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Automotive Cockpit Design 2020

Conceptual design of a human-machine interface for future automotive cockpits

Master of Science Thesis

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Göteborg, Sweden, November 2011

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The cover picture shows the final design of this study.

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Abstract

This study is aimed to develop the cockpit for the future personal vehicle by investigating technology trends and user needs. The study is made in cooperation with Mecel AB, which develops software and vehicle systems. The study outcome is aimed to inspire the Mecel team on the future Human Machine Interface (HMI), enabling them to think ahead and support their customers with state of the art technology. The outcome is also applied as promotional material to attract customers. The study identified current user needs and technical preferences toward HMI of personal vehicles while investigating possible technologies that can be applied to satisfy user needs. The reasonable predictions of user needs and mature technologies in 2020 are conducted based on a literature study and empirical data.

The thesis outcome is two in-car HMIs with focus on displays. The two cockpit conceptual designs are presented to explain the locations and features of the HMIs. The visual materials of the outcome are imported to the company website as promotional material. In the case of attracting Mecel potential customers, the visual material of the study outcome should be aesthetically pleasing to the target market.

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1 Introduction

1.1 Background

Mecel is an experienced company developing software and systematic solutions for the automotive industry. Mecel specializes in in-car communication technologies, human machine interface (HMI) development and consumer device interaction.

One of the products that Mecel develops is Mecel Populus suite. The study is cooperated with Mecel Populus team which develops the Mecel Populus suite. The Mecel Populus suite is a product that develops customized user interfaces for distributed embedded systems. As Mecel states (Mecel, 2010):

The Mecel Populus concept has several unique features compared to traditional HMI development. These features, when combined, remove the barriers that traditionally exist between the people working with requirements, system engineering, HMI design and implementation. An HMI is created and verified in Mecel Populus Editor without having to write any software. The HMI is then downloaded to the target environment where Mecel Populus Engine executes it. Mecel Populus has been designed for the automotive industry to deliver high performance user interfaces with short time-to-market and to enable efficient software life cycle management.

Information Technology increasingly develops over years. As software developer, Mecel always need to know how the future scene of IT industry will be. Developing conceptual HMI will inspire Mecel to think ahead and provide their customers state of the art technological solutions. The development of Mecel Populus Suite is ongoing. Mecel needs to know which features should be developed to make populous suite a competitive product. Nevertheless, which features should be developed is contingent on how cars and HMIs will be in the future. This study helps Mecel fulfill the challenge by developing innovative HMI concepts.

1.2 Purpose/Aim

The requirements to this study are to design HMI concept for personal vehicles in 2020, with a focus on the Western European market. Mecel requires more than one concept, corresponding different types of user groups. This study suggests standard user group and expert user group according to previous experience. The standard users represent the people who using personal vehicle for transport purpose while the expert user indicates the drivers who have abundant experiences and enthusiasm on

driving. Since these two user groups have different needs upon personal vehicle, it leads two design directions.

The study emphasizes on visualization of the in-car HMIs. Additionally, according to Mecel's requirements, the displays system and the relevant technologies have higher priority than others. The final designs will be presented on Mecel's website as promotional strategy. And therefore, the visualizations of the design should be appealing and communicate with Mecel's customers.

Rather than solve an existing problem, this study aims to explore the possibilities of personal vehicle in 2020 and create aesthetic visual materials. The outcomes of this study are to inspire Mecel with innovative concepts and attract potential customers.

During the project, this study engaged in answering the question:

-How could the HMI of personal vehicle be in the near future?

In order to clarify the research question, sub questions were listed:

-What features regarding user interfaces are available in the near future?

-How could the HMI of personal vehicle be used in the near future?

1.3 Delimitations

The study focuses on the personal vehicle field, so other vehicle types would not be considered. The target market is western European. The physical components of cockpit will be studied in a limit extent. Primary user of personal vehicle is studied while the study of secondary user, co-user and side user is excluded¹. Among the primary users, driver is the study focus. Front-seat passenger is studied in a limit extent. The study of rear-seat passenger is excluded.

1.4 Terminology

Human Machine Interface (HMI): Where the human and the machine (technology) meet.

User: A person who use a product.

Primary user: A person who use products for primary propose (Buur&Windum, 1995)

Standard User: A primary user who has knowledge of use and average use experience

Expert User: A primary user who has technical knowledge of product/system and abundant use experience

Touch Screens: Displays that able to receive input by touch of fingers

¹ Primary user, secondary user, co-user and side user are four types of users (Janhager, 2005).

1.5 Overview of the report

The report structure begins with the introduction of the thesis project containing the purpose and background of the project. Then the theoretical framework describes the theories and principles of the development. The theories and principles are the essential guidelines for conducting user study and HMI design. It followed by methods chapter where the methods used in each development phase are theoretically described.

The development process chapter describes the contents and the outcomes of each phase. In the pre-study phase and research phases, the content and outcomes of each method are described. In the design phase session, the design phase is divided into three stages, which are ideas generation, concept development and visualization. After that, the final design is especially illustrated in the final design chapter. It followed by the general discussions on methods, processes and the results. Then the general discussion leads to the conclusion where demonstrated general thoughts on the entire project.

2 Theoretical Framework

Theoretical Frameworks demonstrates the theories and principles, which conduct the project. The user-centered design is the general design principle for the two HMI. Activity theory is applied during the user study to identify user needs. Ecology interface design is assisted to address the functions and features. The visual design principle is the guideline for visualizing the concept.

2.1 User-centered design and Activity Theory

User-centered design aims to develop products that satisfy the user needs. The focus of user-centered design is to identify the needs of the user and provide solutions to fulfill the needs. In the user-centered design process, identify and describe user needs in most cases are the initial point, however according to Rexfelt(2008)'s research, it is concluded that needs are not easy to study. Nevertheless, by observing and analyzing human activity, needs could be identified when *individual seeks the satisfactions of the needs* (Karlsson, 1996). Frameworks and approaches, applying in the field of human-computer interaction, based on activity theory are developed to help identify human needs.

Furthermore, ISO 13407 (1999, p3) provides the description of human-centered design approach; it states the characteristics of a human-centered approach as:

1. *The active involvement of user and a clear understanding of user and task requirements*
2. *An appropriate allocation of function between users and technology*
3. *The iteration of design solutions*
4. *Multi-disciplinary design*

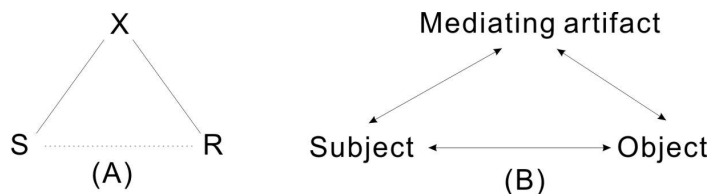
According ISO 13407, the three main activities of user-centered design are:

1. *Understand and specify the context of use*
2. *Specify the use and organization requirements*
3. *Evaluate designs against requirements*

Activity theory was developed by the Russian psychologists, Vygotsky, L.S., Luria, A. R. and Leont'ev, A.N. in 1920's. Activity theory is a clarifying framework for studying humans' practices as development processes. It has been applied to numerous science and technology fields. According to Activity theory, human react to the environment through mediation.

Activity is the unit in the activity theory. The basic triangle structure of an activity contains an object, a subject and an artifact (mediation) [figure 1]. A subject is a person or a group engaged in an activity. An object is held by the subject and

motivates activity, giving it a special direction. An object is transformed through the subject reacting and responding to the mediation, which could be tools, artifacts, and signs, etc. It is the factor that distinguishes one activity from another activity (Kuutti, 1995).



