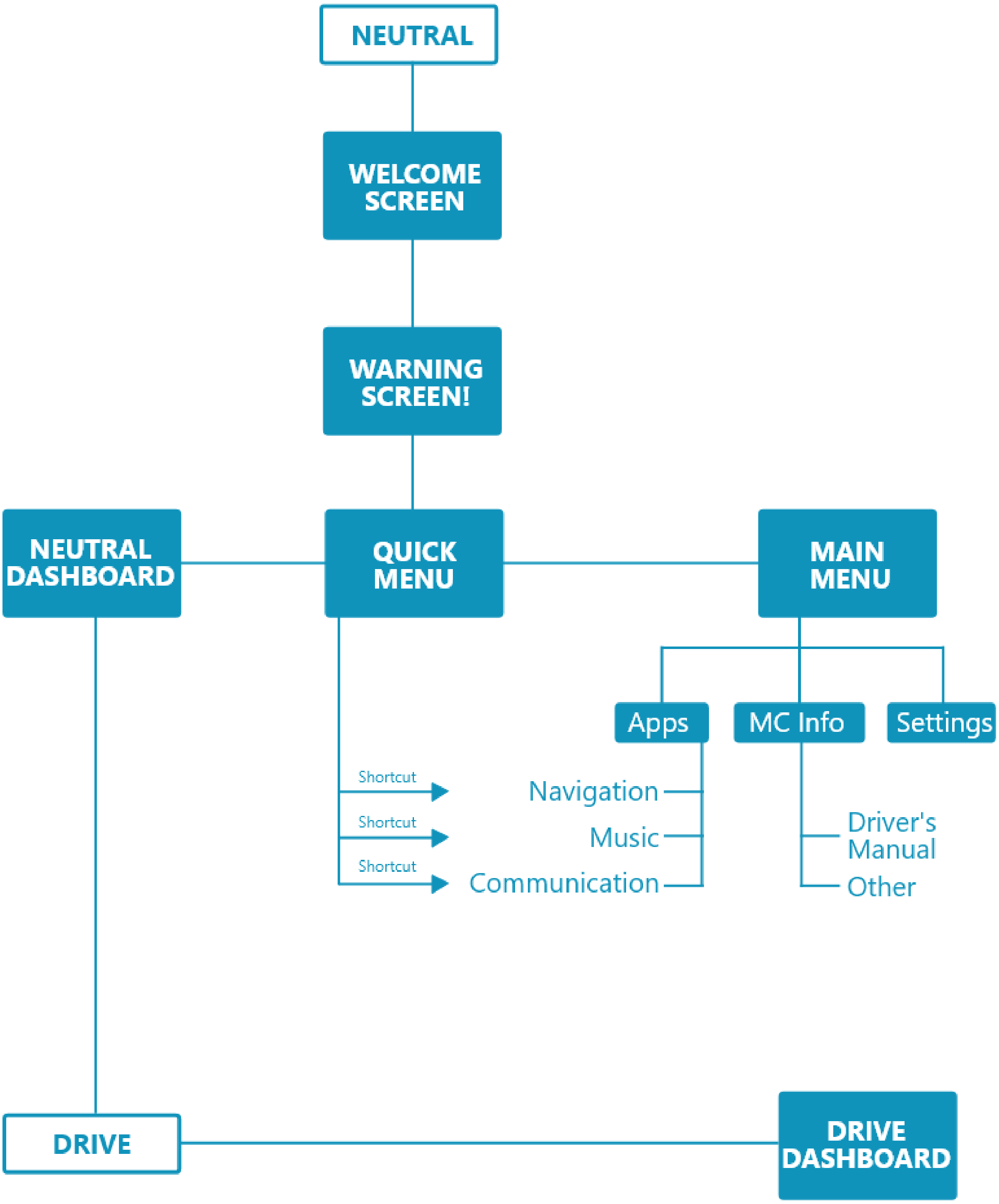

Figure 32. Final system architecture that the iterative concept development led to. This also became the architecture that the final concept was built around.

7

FINAL CONCEPT

This chapter presents the final concept that was created through the iterative prototype development which used the infotainment design guidelines as a basis.

7.1 Overview of the MotoRide Infotainment Prototype

The MotoRide Infotainment is an infotainment system prototype developed for urban electric motorcycles that can be interacted with a keypad or via an eight-inch touch display (see figure 33). Having the display (with touch functionality) also gives possibility to visually display various information and entertainment alternatives. The information and entertainment consist of a music player, navigation, GPS and ability to access phone communication. By wirelessly connecting a smartphone and headset via Bluetooth, it is possible access the smartphone's music player and the communication capabilities.

What type of functionality is accessible depends if the motorcycle is in drive- or neutral mode to prevent unsafe usage while riding. The MotoRide Infotainment is designed to offer effortless user interaction and providing system navigation that is intuitive to use and easy to learn. The infotainment system is designed to simplify riding in urban areas by offering real time information about present traffic situation and giving suggestions on alternative routes to avoid traffic jams. The infotainment system has the option of always being connected to the internet by enabling the ability to connect to the internet.

Figure 33. Visualization of the MotoRide prototype.

7.2 User Interface

The alternatives that the rider have to interact with the MotoRide system are through the touch display, keypad (left handle), control Lever (right handle) and a helmet or headset that is paired connected via Bluetooth (see figure 34).

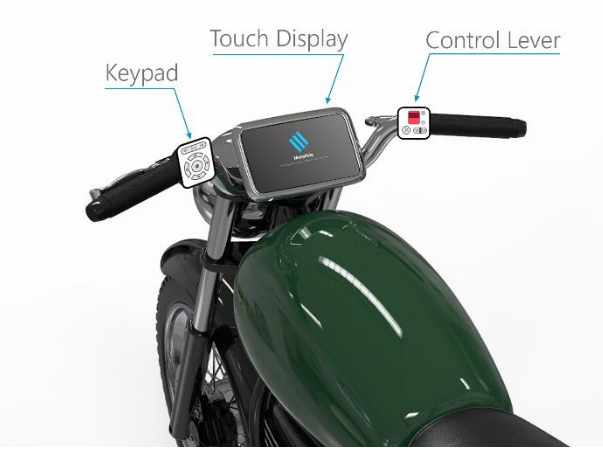

Figure 34. Different alternatives of interacting with the MotoRide system.

Touch Display

The display is an 8-inch adaptive screen that is resistant to dust and is adaptive to dark or light lighting, with touch functionality. Interaction through the touch-display is not enabled in drive mode (which will be described later) as it would put the rider in danger. Using the touch-display is something that would require several steps within a very limited time frame to achieve their objective (see figure 35).

The rider would have to: 1) Remove hand from handlebar 2) Look down and advert attention from the road 3) Visually locate which element on screen that they want to interact with 4) Successfully hitting their target. This would need to be done while they are in urban traffic which already requires maximal attention. As described before, enabling touch while riding would emulate the same negative aspects of using a smartphone while riding.

Figure 35. A closer look at the display when it is in drive mode, which disables touch functionality. The displays correlation to the keypad (left) and control lever (right) is also illustrated.

Keypad (Left Handle)

The left keypad is the primary button configuration used for navigating through the infotainment system (see figure 36). The keypad is positioned beside the left handle since the exclusion of a clutch (since it is an electric MC) leaves room maneuvering more elements. The rider would not have to change gears on an electric bike which is a big relief in riding in urban areas as there are a lot of stop and ride events. It was considered to decrease the mental workload and complexity by having the keypad by the left handle with the exclusion of a clutch. Compared to the right handle where the rider would also need to manage the throttle, it would not be optimal to place they infotainment buttons there as controlling the right handle is more critical.

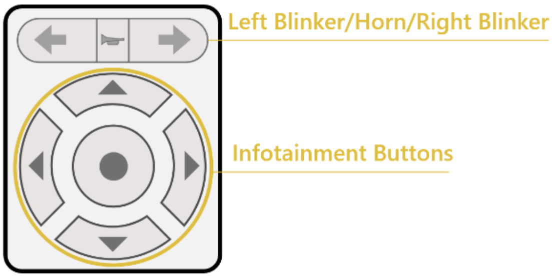

Figure 36. Close up on the keypad placed at the left handle.

Infotainment Buttons - Consists of the five buttons: up, down, left, right and a middle button
Horn Button - Provides the functionality of conveying sound.
Turn Signal Buttons - Provides the functionality to engage the left and right blinkers.

Control Lever (Right Handle)

The button configuration on the right control lever contains interactive elements that does not provide direct interaction with the infotainment system besides initiating visual cues on the display for various aspects of the MC (see figure 37). The button configuration consists of the three interactive groups:

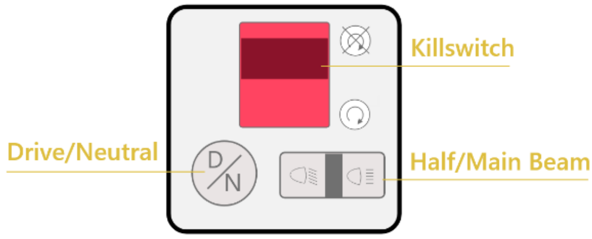

Figure 37. Close up on the control lever placed at the right handle.