(A) Vygotsky's model of mediated action and (B) its common reformulation

Figure 1 Activity Theory

An activity is a hierarchy that contains an action or a chain of actions. An action contains an operation or a chain of operations. An activity can be described as a network of actions and operations that are guided by an object [Figure 2].

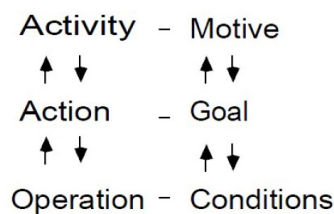


Figure 2 Activity Theory Hierarchy

Activity theory has been applied in human-computer interaction since 1980s. Activity theory allows HCI researchers study the context (Nardi, 1995). In the product development process, activity theory could be used to identify human needs and understand the context (Rexfelt, 2008). Bødker (1995) developed practical techniques to analyze video. Bødker gave a definition of “*good artifact that allows us to focus our attention on the real object*”. Breakdowns and focus shifts interrupted and/or increase the complexity of the original activity (focus shifts are not necessarily caused by breakdowns).

2.2 Ecological Interface Design (EID)

EID was developed involving different theoretical fields. It roots in a control engineering perspective that has been developed in Denmark since 1960s. Jens Rasmussen, Kim Vicente and other Risø researchers argued that the human operator took an important part of the reliability of the complex system. The interface design of a complex system needs to support three kinds of operators' behavior, skill-based, rule-based, and knowledge-based. Abstraction Hierarchy is a fundamental approach to analyze the environment and the work domain in EID. *Rasmussen and Vicente*

combined the analytical tool of the Abstraction Hierarchy with the insights of the SRK Taxonomy to develop an approach to interface design for complex systems where unanticipated situations were a reality (Burns & Hajdukiewicz, 2004,P 10). EID has been applied to develop nuclear power plant, transportation system, process control system, medical system etc.

2.2.1 Work Domain Analysis

Different from user-centered design, WDA begins with analyzing the environment rather than the user. It is crucial to define the system boundary including things the user want to control, must monitor and supervise and that interact with the user's work domain. Abstraction Hierarchy is a framework for understanding work domain constraints in a systematic way. It contains five levels to describe a work domain. The top level is the purpose of the work domain. The following levels are to answer how to realize the level above. The five levels of the abstraction hierarchy are:

Functional Purpose describes what the work domain was designed to do. It is different from the task that contains one or a series of actions that people do. A functional purpose is an attribute of a system or work domain. For instance, the task driving from A to B contains a series of actions that the user must perform. There are numerous of purposes of why a user drives from A to B. But for the car itself, the functional purpose is to transport people from A to B.

Abstract Function demonstrates the causal relationship underlying the work domain. In the actual work, abstract function describes the physical law that cannot be broken and the priorities must be achieved.

Generalized Function describes the processes to accomplish the priorities that described in the Abstract Function. In this level, the description is more concrete and closer to the physical description.

Physical Function means the various components of the work domain. In this level, the questions- what are the components, what are their capabilities and how are they involved in various processes-should be answered.

Physical Form describes the appearances of the work domain. It includes the size, shape, color, location, condition and material of the components.

The application of the work domain analysis and abstraction hierarchy depends on the actual work. It is not necessary to always use the five levels of hierarchy to describe the work domain (Burns & Hajdukiewicz, 2004).

2.3 Design Principles

Since the Users of vehicle HMI is persons who have driving permit within Western European countries, the HMI is designed for the persons who are visually able to drive. When design the user interface, the primary concern is to communicate with the end users by providing understandable message. Color and typography principles are followed to construct the visualization of designs.

2.3.1 Gestalt laws

Gestalt laws, as a common organization principle, used regularly in visual design(Graham,2008) [Figure 3].

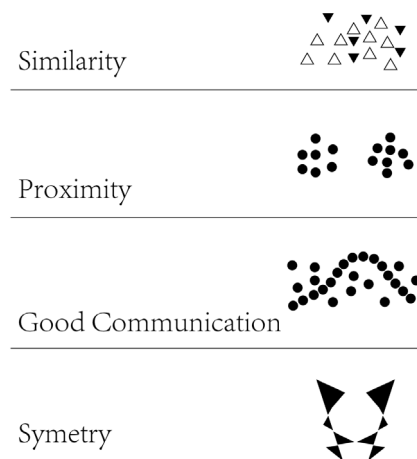


Figure 3 Gestalt Laws








2.3.2Color Principle

From safety perspective, the UI design should be recognizable and understandable under various environments. The color selections should consider western interpretations of color. The perception of colors are usually highly subjective, but when comes to work environment, certain principles could be followed.

2.3.2.1 Color –coding work environments

The US department of Labor’s Occupational Safety & Health Administration (OSHA) has developed guidelines for color-coding work environment (Visocky O’Grady, 2008)[Table 1]

Table 1 *Guidelines for color-coding work environment(Visocky O’Grady, 2008)*

Color		Meaning	Application
Safety Red PMS 1797 C		<i>Stop, Danger</i>	Signifies fire protection equipment, "danger" and "stop."
Safety Orange PMS 165 C		<i>Warning</i>	Signifies dangerous parts of machinery or electrical components which can crush, cut, or shock.
Safety Yellow PMS 124 C		<i>Caution</i>	Signifies physical hazards created by non-moving objects which can be fallen over or into, struck against, or between which one may be caught.
Safety Green PMS 341 C		<i>Safety</i>	Signifies areas and equipment associated with First Aid.
Safety Blue PMS 287 C		<i>Information</i>	Signifies safety information; used on informational signs and bulletin boards.
Black+White Process Black		<i>Boundries</i>	Signifies housekeeping and traffic areas.
Safety Purple PMS Purple C		<i>Radiation</i>	Signifies x-ray, alpha, beta, gamma, neutron and proton radiation.

2.3.2.2 Color Contrast

The Americans with Disabilities Act (ADA) provide a simple suggestion on color contrast. To make for the most legible message, 70 percent contrast an object and its background is the best (Visocky O’Grady, 2008).

2.3.3 Typography Principle

According to Nini(2006), the human vision declined as age raised. The typography used on HMI should ensure that the information is recognizable and understandable even it becomes blurred or in the dark environment.

The Americans with Disabilities Act (ADA) sets typographic standards for signage. It provides optimal body-width to height and stroke-width to height ratios for the use of

appropriate typefaces in signage systems. Compare to serif styles, sans-serif styles works better, due to the thin stroke, which serif styles usually have, would fall away (Visocky O'Grady, 2008)

3 Methods

This chapter theoretically describes the methods applied in the project. The described methods are system description, , SAM, personas and scenarios, image board and brainstorming.

3.1 System description

Numerous researchers have proposed the different definitions of system. Sanders and McCormick (1993) summarized that *a system is composed of human, machines, and other things that work together (interact) to accomplish some goals which these same components could not produce independently*. In a human machine system, human operators and users considered as one of elements interacting and communicating with other elements by transforming energy, matter and information. *An element could be physical, social or abstract*. Elements communicated with each other by transforming matter, information, or energy/force (Bligård L., 2011).

System Description is a method to visualize the human-machine system by identifying the system elements and their connections. It provides a holistic view for the designers to understand the human-machine system and its context. The outcome of the system description is a graphical system model that illustrates the elements and the connections. To make a graphical system model require four steps (Bligård L., 2011):

1. *Identify the element in the system*
2. *Describe the properties of the elements*
3. *Identify the connections between the elements*
4. *Make a graphical system model*

3.2 Emotional Test and Self-Assessment Manikin (SAM)

The Self-Assessment Manikin (SAM) is a non-verbal pictorial assessment technique that directly measures the pleasure; arousal and dominance associate with a person's affective reaction to a wide variety of stimuli (Bradley & Lang, 1994). SAM is used to understand the users emotional reflections upon each task. After the interviews of describing the steps of performing specific tasks, the interviewees are required to rate the pleasure, arousal and dominance scales .The ratings given by the interviewees helps to understand what are the users subjective emotions when performing certain tasks.

3.3 Contextual Observation

The observation aims to study the user context when one operates the system. Video camera is used to record the driving activity that the user involved. The video recording is analyzed, according to the approach described by Bødke (1995). The breakdown and focus shift are paid attention due to their causes are the potential misfits.

When analysis the video recording, the role of each function unit is identified to understand how users interact with the system in their actual use situation. The analysis is done by answering the following questions:

- Who are the users?
- What are the objects?
- Which are the activities in which function unit is used?
- Can the mediation be characterized as tool, medium, or system?

Each focus and focus shifts, the consequences lead to the focus shift are described. In this case, the misfits that arise when user interact with the system could be considered as a potential for improvement.

3.4 Brainstorming

Brainstorming is a method frequently used in ideation. A brainstorming session aims for maximum ideas. The participants are allowed think freely but associating with the scope of topic. A traditionally brainstorming is held in group to solve a specific problem while nowadays an individual thinking and presenting considered as a brainstorming session as well (Toubia, 2006).

3.5 Image Board²

An image board contains varied visual materials. It is used to inspire designers on creating visual forms. The image board present atmosphere, styles and visual elements. The designers are inspired by interpreting the visual materials.

3.6 Persona and Scenario

Persona is a tool frequently applied into user-centered design approaches. Personas are created according to real user or target user information. Each persona represents a user group. It is an effective method for the developer to keep users in mind through

² This is a method generated during the development process. It based on experiences of the authors.

the development process. A persona is usually described with life story, goals, behaviors, and professions etc. The description could be varied depending on the purposes and functions of product or service. It allows development team discussing and determining the product/service requirements and its solutions. An effective persona has to be created based on real user information, in order to convince the project team trusts the persona.

Scenarios present how people might interact with and operate the product or service under certain context. It can assist the designers to identify the new features. It also could be used to evaluate the concept by fit the concept into scenario (Janhager, J., 2003).

4 Development Process

The development was carried through four phases: pre-study phase, research phase, design phase and evaluation phase. At pre-study phase, the knowledge regarding in-car HMI design was explored via academic literature study and manufacturer publications. The thesis project was thus defined. The research phase was aimed to identify user needs toward personal vehicle and investigate new technology features that could be applied into automotive HMI design. The design phase was divided into three stages, ideation, concept development and visualization. At the ideation stage, authors generated ideas based on the knowledge gained from pervious phases. Then, the initial concept was delivered to the concept development stage. At concept development stage, the initial concept was fully developed into a detailed functional layout of automotive cockpit. At visualization stage, aesthetic requirements were considered to visualize the HMI with the focuses on dashboard, climate control panel and passenger touch screen. At the evaluation phase, the usability and technical features were checked at Mecel. The final design was delivered after the evaluation phase [Figure 4].

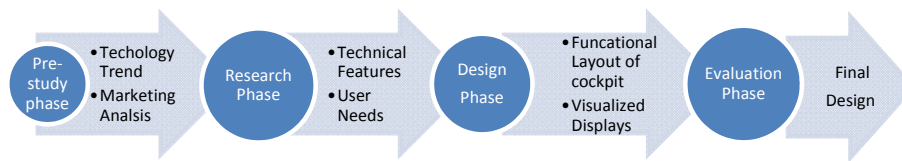


Figure 4 Development Process

5 Pre-study Phase

At pre-study phase, the automotive technology trends were investigated through literature study. The publications from automotive manufacturers as well as scholars were analyzed to predict the mature technologies in 2020. Furthermore, the current marketing with a focus on personal vehicle was studied to define the two types of car.

5.1 Automotive technology trends

In order to foresee the mature automotive technologies in 2020, the technology trends were investigated. It has been identified that sustainable development in the automotive industry has been the curial topic for years. Technologies that assistant and consider sustainable development, are the primary topic nowadays. Technologies, such as electrically driving, clean energy are developed. Safety is still important and will be always important. In the case of constantly maintaining personal and property safe on the road, technologies associating with active safety are trendy. Thirdly, topics on intelligent and interconnected technologies which associated with usability and intuitive design will continued receive attention.

5.1.1 Electronic Driving System and Clean Smart Energy

According to Mitchell, Borroni-Bird and Burns (2010), the three major disadvantages of gasoline make gasoline-powered cars not sustainable. Firstly, the process of powering wheeling by burning gasoline produce local air pollution as well as carbon emissions which becomes increasing concerned over the world. Secondly, as well known, gasoline is not renewable and the source of that only concentrated in few regions, which lead to the third disadvantage that the petroleum-importing countries are in vulnerable positions.

The three major disadvantages of gasoline power make clean and efficient energy power indispensable. Mitchell, Borroni-Bird, and Burns (2010) also state that integrating electrical vehicles into new energy disturbing system as well as replacing today's mechanical power will solve these problems.

5.1.2 Vision Zero and Active Safety

Vision Zero is a vision of road safety that *eventually no one will be killed or seriously injured within the road transport system* (Ministry of Transport and Communications, 1997). It was passed by a large majority in Sweden parliament in October 1997. To realize the vision, safety has to be high priority when designing the vehicles.

Nowadays safety systems are categorized into two major systems, passive safety system and active systems. Passive systems usually refers to the systems and components that protecting injures and lost when accidents happening. Active systems aim to preventing accidents occurring.

5.1.3 Multimodal driving user interface

The basis for a modern human-machine interaction concept is a user-centric design that focuses on the needs of the target user. According Feld, Muller and Schwartz (2010), when design automotive user interface, it is not sufficient to implement a set of fixed interactions for the target user. Since the users and use cases are various, the interface design should consider the actual state of the user and its context. The multimodal stimulus can strengthen and simplify the information while different input methods allow the use preferences. Numerous researches have done on the acquisition of knowledge. The user and context parameters could be detected by different sensors, such as temperature and weight sensory. In addition, the user information could be collect by the users identify themselves; in this case, the basic information from the local database could be obtained.

According to Batliner, Hacker and Nöth(2006), the computer could notice the different human utterances, speck to a computer, speak aside or speak to themselves. So far in the most voice recognition systems, certain inputs, such as press a button, must be delivered by user before user interaction. An elaborate automatic dialogue system can detect on talk speech without any push-to-talk buttons. User interact with computer will be more naturally. Since the spreading of Multi-gesture user interface on handheld devices, gesture based operations become intuitive to individuals.

5.2 Market Analysis

Market analysis was carried out to understand the current car market. To identify some basic points for the concept development, such as the capacity, price level, speed range etc. For each type of car, 8 cars were studied (Appendix A).