Drive/Neutral Button - Alternates between drive- and neutral mode
Headlight Buttons - Manages the lighting for half beam and main beam
Kill-Switch Button - Enables the Rider to directly stop the MC in an eventual accident as a safety measure.

Paired Helmet or Headset

By connecting an integral helmet or headset to the infotainment system via Bluetooth, the rider can access their phone's communication capabilities (if a smartphone is paired with the system), listen to music and receive voice and sound feedback from the system (see figure 38). The feedback from the system come from interacting with the system, as instructions or directions for reaching their set destination.

Figure 38. Illustration of a rider with a connected integral helmet.

7.3 Navigating and System Feedback

The interaction with the MotoRide Infotainment and how it enables the user to navigate through it is designed to be in coherence with the button layout from the keypad. Thus, it is possible to navigate up, down, right, left and a middle button (see figure 38). Considering that the infotainment system is designed to be used in urban areas where it is critical that the rider pays attention to their environment, it was vital to design a pattern for navigating through the system that is intuitive and easy to learn. Therefore, the navigation that is necessary to maneuver the interactive elements that are available in Drive Mode, do not require more than one press of a button to access. Each button is mapped to a specific action as they do not need to move between several elements which would require the rider to look down for reassurance. Navigating in the system is designed to be intuitive and not contribute to high mental workload.

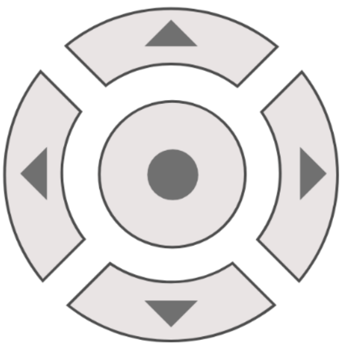

Figure 39. Illustration of the navigation logic in the system and keypad infotainment buttons.

Since the amount of functionality is limited while in Drive Mode, it also aids with helping the rider to remember what each button is mapped to and interact with the infotainment system without needing to look down for reassurance. If a headset is connected, the sound and voice feedback from the system could also contribute to additional reassurance.

System Feedback

To reassure the user and confirm that their intended action has been achieved, the infotainment system provides feedback to the user by utilizing visual-, tactile-, sound- and voice feedback with the purpose of creating increased trust to the system.

Visual Feedback

The interactive elements which are available during Drive Mode, are positioned strategically on the display to give visual cues and create coherence with the buttons if the rider would need to look down at the display for reassurance (see figure 40). For example, the Navigation element which is positioned to the right can be accessed by pressing and holding down the right keypad button and to turn off the Navigation. To play the next song the user would simply press the right button, the middle button to pause/play music and press left button to switch to the previous song.

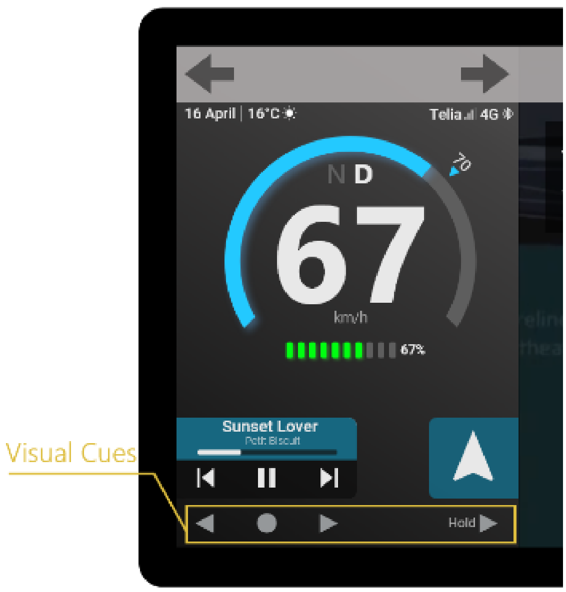

Figure 40. The dynamic section of the screen that shows visual cues for button inputs for music player (left) and for engaging with the navigation (right)

Visual feedback or cues for the up and down keypad button are not displayed until the rider interacts with it as it the up button would raise volume and the down button would lover volume. It functions much as the volume control does in a smartphone where it only shows up when engaged since the purpose is to minimize the amount of information being constantly displayed.

Tactile Feedback

The keypad infotainment buttons should be designed to give tactile feedback by providing tactile clues for each interacting button and making them unique so that the user can identify them without having to look down at the buttons.

Sound Feedback

When interacting with the infotainment system it is desirable to have access to sound feedback that an intended action has been executed. For example, after holding in the right navigation button which results in the GPS switches to the Navigation, it is desirable to hear recognizable sound that indicates that your intended action has been conducted without having to look down on the display. Concerning sound feedback for the music player, is desirable to get sound feedback when your phone becomes connected through Bluetooth or when your connected device has low battery left.

Voice feedback

When the rider has set a destination and has an integral helmet or headset connected via Bluetooth, it is possible to get vocal instructions for navigation and what turns to make to reach their intended destination. Other information could also be mediated through voice feedback such as traffic information and if the route has been updated due to an event. The voice and sound feedback ultimately aid with minimizing the amount of time that the rider needs to deter from paying attention to their surroundings to look down at the display. This is also enabled by the system providing sound feedback for confirming that button inputs have been registered.

7.4 Features & Functionality

The MotoRide infotainment system offers a variety of functions that are available exclusively available depending if the motorcycle is in Neutral or Drive mode. Switching between neutral and drive mode fulfill the purpose of limiting what functionality is available when riding (Drive mode) or standing still (Neutral Mode) from a safety perspective. An important limitation in the user interface is that the touch-functionality on the display is deactivated when the motorcycle is in Drive mode to hinder riders from engaging in unsafe usage. The keypad infotainment buttons are therefore optimized to enable the rider to safely engage with the available features when riding.

Starting MotoRide Infotainment

When the rider starts the MotoRide infotainment system, the display lights up to indicate that the system is starting and then the MotoRide logo is presented (see figure 40.).

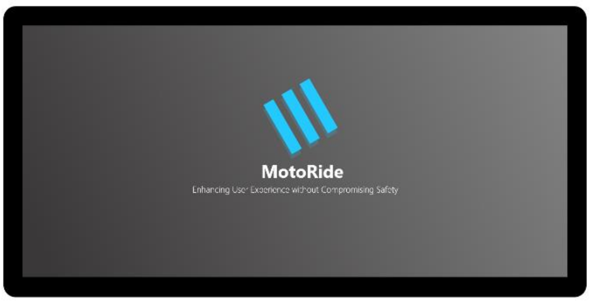

Figure 41. Welcome Screen when starting the motorcycle.

The final screen that is displayed to the rider before being able to interact with the MotoRide system is a warning screen that function as a reminder that they should be mindful of how they use the infotainment system. If it is the first time someone uses the motorcycle, then it will also be mediated regarding the limited functionality when in Drive mode. The user is also recommended to read the owner's manual for more information.

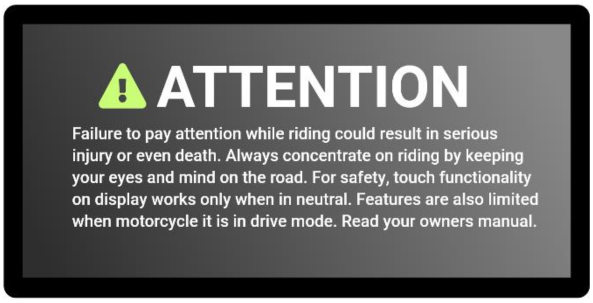

Figure 42. Warning Screen which serves as a reminder for the rider.

Neutral Mode

When starting the motorcycle, the motorcycle is automatically in neutral mode and the rider is restricted from accelerating the motorcycle. The rider has access to more functionality in neutral mode than in drive mode since there are lower requirements in terms of aspects such as attention and amount of mental workload that can be handled when standing still compared to riding. While in neutral mode, the rider will be able to navigate through the main menu and access high level functionality such as changing settings that otherwise would be considered dangerous. The three different screens that the rider has access to when standing still is the quick menu, main menu and finally the dashboard. The dashboard will be the main screen which is seen when in drive mode, however what is available is adapted compared to when in neutral which will be explained later.

Quick Menu

The quick menu is the first interactive screen that the rider is met with. The quick menu is designed to offer easy access to the most desirable features: navigation, playlists and contacts (see figure 43).

Figure 43. Quick Menu screen

The reason for having shortcuts specifically for contacts (to make calls), changing playlists and setting destinations is because they were considered the most desirable to have access to quickly when in Neutral mode as these features are not available in Drive mode. If the rider would want to access these features, they would have to make a stop and set the motorcycle switch to Neutral mode. This is to prevent scenarios where riders are distracted with interacting with high level features when e.g. stopped at red lights, as they would still be in Drive Mode. The only interactive features that are available in Drive mode is only being able to receive calls, raise/lower volume, pause and change songs within their current playlist and switching on/off the navigation for the last set destination.

As seen in the quick menu, they would also be able to access the main menu or go to the dashboard. The design of the quick menu is optimized to be interacted with either the keypad buttons or directly on the touch-display.