5.2.1 Result of Market analysis

From the marketing analysis, gasoline powered vehicles remains dominated nowadays while city car and smart car on their way of being electrical powered or alternative clean and efficient energy. The capacity of long distance vehicles is usually above five persons while the capacity of city car is two persons to four persons. With

existing technologies, electrical powered car has a major disadvantage on limited speed range and long hours charging.

6 Research Phase

6.1 Workshop

Workshops were held to gain various ideas. The purpose of the workshop was defined as exploring the possibilities and new features of future personal vehicle.¹⁵ participants³ who have educational backgrounds on automotive engineering and product development were invited to this workshop.

6.1.1 Workshop Procedure

The questions (Appendix B) that lead to discussions of future personal vehicles were listed. When gathered the participants, authors played as hosts to lead the discussion. The discussions were recorded as audio materials. After the workshop, materials were analyzed and compiled.

During the workshop, all the participants were allowed to think creatively and freely. The participants were divided into sub-group. At the initial phase, the discussion was conducted in the sub-group. Then the sub-groups could give comments to each other group.

6.1.2 Results from workshop

The results of workshop provided ideas to the study and inspirations when ideation and concept development. Furthermore, automotive features were consistently discussed during the workshop which provided the study information on automotive technological trend. The original record from the three workshops can be seen in the Appendix (B), but from the vast amount of ideas, there are some thoughts can be summarized.

6.1.3 Thoughts on Standard User Car concept

Interactive displays widely apply in automotive HMI. A lot of the ideas from the workshop are emphasizing the application of multimodal interface. Touch screen, which is widely applied in consuming electronic products, is considered to be applied

³ 15 students have participated in the workshop. Among them, 4 students are from Automotive Engineering program, 3 students are from Solid and Fluid Dynamics program, and 8 students are from Industrial Design Engineering program.

in personal vehicle HMIs in a larger scale. Other advanced displays, such as Head up Display (HUD) and Hologram are also considered to be feasible in ten years.

Cars will be developed even more environmental friendly. This is a fact agreed by all of the participants, electric powered and hybrid cars are trendy, as well as the energy recycling system and components, such as Kinetic Energy Recovery System (KERS) and efficient tires.

Automatic functions are even more developed. Cars are driven by themselves is not a fairytale. A lot of participants in the workshop mentioned different automatic technologies for cars, such as Autopilot⁴ and Road Train Technology⁵.

Internet Access will be widely available and vastly improved in the future. New generation mobile telecommunication brings revolutions to the world over time. It is technical possible to watch Blu-ray movie on-line by the in-car infotainment instrument in the near future.

Natural Speaking Command will be available in the future. The voice control could be applied in many kinds of operations to reduce the workload for the driver, and in the future more natural speaking control can be realized.

Smart Navigation System will be popular. It is widely agreed that more information should be provided in navigation, with a more intelligent system, with information on traffic and road condition, even more geographical details and instantly updating route selection.

Infotainment and Communication will be improved. Since the automatic driving functions will be developed, the infotainment experience could be enhanced by adding functions which allows video chatting, watching movies, playing games and so on, diverse communication process could also be done in the car while driving.

Customization is going to be the trend. With memory function developed, the car can remember the driver's settings over different facilities and adjust to fit the driver when recognizing.

Brand New Vehicle Service System. Future vehicle service system may be developed, such as personal vehicle can be combined with public transportation, or the personal vehicle can be leased in some way.

Future Exterior System will be more efficiently structured and intend to have neutral and standard styling. For efficiency purpose, the workshop proposes the car can be smaller, and with larger visual area for driver. Also the exterior can be more aerodynamic efficiency. Also to the user category, the workshop suggested the neutral and standard styling would suit the standard user car.

⁴ An autopilot is a system that allows vehicle drive itself.

⁵ Road train technology allows vehicles follow other vehicles. When "road train" is formed, each vehicle in the line drives itself.

6.1.4 Thoughts on Expert User Car concept

Interactive displays widely apply in automotive HMI. As mentioned in the standard user category, Touch screen, Head up Display and Hologram is also widely suggested by the participants in the workshop.

New technologies applied in cars for enhancing driving experience. For expert users, the workshop delivered ideas mostly about enhancing driving joy. For example, the gearboxes are remained as manual operation, also more advanced electrical systems like steering by wire.

Internet Access will be widely available and vastly improved in the future. Also the same as standard users, more advanced Internet in vehicle is predicted available in the future.

Natural Speaking Command will be available in the future. More developed, natural speaking recognizing system to be installed in the future vehicle

More car performance features could be set in the expert users cars. The cars for expert users are suggested to have more settings over driving performance, e.g. adjusting the tire pressure or the differentials, since the expert users have more interests and knowledge on this.

Infotainment and Communication will be improved. Like the standard user car, the Infotainment and Communication system is required to be more reliable and advanced as well, especially when it's focused on such an experienced user group.

Customization is going to be the trend. The expert user car will more adapt to the personal use. On top of the memory function mentioned above, the expert users car can be customized to users' preferences in terms of different vehicle systems and exterior styling.

The expert users car will be much more fuel-efficient. The workshops suggest the cars for expert users are remained with gasoline car since it is only ten years ahead; it is difficult for the electric powered cars to be improved to have equal performance as gasoline cars. But the fuel efficiency will be improved dramatically.

Future Exterior System for expert users car will remain Classic and Premium, yet Sporty, Futuristic, and Aerodynamic. Because of the target user group and the higher price level, compared to the standard user car, these keywords are dragged out by the workshops. The exteriors should also image the performance of the vehicle, as an expert user car, the look itself should provide the same feeling as its performance.

6.2 System Description

The system study aims to understand the current in-car driving system, relations of systematic elements, and the context of that. The automotive cockpit was studied by analyzing three cars, Volvo V70 2.4, SAAB 93 2.0T and Nissan LEAF electric car. The three cars have some differences on driving control system since Nissan Leaf is

an electric powered vehicle. When generalized as functional units, these three cockpits have similar layouts and functions. The system description was formulated in a general manner for the current automotive cockpit. Two contextual observations were conducted to identify the relations between elements and understand the context.

The procedure of system description is:

1. Identify the elements of in-car driving system.
2. Describe the properties of the elements and components of the elements
3. Identify the connections between users and other elements. The connections are categorized into transformation of energy and transformation of information.
4. Make a graphic system model.

To identify the elements and their properties and components, the three automotive cockpits and user manuals of those were studied. The investigations of relations between users and other elements mainly through observing two use cases; however some elements were not used in those two use cases. The user manuals were studied as supplementary materials to identify the interactions of users and other elements. The system model is a visual result of the system description.

6.2.1 The elements of in-car driving system

The boundary of the driving system is automotive cockpit. The Volvo V70 2.4, SAAB 93 2.0T EW were analyzed to acknowledge the general system description for the conventional sedan and hatchback. Nissan Leaf was analyzed as the electrical car (Appendix C).

Besides the primary users, the other elements were summarized as functional units rather than physical components. The elements were categorized into four types: primary user, driving control system, infotainment system and driving assistance system, and comfort system [Table 2].

Table 2 System description

Driving Control System	Main instruments panel, Pedals, Gear Box, Steering Wheel, Hand Brake, Mirrors, Wipers, Head Lights
Infotainment and driving assistance system	GPS, Radio, In-Car Telephone, CD Player
Comfort System	Climate control, In-Car Lighting, Seat, Windows
Primary Users	Driver, Front seat passenger

6.2.2 Relations of users and other elements

The contextual observations help authors identify the relations between users and other elements. Two participants are both expert users who have driving experiences more than ten years. The contexts are that the users drove in a familiar city without certain destination and time limit. The weather and road conditions are fairly fine for driving. The video recording was analyzed, according to the approach described by Bödke (1995).