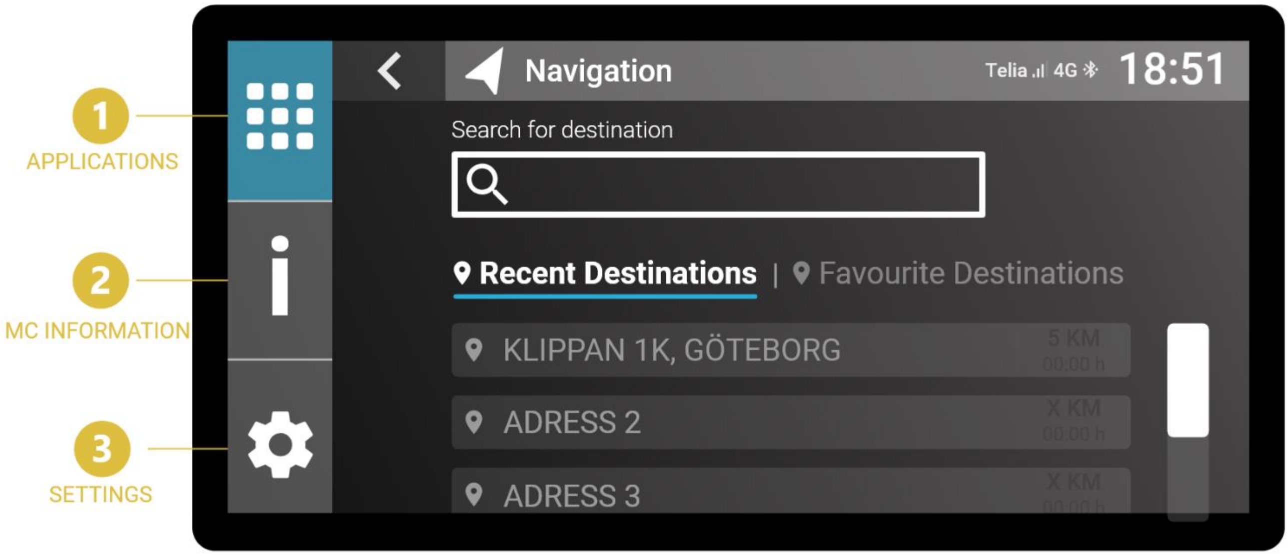

Figure 44. The navigation application opened in the main menu. To the left, the different sections of the main menu are highlighted.

Main Menu

In the main menu, it is possible to access (1) applications, (2) MC Information and (3) Settings. The main menu is designed to be optimized for navigating with both the touch-display and they keypad infotainment buttons (see figure 44).

Applications

In the applications section, the user can access entertainment- and information services that provide the functionality of navigation, music and phone communication. By accessing one of the available applications, the rider gets redirected to the applications main screen where the rider has access to broader range of options. What is seen in the figure (see figure 44) is when the application for navigation has been opened. This is also where the navigation shortcut in the quick menu would directly send the user to.

MC Information

The MC Information section provides the rider with access to various information concerning the motorcycle such ass battery status, instructions for the infotainment system and a digital manual for the motorcycle. By providing the rider with a digital manual, it also provides maintenance information and recommendations for how to efficiently use the and motorcycle.

Settings

The settings section offers the possibility of regulating all the relevant settings for the infotainment system such as settings for music, system feedback, internet and Bluetooth.

Dashboard (Neutral Mode)

After setting the desired destination, the rider would receive a route overview where a they could see a visualization of the route, the distance and estimated time to arrive (see figure 45).

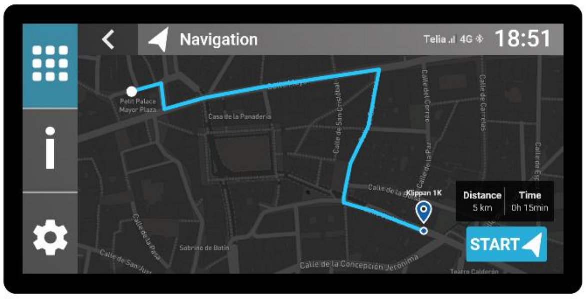

Figure 45. The route overview after choosing a destination.

After choosing to start the navigation, the rider is sent to the dashboard screen with the navigation initiated (see figure 46). The rider now has access to interact with the elements: (1) music player, (2) navigation/GPS and (3) quick menu.

As earlier presented, visual ques are positioned below the interactive elements to help guide the rider of what keypad infotainment button they need to press to interact with a specific element.

When the rider is in the dashboard screen and in neutral (4), the rider still has access to touch functionality and can still access the quick menu. They would not be able to start riding until the Drive mode is initiated.

If the rider feels unsure about having set the right destination for the navigation, the rider can examine if the right destination is set, distance and estimated time for arrival the (5). If the rider has paired headset or an integral helmet with the MotoRide infotainment, the rider will also be informed through voice feedback about what destination is set when switching to Drive mode to start riding.

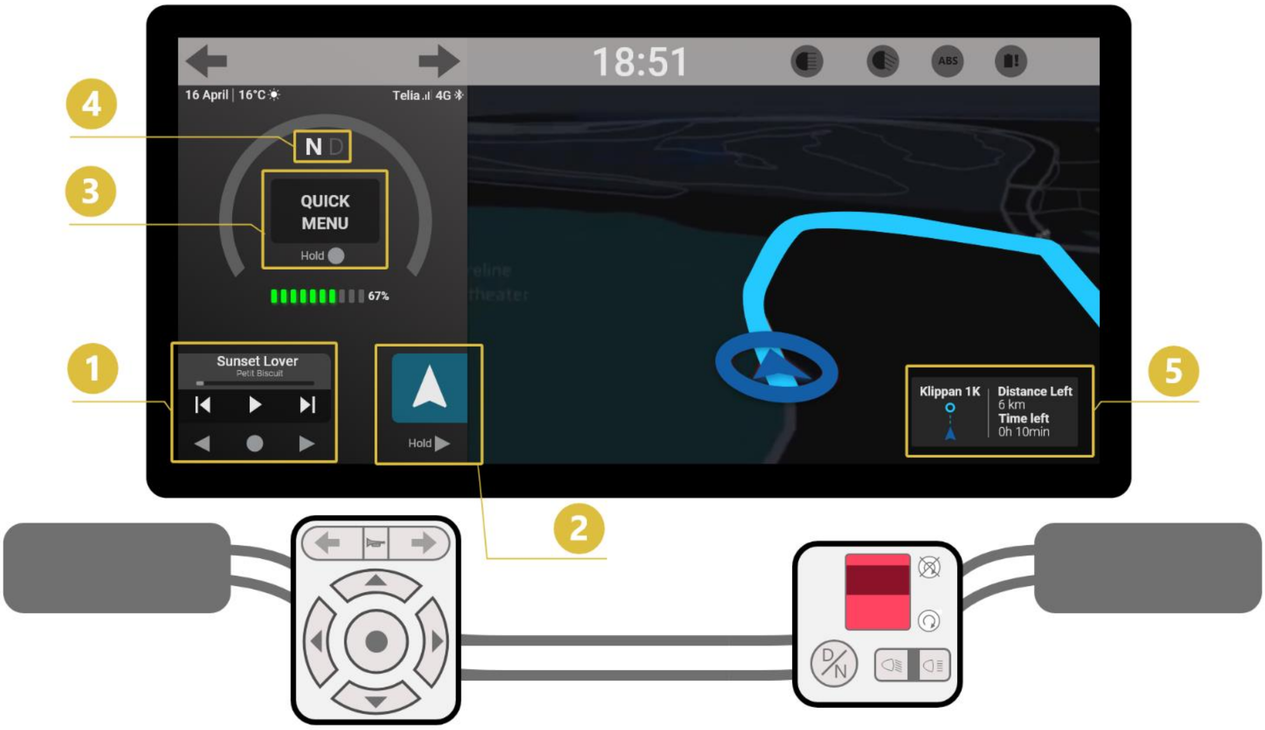

Figure 46. The dashboard in neutral mode. Also shows acess to the quick menu that can be accessed via touch functionality or on the keypad by holding down middle. Highlighted are different elements.