In a driving context, the primary users are the driver and the front seat passenger. The objective is actually helping the authors study the driving context. The activity of driving from destination A to destination B could be divided into three actions: start up the car, driving, and parking at a familiar parking lot.

For the action-start up the car-the bellowing elements are used:
seat, handy brake, gear shifter, front mirror, rear mirror, clutch pedal, accelerator pedal, brake pedal, side window, main instrument panel

For the action-driving-the bellowing functional units are used:
Gear shifter, front mirror, rear mirror, clutch pedal, accelerator pedal, brake pedal, radio⁶, main instrument panel

For the action-parking -the bellowing functional units are used:
Seat, hand brake, gear shifter, front mirror, rear mirror, clutch pedal, accelerator pedal, brake pedal, side window buttons, main instrument panel

Since the observation participants are both expert users and familiar with the driving environment, GPS was not used during the two observations. However, one participant kept the radio on in case of being updated by traffic condition news. The in-car telephone and CD-player were not used during the observations either.

Among these elements, driver had energy / force transformation with all the other elements except main instruments plane which remain as display in the automotive cockpit. Driving assistance system, infotainment and climate control transformed information to the driver while driver operated them during driving.

⁶ Only one participant used it.

6.2.3 System Model

System Model is applied to visualize the relationships of the elements within the in-car driving environment [Figure 5].

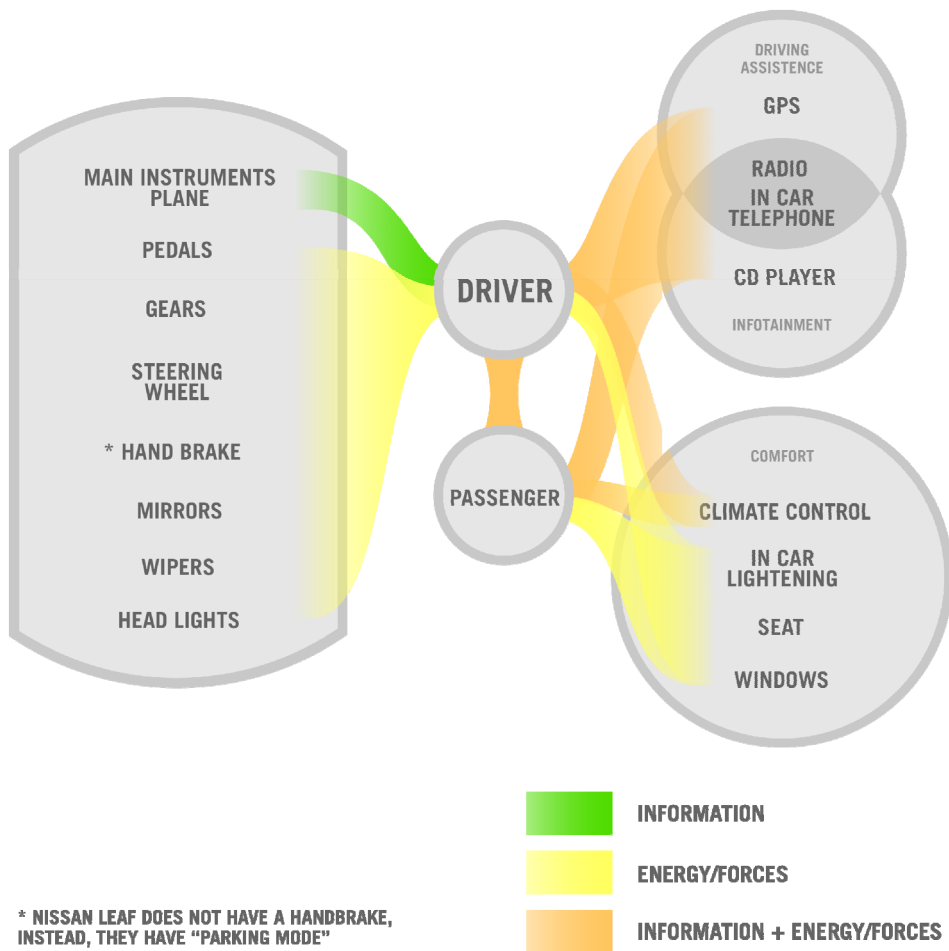


Figure 5 System model

6.2.4 Results from system description

Results of system description provide this study understanding of current personal vehicle system and relations of user and system. According to the system model, driver dominantly controls and operates the driving control system. For the current automotive cockpit, all the driving operations are made by driver. Driver is able to access to all the elements while the passenger is able to access to driving assistance system, infotainment system and comfort system. Besides observing road conditions

and outer environment, information is provided via main instrument panel, driving assistance system and infotainment. Besides the main instrument panel, driving assistance system and infotainment systems requires interactive operations. Overall, the elements that interact with the driver are main instrument panel, GPS, radio, in-car telephone, CD player and climate control.

6.3 User Interview

6.3.1 User Interview Content

User Interview was divided into two parts. The first part was mainly questions about driving experiences in general; the second part was a mental model test together with SAM. The original question list is attached in Appendix (D), but according to different profiles from each interviewee, the questions are modified properly.

6.3.2 User Interview Participants

The Target User Interview aims to have users from two categories to be interviewed. The ideal interviewee group would be 10 persons in total, in each category the interviewees are not only matched with each user category's profile, but also among the total 5 from each group, 4 would be the users today and 1 would be the potential user.

The number of final selected interviewees was 9. Among these 9 people, 4 of them were employees in the automotive industry, while 3 were university students with academic background on international marketing, humanity and industrial design engineering. One interviewee was a senior citizen who had driving experience more than thirty-five years. With the definition before the research started, the authors found out that only three users fully matched the standard users' profile, the other six users all had characters belong to both expert users and standard users as defined: they had strong knowledge or interests in vehicles, but when considering their choice and usage of their own cars, it turned out to be very much like the standard users. As a result of this, the user interview didn't give major input about emphasizing the difference between the two user categories, but the common input to both concepts.

6.3.3 Results from user interview

As stated above, the user interview provided input mainly concerning the common input to both user category concepts, thus the outcomes mainly offered information to the scenarios and the details of the HMI designs in later concepts.

Input To Scenarios

What the user interview introduces to the scenarios is their various situation of using their own car. From the interview, there are several scenarios that happen frequently:

1. From home to workplace: this is one of the most frequent scenarios among the users. The differences among this scenario are distance and context: from downtown area to downtown area, from suburbs to downtown area.
2. Shopping: frequent as well. Parking and finding parking lot could be this scenario concerns to some extent parking problems.
3. Taking child from or to the school.
4. Travelling for a short or long distance.

Input To HMI Designs

All of the interviewees have more or less stated some problems they have ever met or their comments on the vehicles and the trend. As a matter of fact, this plays a strong role while developing the concepts, both functional layout and visualization.

1. One of the interviewee complained the central control stack of her car is inconvenient to be used during driving due to the display is a touch screen. There are users saying that it would be major inconvenient to use touchscreen while driving since touchscreen always requires visual recognition and the display is not located within nature sight angle.
2. There are two interviewees complaining about unpleasant experiences on using navigation system while driving. There are also unpleasant driving experiences from two other interviewees, which concerns the traffic condition. One of the interviewees who has been involved in navigation system development, stated his opinions on what is a good navigation system and what can be improved in the future navigation system:

What is a good navigation system?