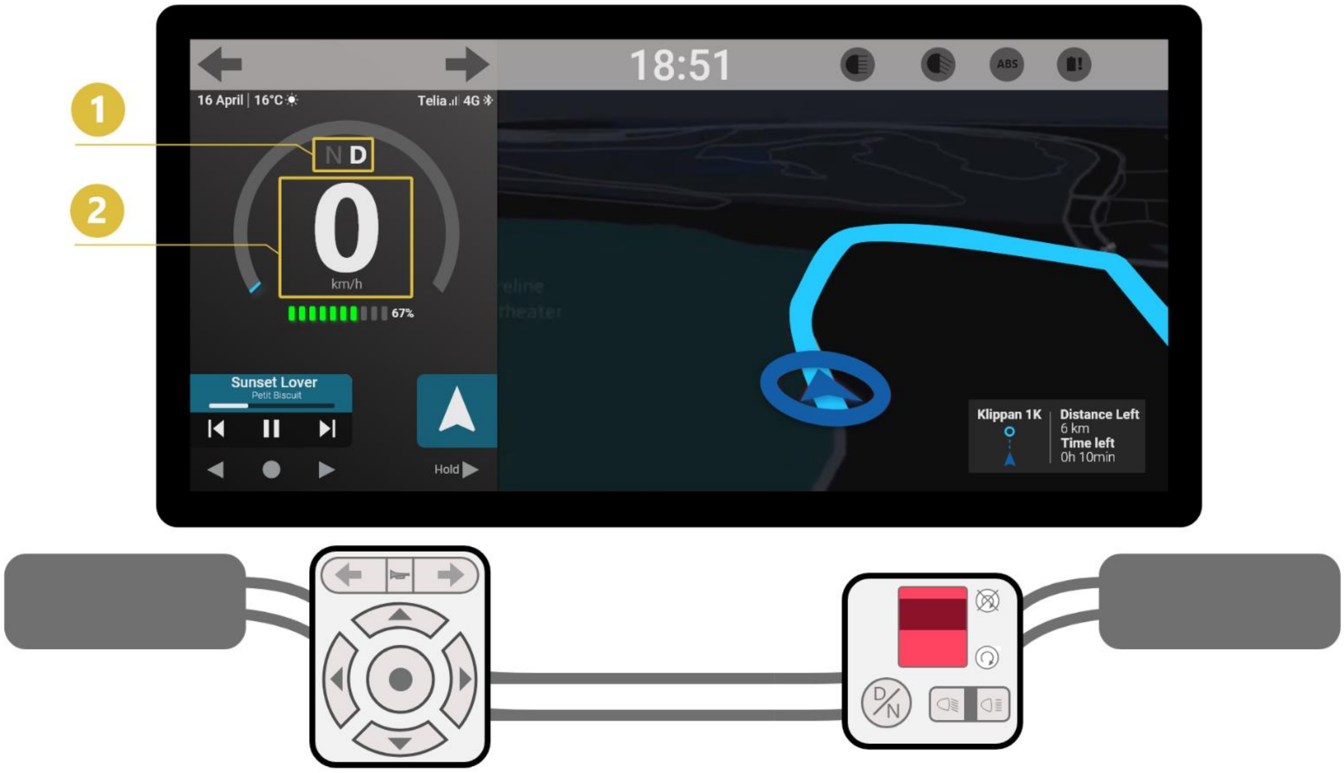

Figure 47. Dashboard changes when Drive mode is initiated. The rider no longer has access to quick menu and can no longer interact via the touch display.

Drive Mode

When the rider switches to drive mode by pressing the button from the other button configuration (see figure 47). The letter D from the (1) Drive mode indicator lights up and takes priority to indicate status. The interactive element (2) quick menu is now replaced by a number that mediates the motorcycle's velocity in the unit kilometers per hour (depends on country). The Quick Menu would no longer be able to be accessed in Drive mode.

While the MotoRide system is in Drive mode, the touch functionality is disabled, and the user has only possibility interact with the music player, navigation or GPS and answer phone calls (which will be presented later). Quick Menu can no longer be accessed until motorcycle is set back in Neutral.

The dashboard consists of three sections: top section, dynamic section and Navigation/GPS section. See next page for detailed information about each section.

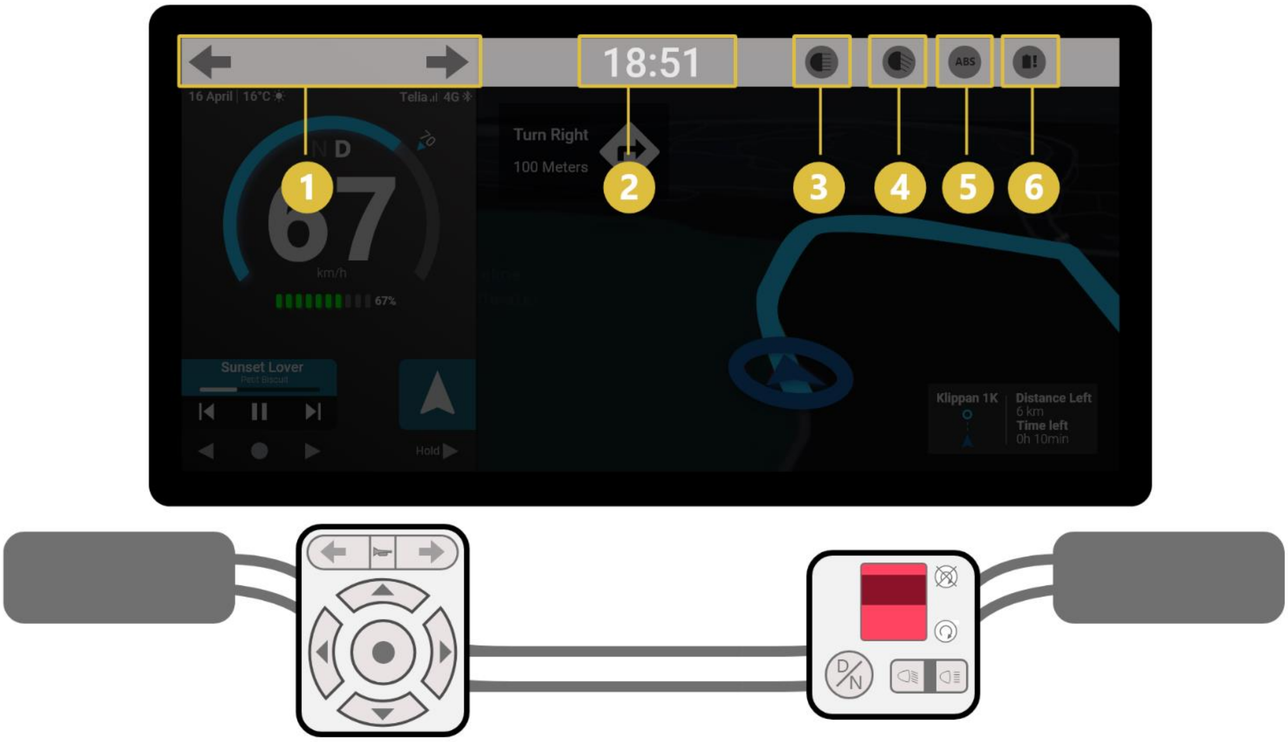

Figure 48. Dashboard in drive mode and the motorcycle is going at 67 km/h. Focus in this illustration are the telltales in top section.

Top Section

The top section consists of the visual elements (1) blinkers, (2) digital watch, (3) main beam, (4) half beam, (5) ABS and (6) generator or battery malfunction (see figure 48). The elements, also called telltales, are represented with descriptive icons in the middle of the telltale that glow when active. In the scenario that a function is not on, the telltale blends in discretely and do not take as much attention. To inform the user that everything is working correctly with the motorcycle, all telltales light up for a second when the motorcycle starts.

Blinkers

The blinker telltales fill the purpose of mediating information about turning right or left depending how the rider interacts with correlating buttons.

Digital Watch

The present time expressed in digital format.

Main Beam and Half Beam

The main- and half beam are regulated by the Button dedicated for switching headlights on the right control lever. When the motorcycle starts, the half beam lamp is standardly turned on as well and the half beam telltale indicates that the front lamps are working correctly.

ABS

Informs that ABS-system is currently working.

Generator or Battery Malfunction

The telltale for battery/generator malfunction informs about issues related to the battery and hub generator.

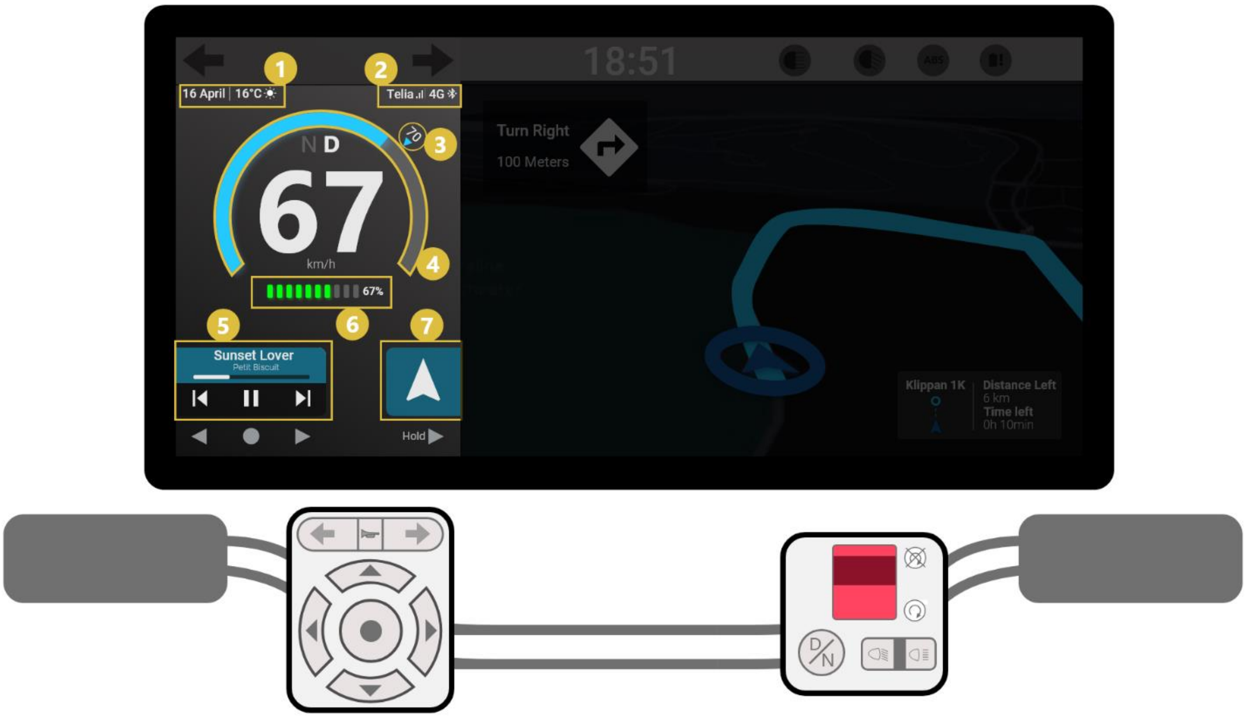

Figure 49. Dynamic Section with highlighted elements.