- The map has to be updated. It is usually two times a year.
- The navigation system should have clear instruction from its voice and display. Such as the distance instruction should come before the actual action instruction.

What can be improved in the future navigation system?

- The parking space updating could be available
- The traffic information could be more accurate, such as the information of which lane has accident.
- The navigation system should point out the best parking place for the driver in the future.

3. One interviewee who has driving experience upon the car equipped with HUD system, pointed out that the head up display on the windscreen might be annoying while it has blocked the driver's view in some extent.
4. One interviewee stated positive opinions upon the active safety system; while two others thought that the too frequent active safety system would be too annoying for the drivers.

6.4 Scenario and Persona

As a result from the analysis of the target user interview and the definition in the very beginning, personas and scenarios were created (Appendix E). The personas and scenarios reveal the specialties of the standard users and expert users, which was an important input for the concept development later on.

The Summary features of personas and scenarios are listed:

Table 3 Personas and Scenarios

	Persona	Scenarios
Standard User Concept	All ages that can obtain a valid driving license Limited or good financial ability Not that interested in cars and stuff related Male and Female Residents in western European countries	Inner city driving + City to suburb driving Western European cities
Expert User Concept	Car lovers Experienced driver, more than 10 years of driving cars Mid age Mid class	Drive within the city, from outskirt to downtown, trip (long distance) Western European Cities

6.5 Summary

The results of the research phase are vast. By holding workshops, possibilities and thoughts of personal vehicles for the future were explored. These thoughts provided amount of information on technologies which haven't been widely applied in automotive industry while feasible and useful to applied in personal vehicle. These thoughts also inspired authors on constructing the vision of future car, cockpit and HMI.

By conducting the system study, authors understood the current automotive cockpit and relations of functional units and users. In the current automotive cockpit, besides observing outer environment and other telecommunicate device, information came from main instrument panel, driving assistance system and infotainment.

User interviews provided many inputs to the constructions of personas and scenarios. The use problems mentioned in the interviews compiled. When design HMI, these problems were discussed to evaluate ideas and concepts in some extent.

Personas and scenarios were constructed based on the data from user interviews. The personas and scenarios described the context of design.

7 Design Phase

As mentioned in the purpose/aim, the design phase has two major tasks: creating the functioning interior layout with a focus on the display, and visualization of these parts. After the design phase, two HMI designs, one for each category, were delivered. The two HMI designs should involve the incoming technologies and new thinking, which should feed the users' needs in both physical and mental dimensions. The visualization should correspond to each user category, and be aesthetic to the users.

The design phase was divided into three stages, ideation, concept development and visualization. It was carried based on the conclusions from previous phases, discussions with Mecel, and experiences and knowledge upon HMI design. At the concept development stage, concept proposals were generated by individual brainstorming and discussion. Then the concept proposals were discussed with the Mecel Populus team. During the concept development stage, the features, function area and functional hierarchy were defined. Eventually, the graphic user interfaces were designed and visualized at the visualization stage.

7.1 Ideation

The ideas generation stage mainly contained individual brainstorming, creative discussions and sketching the ideas. The purpose was to generate new ideas upon the entire automotive cockpit with the results and thoughts from previous study. At first, the authors sketched the ideas and designs individual. Since at this stage it aims for as many ideas as possible, the individual sketch and brainstorming are to explore new ideas without being affected by each other. Then the discussion was carried on with the principle of developing the ideas not judging. At the discussion sections, details were naturally developed for each idea. Six concept proposals were generated during ideation. They are different in functional layout. Four concept proposals are for Standard User Car while two for Expert User car.

When generating ideas, there are two prerequisites. First, the keywords of standard user car are city car, small, purely electrical powered while those of expert user car are safe, fuel-efficiency and fun to drive. Secondly, when brainstorming, the five functional areas (windscreen, dashboard, steering wheel, and passenger infotainment instrument and climate control panel) were the focuses.

7.1.1 Concept proposal and Analysis

Standard User Car –concept proposal 1

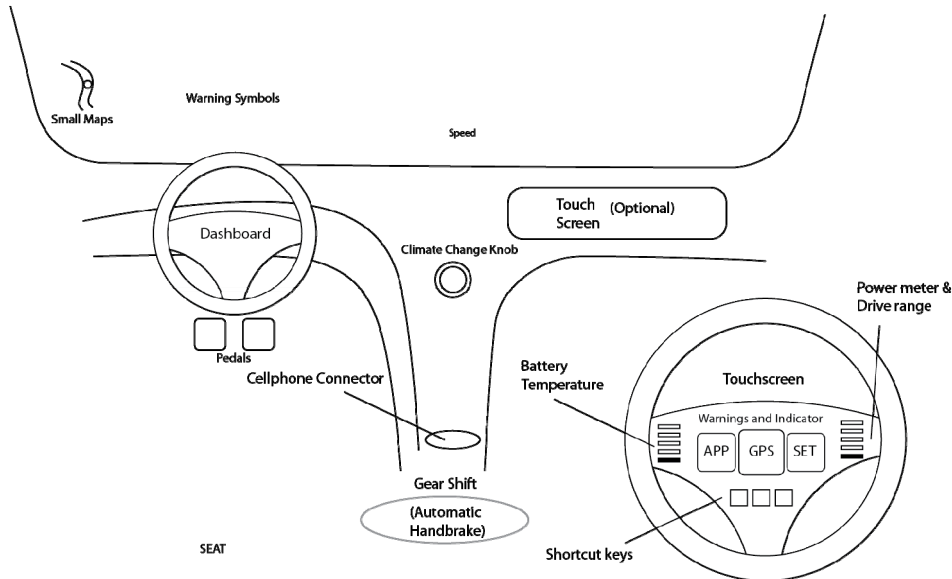


Figure 6 Standard user concept1

The standard user concept 1 has the dashboard and functional shortcut keys on the steering wheel. The dashboard is a touch screen, and therefore driver could intuitively operate the car on the steering wheel. The windscreen has a head up display which demonstrates speedometer, turn by turn navigation map and warning symbols. On the front passenger side optionally installs a passenger infotainment instrument.

Standard User Car-concept proposal 2

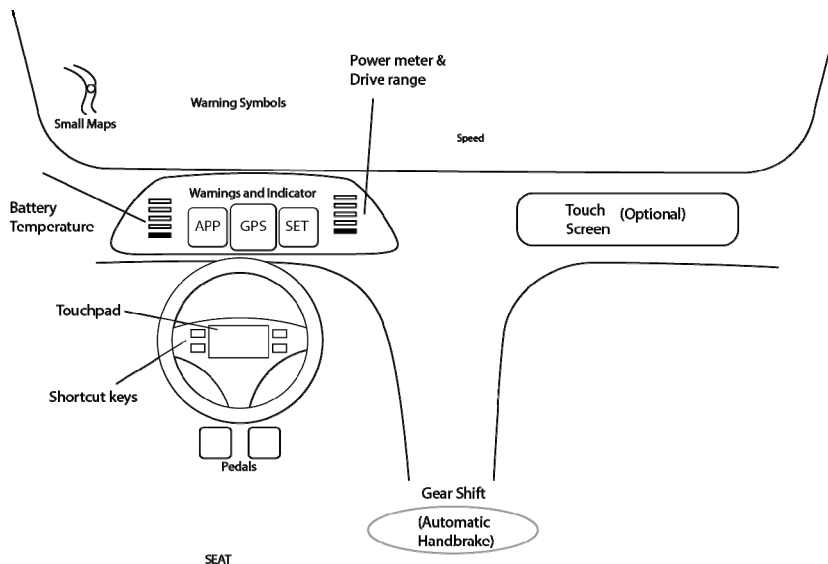


Figure 7 Standard user concept2

The standard user car remains the main functional areas of the current conventional car. A touch pad is installed on the steering wheel that allows user operating the car. The operation approaches are gesture based. Similar to the concept 1, the priority information illustrates on the head-up display.