Dynamic Section

The dynamic section contains the interactive elements that can be controlled with the infotainment keypad buttons (see figure 49). The interface elements consist of (1) present conditions, (2) connectivity, (3) speed limit, (4) speedometer, (5) music player, (6) battery level and (7) navigation/GPS. While the MotoRide system is in drive mode, the functionality of phone communication is limited to only being able to take or decline calls.

Present Conditions (1)

Present conditions display information about current circumstances with regards to date, temperature and weather. The weather is presented by a distinguishable icon, the temperature is presented in the unit Celsius (depends on country) and the date is presented by current day and month.

Connectivity Information (2)

The rider can pair their device, headphones and integrated helmet to extend what functionality is accessible. Connectivity cues consists of Bluetooth pairing icon that mediates whether devices are paired, access to internet and relevant information regarding the connected phone which entails signal strength and phone operator.

Speedometer and Speed limit (3 and 4)

The speedometer is visualized by numbers that represent the current speed and a dynamic figure that displays how the speed changes due to acceleration in relation to the maximum speed.

Figure 50. Exceeding the speed limit.

The dynamic figure that displays how the speed changes due to acceleration, changes color if the rider drives above the present speed limit (see figure 50). The speed limit (in this case 50 km/h) is illustrated by an arrow and number that changes position on the dynamic figure depending on what GPS location is present in the area where the motorcycle is.

Music Player (5)

The music player has a minimalistic design with interactive elements (see figure 51): pause (middle keypad button) play (middle keypad button again), next song (right keypad button), and previous song (left keypad button). If the rider wants to adjust the volume, they would use the up and down button. That will initiate the visual feedback of a volume bar (see figure 51) much like it does on a smartphone (as earlier mentioned).

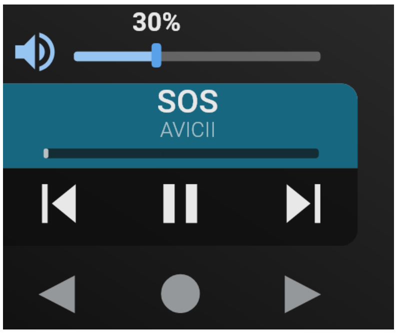

Figure 51. Volume bar that shows up when engaging volume control with up and down buttons.

Within the music player, it is shown what song is currently playing besides a music icon to more clearly highlight the current song. The music is accessible through internet. Since the user can pair their phone through Bluetooth, it provides them the ability to directly stream their music. As mentioned before, if the rider would want to change the playlist while riding, they would have to make a stop and switch to neutral. Switching between playlists would require screen real estate and would not be safe to toggle between long lists as it also would require the rider to look down and would require too much attention and interactions.

Battery Level (6)

The battery level is visualized by a set of green bars that consists of ten grey rectangles which are filled up with a specific amount depending on how much battery is left.

There is also a percentage available to the right of the set of bars to inform the rider about exactly how much battery is available. When the motorcycle has 20% battery left, the green color changes to red to warn the rider of battery status (see figure 52).

Figure 52. Visualization of low battery level.

The percentage text can be changed in settings to show possible distance left that the remaining battery would suffice for.

Phone Communication (7)

The infotainment system gives possibility to access phone communication if a smartphone is paired via Bluetooth as the system becomes an extension of the phone. As earlier mentioned, the rider can only receive calls while in Drive mode. The reason for that limitation is the same reason for limiting the rider from changing playlists. It would require the rider to look down and toggle between contacts in a long list. This only provides more reason for being distracted and is also considered a high-level feature.

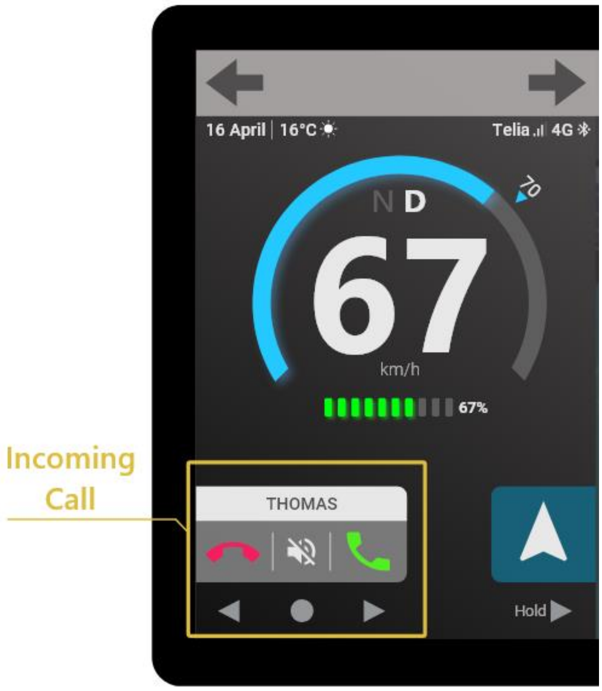

Figure 53. Incoming call taking priority over music player.

When the rider is receiving a call while driving, they can choose to answer by pressing on the right keypad button, decline call by pressing the left keypad button or mute the call by pressing the middle button (see figure 53). Receiving calls takes priority over the music player visually on the display but it would however also be ringing if a headset is to mediate that someone is calling. The visual elements that appears for incoming calls consists of three interactive elements where a horizontally positioned red phone indicates decline call, a mute icon indicates mute and a 45 degree vertically positioned green phone indicates accept call. Above the icons it appears which contact is calling or what number is calling. The visual cues for interacting with calls are the same as when the music player is present. The purpose is providing continuity which increases the intuitive and safe use.

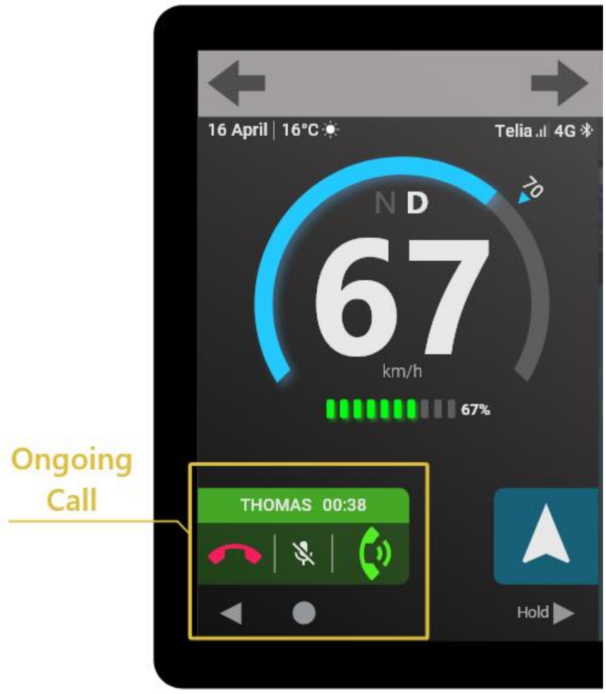

Figure 54. Ongoing call.

If the rider chooses to answer an incoming call, the green icon becomes replaced by a new green phone icon that is still green but is now totally vertical and has signals emerging from the phone to illustrates that a phone call is ongoing (see figure 54). In addition to a change of icon, a new text emerges to the right side of the name that shows call duration time. The grey color behind the information of who is calling or what number is calling changes to green to further indicate that a call is active. After the call has ended or been declined with the left keypad button, the music player emerges again visually, and the music starts playing from where it stopped before the call.

Navigation & GPS Section

The navigation is used to take the rider from present position to desired destination. The rider can choose or write their destination by accessing the navigation tab inside the menu when standing still in neutral mode.

When the navigation is on (see figure 55) it is possible to get voice feedback of turn by turn and visual instructions on the display to inform the rider of how they should drive to reach their intended destination (turn by turn). The navigation screen also presents information of what destination is set and how much distance and time is left to reach the destination. The navigation is designed to simplify driving by offering real time information about present traffic situation and giving suggestions on alternative routes to avoid traffic jams.