Standard User Car –concept proposal 3

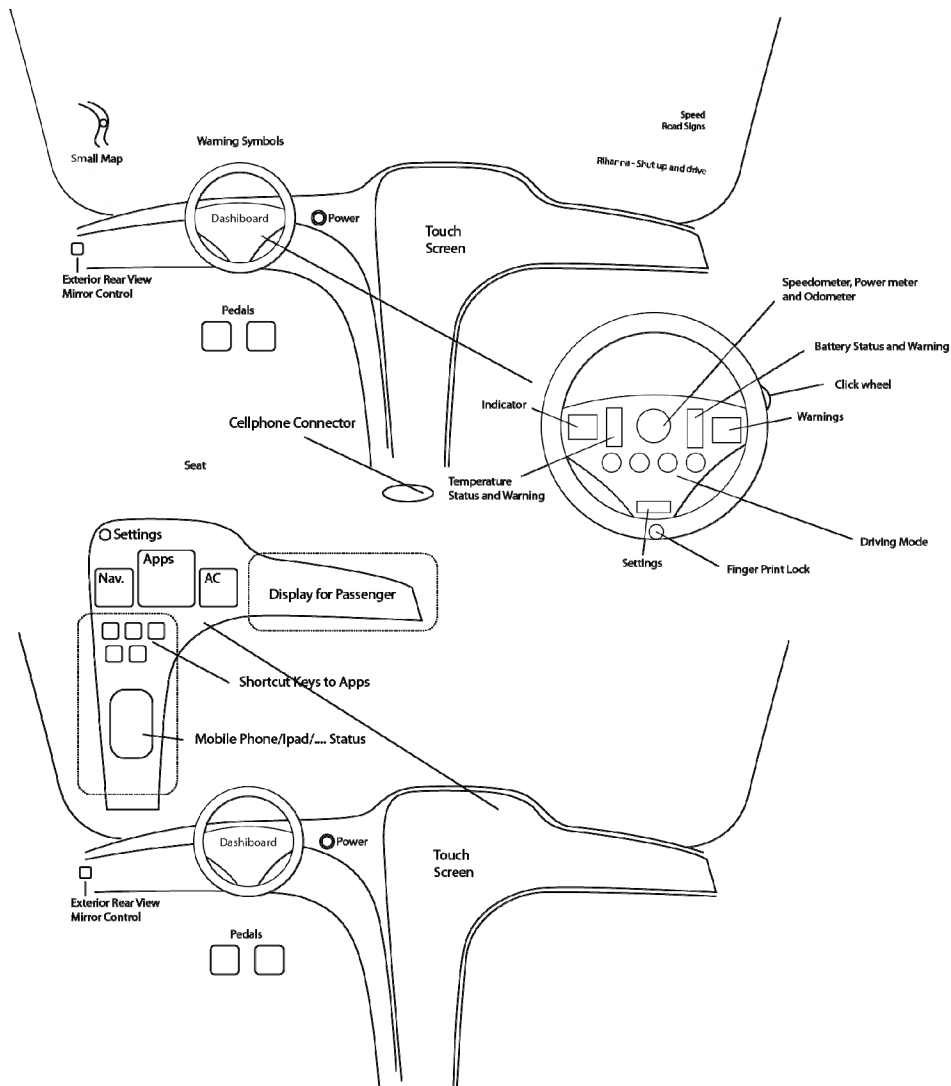


Figure 8 Standard user concept3

The concept 3, as the concept 1, moves the dashboard on the steering wheel, while the operations are through a button, knob panel on the side of steering wheel. The main information presents on the steering wheel. Navigation map, speed, and a taskbar (shown processing) demonstrate on the head up display. The main instrument panel is positioned on the center.

Standard User Car-concept proposal 4

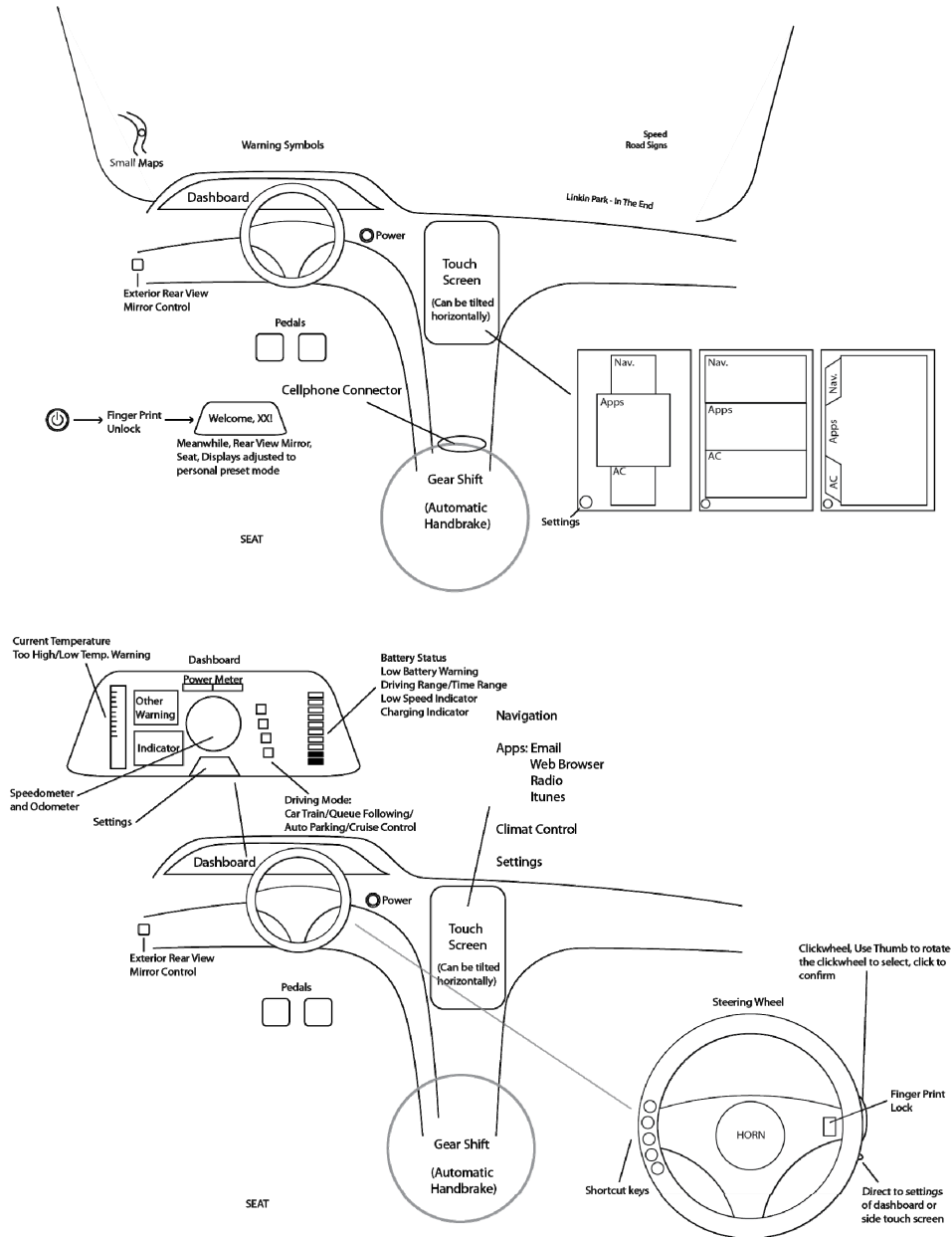


Figure 9 Standard user concept4

The concept 4 is similar to concept 2, except the touch pad is replaced by shortcut keys on the steering wheel and click wheel on the side of steering wheel.