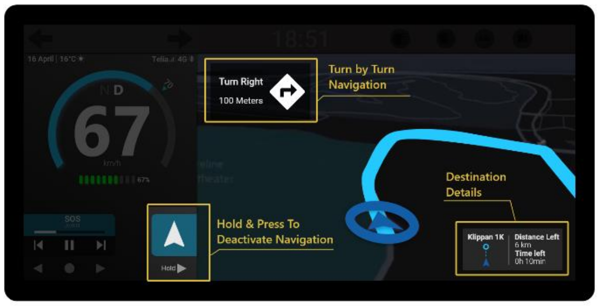

Figure 55. Navigation details.

If, however the rider would like to deactivate the navigation by pressing and holding down right button on the keypad. The GPS will then stay on as default and is used to display the current position and show information of charging locations that are nearby (see figure 56). The GPS is intended to be used for driving casually and making spontaneous stops to interesting locations that are nearby. If the rider would want to activate the navigation for their last set destination again, they would simply press and hold right keypad button again (see figure 56).

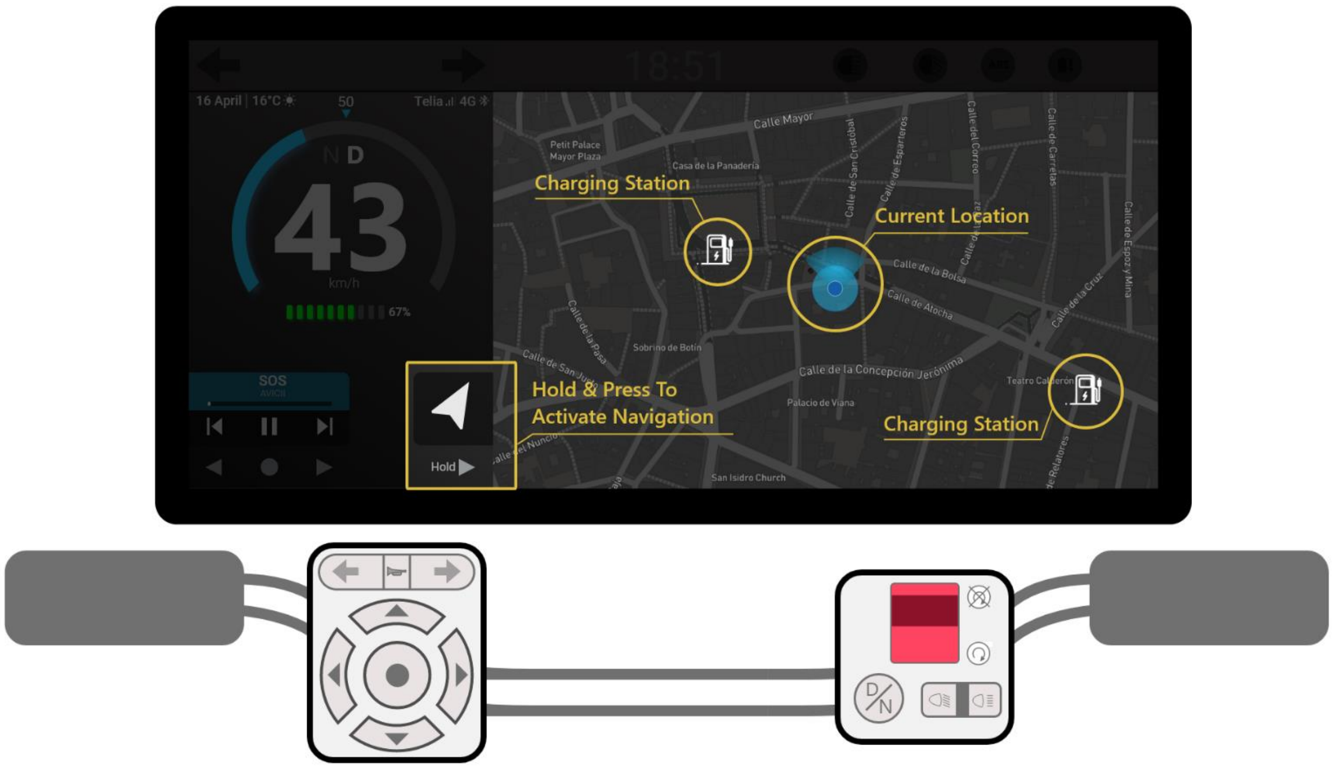

Figure 556. Shows GPS which is set as default if navigation is not activated.

8

DISCUSSION

This chapter presents the discussion revolving the project contributions, method & process, results, relation to the literature review and presented are also recommendations for future work.

8.1 Aim and Project Goals

The project aim has been achieved by addressing the two stated research questions in the introduction. The two research questions stated were:

RQ1 - What are the requirements and user needs for an infotainment system being designed for an electric motorcycle which is mainly used in urban cities?

RQ2 - How should an infotainment system be designed for an electric motorcycle so that the identified requirements and user needs are fulfilled, and in turn also heighten the user experience without compromising safety?

Both research questions were addressed by fulfilling the two project goals. The first research question was addressed by combining the gained theoretical knowledge and the empirical data with the framework as a guideline. With this, a relevant and focused research was conducted to define requirements and user needs for a motorcycle infotainment system. The second research question was however not completely addressed until the end of the iterative concept development process where the usability tests resulted in an infotainment system concept that aimed to provide a balance between heightened user experience and safety.

Ultimately, by fulfilling both project goals, guidelines have been provided for how to approach designing an infotainment system for an electric motorcycle which is meant for urban commuting. The first goal was fulfilled with the infotainment design guidelines that defined product requirements and desired features. The second goal was fulfilled with the final MotoRide infotainment system concept which is a concrete example of a concept that embodies the defined requirements and the most desired features.

8.2 Method & Process

This section discusses how the project demarcations, chosen methodologies and process for finding and synthesizing research and empirical data have influenced the project and intends to provide insights that can be useful for similar projects.

Project Demarcations

Setting the demarcation of defining an MVP has been an essential factor to the final concept. As the stated in the project demarcations, time was a limiting factor for this project. Therefore, one specific feature that was not included in the MVP and had an enormous impact on the result, was the choice of not including voice command in the final concept. As the priority was to design a concept that prioritized features that heightened user experience while enabling safe interaction between the user and the infotainment system, there would not be time to design the implementation of voice command and test it. The expectations of the number of features would also increase drastically as the users would expect access to a lot more features. A well-developed voice command system (voice assistant) would at an assumption have an immense positive contribution to the user interface as a complement if developed correctly and it would work in an optimal way where users trust it. However, developing a voice assistant is not a simple task and Polestar 2 choosing to implement Google's Assistant instead of developing their own is a strong indication of that. As presented in the results of the user research, people do not usually trust the voice command to work and would rather prefer a keypad as a main input device if they had to choose one user interface. Which is also a contradiction to the fact that they would also expect more functionality if it was available. As time was a limiting factor in this project, it would be difficult to design voice commands and test them. The likelihood reaching an incomplete concept would increase which would contradict the second project goal of producing a holistic infotainment design concept that has been tested and evaluated together with users.

Framework

The framework aimed to provide knowledge in relevant areas and to provide the reader with insight and understanding of the project which was considered to achieve the project aim. It expanded the knowledge base and the empirical findings could be contextualized which led to infotainment design guidelines that were relevant and based on research proven research. The framework was very important as the market for infotainment system for motorcycles was rather limited and specific research on using an infotainment system while riding specifically a motorcycle could not be found. By reviewing literature on aspects that were identified to affect riding a motorcycle and operating an infotainment system simultaneously, it provided a compass for what needed to be considered throughout the project.

Concept Development and Usability Tests

All the participants in the usability tests were respondents of the questionnaire and the majority of those that responded also signed up for participating in interviews and usability tests. The majority of those selected to participate in the tests had over 4+ years' experience of riding PTW:s. This could have influenced the results from the usability testing as they would be more confident as they had more experience of riding and would probably be able to multitask more easily while riding, which could have influenced their feedback. In afterthought, it would have been a good idea to include more novice riders to accommodate for the potential parts of the target group (urban commuter) that did not have MC rider's licenses and evaluate if the feedback the MotoRide concept would vary.

The tests were performed in controlled environments and if a more realistic use scenario could have been created, it would have been optimal to test a live and functional prototype on a moving motorcycle. Evaluations could have been made of how users would behave and manage to finish user tasks while riding an MC and having to pay attention to other things as well. Overconfidence in how participants think they would be able to use the system in a real scenario might have occurred since the they were never really put in any real danger. This can be correlated to the assumption that people tend to take more risks when there are low costs. The participants were however quite considerate to the rather limited test environment and tried to be rational and objective in their feedback.

Even though the design approach was to scale down the infotainment system as much as possible to compensate for the lack of a realistic test scenario, it cannot be fully evaluated and confirmed that it is the most optimal suggestion for an implementation. The concept has however provided clear guidelines for what a final implementation should strive for and it is based on the feedback and design implications from the usability tests. Given that the allocated time for creating an HMI concept was limited, it was decided that the four design iterations would form the outline for the entire prototype development process in the Deliver phase. The way of reassessing, evaluating and setting new goals by the end of each iteration helped the authors take the development process forward rapidly. Despite the time limitation, the use of design iterations was successful in helping to adapt to feedback from the usability tests and iterate the prototype. By the last design iteration, the prototype had reached the desirable status where participants could understand all elements and navigate through it, without needing explanation.

Infotainment Design Guidelines

The process of creating the infotainment design guidelines was iterative by nature. By summarizing the findings from theory, market research and user research, the authors managed to create a first draft which consisted of first identified product requirements and user stories. By analyzing the insights gained throughout the iterative concept development and usability tests, it was possible to synthesize it into updated and even new infotainment design guidelines. The conclusion of the infotainment design guidelines at the end of the discover phase was revised by adding new empirically based requirements. This process gave the authors the possibility to create a finalized set of infotainment design guidelines which both has theoretical and empirical weight. The usability tests aimed to investigate how users understood the prototype and ultimately try to emulate to them using it while riding in real time and in a more realistic scenario. Therefore, further and more realistic testing would be necessary and more empirical data would be good to validate the prototype on another level.

8.3 MotoRide Concept

The MotoRide infotainment concept was the result of identifying patterns in the findings from theoretical findings and empirical findings which were then synthesized. The design implications that were identified during the usability testing was a major contributing factor for refining the prototype and understanding how users related to it and how they thought they would behave in relation to the infotainment system in more realistic scenarios where their safety would be on the line.

A big aspect of the MotoRide infotainment system has been to scale down the amount of information, features and interaction possibilities to maximize safety and finding a good balance in relation to users' expectations and the provided user experience. Considering the individual factors described by theory (see 2.2.1 Level 1 - Individual Factors), the goal is to reduce human error, increase productivity and enhance safety and comfort with a specific focus on the interaction between the human and the system. The individual factors which has been clearly noticeable during usability testing was the factors considering attention, memory, automaticity and user goals. The Motoride concept has aimed to reduce the need of straining the user in terms of paying too much attention to the display and removing the need for remembering too many actions. By enabling simple interaction and navigating logic, users can achieve their goals by using a system that builds automaticity. This in turn also impacts how the user is affected (see 2.1.2 Level 3 - System Design and User Interface) in terms of stress and cognitive workload. By minimizing features and information available, the user's "responsibility" is lowered as they would not have to worry about more features. That burden is removed by offering a scaled down infotainment system which according to the usability tests, have shown to not have a significant negative impact on user experience. The contribution to the safety aspect was appreciated by the participants in the usability tests as their safety and how they would behave in traffic was taken into consideration.

By minimizing the need for paying attention to the display for reassurance, the rider is put in a better position to still have access to desired features and pay the same attention to the road. In this way, the aim is to put them in a position where they can maintain situation awareness more efficiently (see 2.1.3 Level 3 - Contextualization of Dynamic Environments). As stated there, the time necessary for glancing on the screen to perform an action should not exceed two seconds for automobiles which in turn has for served as a guideline for this project. The assumption was made that the glance time for performing an action on a motorcycle infotainment system should not only aim to not surpass the two seconds but aim to reduce it as much as possible since the conditions when riding a motorcycle are very different. Firstly, the motorcycle rider has much more to pay attention to that a car rider does not, such as placement on lane and turning head to get a clear view of what is happening around them. Secondly, the consequences of a resulting accident is more likely to be more severe for a motorcycle rider as they are not protected in the same way. Therefore, the recommended glance time should be reduced heavily compared to cars, especially for urban traffic.

Discussing how the behavior of the riders is affected, one can argue that interacting with the display is encouraged since the option to engage it is available. However, statistics and empirical findings implied that many motorcycle riders chose to engage with their smartphone while riding their motorcycle due to the need of certain functionalities. Therefore, the aim of the MotoRide concept is to provide a safer option. However as presented in the framework (see 2.1.4 Level Four - Driving Culture*)* people will more likely engage in risky behavior if they expect that the costs are low. Therefore, it is important to implement indicators within the infotainment system to "remind" the user to be mindful and careful. The warning screen that has been implemented in the final prototype is one measure to increase the rider's awareness and to encourage them to be mindful. The implementation of the speedometer turning red in the display if the rider is going over the speed limit, is another example of that. According to the theory on riding behavior presented in the same level as well, is that motorcyclist also tend to take more risks in general in relation to the joy of riding. Adding an infotainment system to that could be dangerous if not considered thoroughly. Implementing an infotainment system only for the sole purpose of replacing a smartphone is not enough as it needs to be adapted to the users' needs and the conditions of riding a motorcycle. It could be even more dangerous to implement an infotainment system that just provides a lot of functionality without considering how it would relate to riders.

Societal, Ethical and Ecological Considerations

Regarding the ethical considerations, argument could be made that it would be safer to not use an infotainment system at all no matter how much safety is considered when designing one. However, even if that is a valid argument, this project has shown that people turn to other alternatives that are not optimized, such as using their smartphone. The MotoRide prototype aims to provide an alternative to a smartphone which provides functionalities that urban riders would expect and thus, the need for using their smartphone would be removed. This project has also used an electric motorcycle as a reference for developing an infotainment system concept. Implementing an infotainment system on electric motorcycles might increase their appeal and in extension encourage the use of electric transportation. This in turn can have great societal and ecological impact if people convert to electric transportation on a larger scale.

8.4 Recommendations for future work

To conclude the discussion, the following recommendations are provided for future work:

Testing MotoRide Concept in a more Realistic Scenario

With regards to the limitation in the testing environment, what can be guaranteed, is that no more features or information should be implemented until a more realistic test scenario has been created where riders can interact with the final prototype while riding. The MotoRide concept can serve a purpose of a baseline that can be used as a reference that can be developed further based on the feedback that could potentially be provided by such tests. More realistic user tests might even imply that users could cope with remembering more button combinations and being able to use more functionalities without looking at the display for reassurance. There is room for evaluating the learning curves in with increasing the amount of functionality (without voice command implemented).

Physical Keypad Design

The physical design of the keypad has been outside of the limitations of this project, however this would be a very important aspect of developing the MotoRide concept further. Combined with defining exactly how the buttons would be designed and their capability to be used with gloves must be evaluated as the tactile feedback have been expressed as being vital for providing trust for the users and enabling safe use without them having to look down for confirmation. Based on the design of the keypad and their relation to other buttons such as blinkers, horn, neutral/drive, half/main beam and Killswitch should be evaluated in a more realistic scenario as well.

Firstly, the thing that would need to be addressed is building a physical keypad that is connected to the final prototype to test it with real time feedback, as the method of testing in this project was lacking in this area. Other aspects are that the keypad needs to have distinctive buttons, be tactile and provide clear feedback. Especially since motorcycle riders usually use with gloves due to high wind conditions and the resulting cold environment.

Implementation of Voice Command

Once the MotoRide Concept is validated, an evaluation should be made regarding testing and implementing voice command and what level of functionality would be required for users to trust it. As identified in the empirical findings, users in general not trust voice command systems and would rather rely other interfaces. However, if a well developed and tested voice command would be implemented correctly, it would have an immense contribution to the user experience, enable more functionality and in turn also heighten the safety as users could almost perform most actions without even having to look down. This would however require a level of performance which enough trust, for the users to completely rely on it. However, a prerequisite would be that the users have access to the hardware required (headset or integral helmet) to translate the voice input into expected outcome in the system.

9

CONCLUSION

Even if there were other options of motorcycle infotainment systems on the market, they were still considerably limited with regards to alternatives. This also implied that the development of this market is in its initial stages and there are no clear standardizations. However, with the increasing dependency of being connected and the smartphone functionality that that riders have started to expect to have access to, more research should be conducted to evaluate other suggestions for how an infotainment system for an urban motorcycle could be developed as well. As it has been discovered in this project, many riders turn to using their smartphones while riding since there are lack of desirable alternatives.

The Motoride prototype addressed the project aim by fulfilled the project goals which entailed providing guidelines for how an infotainment system should be designed for an electric motorcycle that is meant for urban commuting. Some of the identified requirements in the infotainment design guidelines are unquantifiable which means that those can only be strived for, however the requirements that were set to be quantifiable, should be fulfilled in a final implementation. Even if the MotoRide concept was designed for the identified target group in this project in terms of user experience and providing desired features, the concept is still based on the needs of motorcycle riders and the complete list of user stories in the can serve as a catalogue to choose from when developing a concept. The MotoRide Infotainment is just one example of how to design an infotainment system that aims to satisfy urban riders and keep them safe at the same time. Ultimately, the infotainment system design guidelines together with the final prototype, still provides a synthesis of what is expected from riders in terms of user experience and safety, no matter the urban motorcycle an infotainment system is being designed for.

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APPENDICES

Appendix A: Expert - Interview Template

What are common mistakes many people make in urban driving with MC?

What critical moments exist in urban driving? What is different from driving a car, what more do need to you need to think about?

Is there something missing in today's motorcycles? What could be added to provide a safer and better driving experience?

Have you identified any trends or technologies that are interesting?

What is an Infotainment system?

What do you think of the possibilities of implementing an infotainment system on motorcycles? How would it look like? What needs exist?

What problems could an infotainment system bring?

What are your thoughts of an electric motorcycle?

What are the best ways of interacting with a motorcycle that has an infotainment system?

Who would be interested in using an infotainment system on an electric motorcycle?

Do you have any recommendations on what we should take into consideration during the product development process?

Other questions or final remarks?

Appendix B: PTW Riders - Interview Template

What mistakes have you done or have heard about other doing when driving MC in urban areas?

What critical moments exist in urban driving? What is different from driving a car, what more do need to you need to think about?

Is there something missing in today's motorcycles? What could be added to provide a safer and better driving experience?

Have you identified any trends or technologies that are interesting?

What is an Infotainment system?

What do you think of the possibilities of implementing an infotainment system on motorcycles? How would it look like? What needs exist?

How do you use your smartphone or other device when driving your motorcycle? What functions from the devices do you use?

What are the best ways of interacting with a motorcycle that has an infotainment system?

What problems could an infotainment system bring?

What are your thoughts of an electric motorcycle?

Who would be interested in using an infotainment system on an electric motorcycle?

Would you be interested in buying an electric motorcycle that has an infotainment system?

Other questions or final remarks?

Appendix C: Complete User Story List

User Stories				
Feature	Who/What/Why	User Perspective (Must/Need/Nice)	Fullfillment according to Project MVP	Comment
Information				
GPS	As a rider, I want to receive information regarding my current position so that I where I am currently.	Must	Yes	
Navigation	As a rider, I want to recieve information regarding how I can get to my destination so that i navigate myself.	Must	Yes	Furthermore what information users need in correlation to navigation is: - *Turn by turn* - *Distance to arrive* - *Time to Arrive*
Turn by Turn (Navigation)	As a Rider, I want to receive turn by turn information so that I receive additional help for reaching my destination.	Need	Yes	
Mediate Telltales	As a rider I want to have acceess to information about the current telltales to manuever the motorcycle in a safe manner	Must	Yes	
Mediate Speed	As a rider I want to have acceess to information about the current current speed to manuever the motorcycle in a safe manner	Must	Yes	
Mediate Battery Level	As a rider I want to have acceess to information about the current current battery level so that I can adjust my driving	Must	Yes	Furthermore what information users need in correlation to navigation is: - *Travel distance left* - *Battery % left* - *Driving time left?*
Current Time	As a rider I want to see the present time so that I can relate to the time of day and plan thereafter	Must	Yes	

Trafic information	As a Rider, I want to recieve trafic information so that I can avoid ques and get to where I am going faster	Nice	Yes	
Location of charging stations	As a Rider, I want to know where I can charge my MC so that I dont run out of battery	Need	Yes	
Date	As a rider, I want to be able to see what date it so that I can adjust my planning.	Nice	Yes	
Information on weather	As a Rider, I want to recieve information regarding weather so that I can adjust my travels if necessary.	Nice	Yes	
Cover MC blind spot	As a rider, I want assistance with covering my blind spots when I am in traffic so that i can drive more safely	Nice	No	This would be connected to if hardware and sensors are implemented to provide this. In that case, the user would want to recieve that information in a unintrusive and intuitive way.
Collision Warning	As a Rider, I want to be warned if I am close to a collision/dangerous situation so that I can avoid it	Nice	No	
Find my MC	As a User, I want to be able to locate my MC remotely with my smartphone so that I can find it if I dont know where it is	Nice	No	
Travel and Battery Planning	As a Rider, I want to make longer trips without having to worry about battery running out	Nice	No	
Distance Keeping (Indicator)	As a rider I want to have assistance for keeping distance to other vehicles so that I can drive more safely	Nice	No	
Information on Braking Distance	As a Rider, I would like to be able to know what the braking distance would be according to the	Nice	No	This would be connected to hardware and sensors that are implemented to provide this. In that case, the user

	current speed and road surface			would want to recieve that information in a unintrusive and intuitive way.
See Behind without using mirrors	As a Rider, I would like to have the ability to see behind me when I am driving without using rear mirrors or turning around	Nice	No	This would be connected to hardware and sensors that are implemented to provide this. In that case, the user would want to recieve that information in a unintrusive and intuitive way.
Entertainment (Media & Social)				
Communication Capabilities	As a rider I want to be able to access my phone's communication capabilities so that I can communicate with others.	Need	Yes	
Music	As a rider, I want to be able to engage with a music player where I can manage my music so that can adjust what I am listening to	Must	Yes	
Log travels	As a rider I want to be able to log my routes so that I can follow up on my driving experience	Nice	No	
Share Travels	As a rider I want to be able to share my routes so that I can connect with others and share my experiences	Nice	No	
General				
Bluetooth Connectability	As a rider, I want to pair my smartphone & headset to the infotainment system so that I have access to the functionalities they provide.	Must	Yes	This could be connecting their smartphone, to be able to acess compatible functions or connect their headphones to receive sound and a interface for talking
Regulate Sound Volume (For Information & Entertainment)	As a rider I want to be able to regulate the sound volume for the infotainment system so that I can adapt volume to my needs.	Must	Yes	
Voice Command	As a rider I would want to have voice command so	Need	No	

	that I can navigate the infotainment system by using my voice			
Voice Feedback	As a rider I would want to have voice feedback so that the infotainment system can interact with me	Need	Yes	
Customization	As a rider, I want to tailor the infotainment system to my needs and preferences so that my experience is heightened	Need	No	
Translate apps from phone to infotainment system when paired	As a rider I want to translate apps from phone to infotainment system when paired ro have the same functionallity on the infotainment system	Need	No	
Minimise interaction with updates	As a rider I want to minimaly work with updating and upgrading the software and functionality because it is boring	Nice	No	
Help with Attention	As a Rider, I would like to be notified if I am not paying attention to the road so that I can drive more safely	Nice	No	This would be connected to if hardware and sensors are implemented to provide this. In that case, the user would want to activate/deactivate and recieve that information in a unintrusive and intuitive way.
Cruise control	AS a rider I want to be able to use cruise control to maintain my current speed so that I get assistance with my driving and can relax	Nice	No	This would be connected to if hardware and sensors are implemented to provide this. In that case, the user would want to activate/deactivate and recieve that information in a unintrusive and intuitive way.
Remote interaction with motorcycle	As a rider I would want to start some specific functions through a device so that I can interactio with my motorcyle on distance	Need	No	Would requaire development of an application that is accesable on different devices The user would be able to have access to start/turn off

				som functions as lights, music, from a device that is connected with the motorcycle It is also desirable to start and turn off the motorcycle
Internet Access	As a rider I want to have acess to internet my infotainment system so that I am connected	Need	Yes	

Appendix D: Usability Testing

The usability testing was done in a screened room where a participant and two group members were present. One group member was the test leader and had the responsibility of leading the testing and informing what the participant of what they should do. The other group member worked as a observer and took notes of how the participant performed and executed their tasks. The testing environment consisted of one computer with a digital prototype (1), an external screen (2), one computer used to take notes (3) and a controller used as a mediating object by the user (4) (see figure 57). The placement of the buttons on the controller were assumed to be placed on optimal positions to facilitate navigation in the system. However, this was just an assumption based on research conducted during the discover phase, which was to be evaluated in the usability testing.

Figure 57. Setup for conducting usability testing.

The computer screen (1) from the test leader was duplicated to the external screen (2) which the participant used to interact with the interactive prototype. The usability testing was conducted by doing wizard of oz with the participant. Wizard of OZ is described as a technique, were a researcher (the "wizard") stimulates system responses from behind the scenes, while a participant engages with a system that appears to be real (Hanington B & Martin B, 2012). The test leader would ask the participant a range of predetermined questions and the participant would then interact with the controller (4) and loudly say their actions so that the test leader would be able to create coherence between their intended actions and what was shown on the external screen (2). When conducting the usability testing, there was space for probing and get deeper answers for some questions.

Questions asked during the usability testing:

- What is a Infotainment system?

    - What would you like to do with such a system?
    - What do you want to do while driving?
    - What would you want to do while standing still?
- Can you describe what you see on the screen?
    - What is easy to understand and what is not?
    - Is there something that you feel is missing?

In addition to asking questions, the participant got the possibility of share their experience of navigating through a predetermined path through the system. They were asked to conduct to some specific tasks without having gained the information of how it exactly should be done. This was done to evaluate whether the system was perceived to be intuitive or not.

Tasks which the users were asked to conduct:

- Start and turn of the music player
- Play, pause, play next and previous song
- Raise and lower the volume of the music player
- Start and turn of navigation
- Answer an upcoming phone call and then cancel the call.

A final evaluation was done by asking the participants questions to try and understand their perception of the interactive prototype from a holistic perspective.

Final questions:

- How do you perceive the aesthetics of the system?
    - Can you perceive the difference between navigation and GPS?
    - Do you understand how the music player works?
    - Did the illustrations below the interactive elements help hint what you need to do to conduct an action?
    - Is there something that you perceive not making sense or is strange?
- What do you think of the concept,
- What do you think of the button layout?
- What did you like and what could be better?
- Is there something you would want to add or something that you would like remove?

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