Expert User Car-concept proposal 1

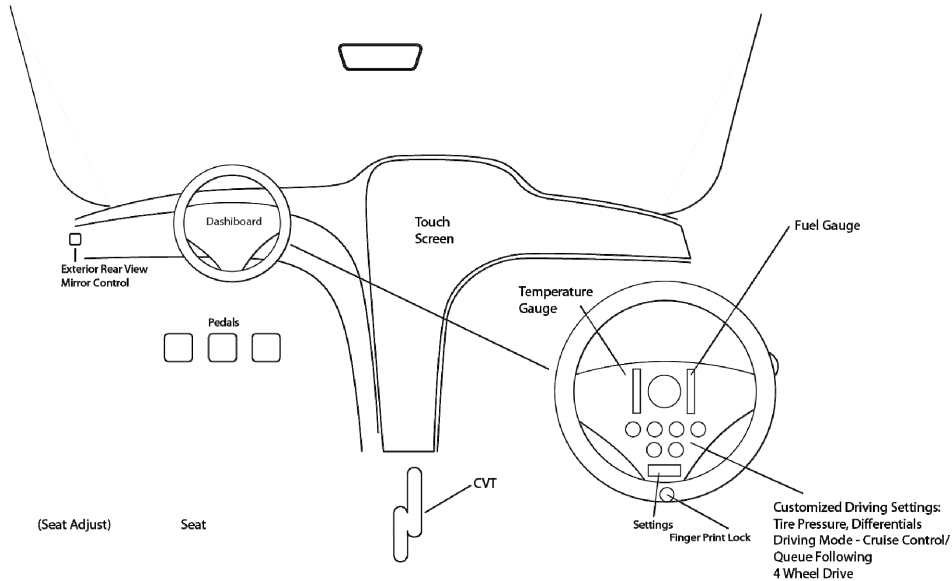


Figure 10 Expert user concept1

The expert user concept 1 also has dashboard on the steering wheel with the operation panel on the steering wheel. The information associating with controlling system is demonstrated on the steering wheel while driving assisting and infotainment information are shown on the touch screen.

Expert User Car-concept proposal 2

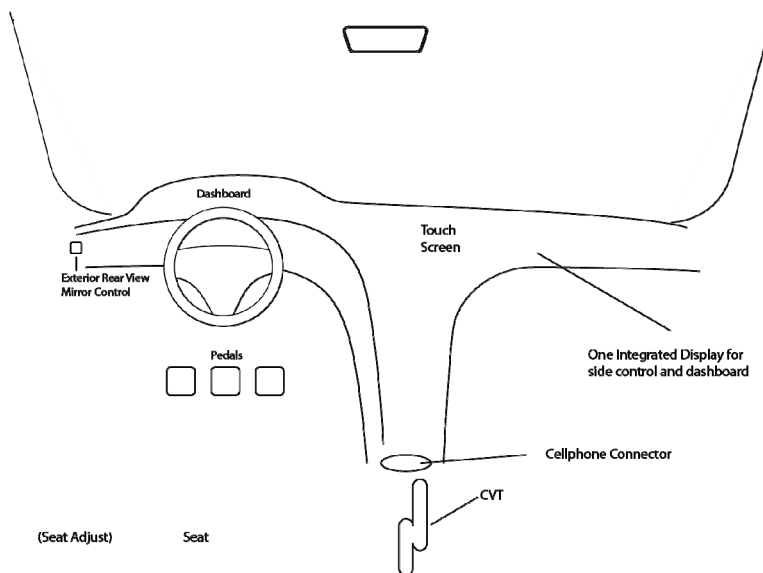


Figure 11 Expert user concept2

In the expert user concept 2, the passenger infotainment instrument, climate control panel and dashboard formed a gigantic display while climate control panel and front passenger infotainment is one unique touch screen. The driver operates the car by controlling panel on the steering wheel.

7.1.2 Result of ideation

After discussion with Mecel, the concept proposal 2 is selected for developing both standard user cockpit and expert user cockpit. There are two reasons for the selection of concept proposal 2. For one thing, Mecel questioned on physical ergonomics of the idea to place the main instrument panel on the steering wheel. The authors agreed with the opinions that in a conventional car the location of steering wheel is not an optimal choice for the dashboard from the physical ergonomic aspect. This solution may solve the problem of intuitively interacting with dashboard but bring the problem of placing the steering wheel with physical ergonomic consideration. To solve the problem of that required designing the physical components of the car, which is out of the scope of this study. And therefore, standard user proposals 1,3 and expert user proposal 1 are excluded. The other reason of the selection is that compared with knobs and buttons, placing touchpad on the steering wheel is an innovative solution to the problem of interacting with complicated HMI from the perspective of Mecel. Gesture based interactive manners are commonly applied on laptop but seldom used in the automotive cockpit from knowledge of Mecel and authors. Since the outcome of the study required to be perceived as futuristic, innovative solution is preferable.

At the beginning of the ideation, the proposals are produced into two categories which corresponding the two types of personal vehicles. But only the proposal 2 is selected for the further development of both types of cars. To dig into the reasons, the proposals for the standard user car and expert user car are not distinctive. They have similarities. The differences are only reflected on the gear shifter and the content of the main instrument panel. The proposal 2 can be produced for standard user car but it also could be applied into expert user car by modifying the content of dashboard and changing gearshift. To sum up, Mecel and authors select the proposal 2 to continue the development of standard user car and expert user car.

7.2 Concept Development

The primary task of concept development is creating the functioning interior layout with a focus on main instrument panel, windscreen, steering wheel, climate control panel and front passenger touch screen. The initial concept of automotive cockpit is fully developed through designing how user should interact with the car and the locations of cockpit features. Then, the focus shifted to design the functional content

of main instrument panel, climate control panel and passenger touch screen for each category.

7.2.1 Functional Layout

The functional layout was developed. The cockpit is divided into five functional areas, as mentioned. At this section, the task is to locate the features into functional areas. The method for locating the functions is scenarios, personas and use cases.

The persona and scenarios were set at the research phase. Then, authors brainstormed the possible use cases. The use cases are the activities happened in the car.

For instance, scenario A is “persona A drives to the work place from home, persona A lives and works at inner city”. The primary goal is “drive from home to work place”. The context is driving within inner city. Use cases are possible to be produced by brainstorming. The first level of use case is to fulfill the primary goal, which is “drive from home to work place”. With the system describing in the initial concept, the possible second level of use cases is:

Table 4 the second level Use cases for scenario A

The Second level Use cases category	The second level Use cases
Communicating	Making a phone call Answering a phone call Texting Emailing Messaging (MSN/Skype etc.) Video Chatting (MSN/Skype etc.)
Entertaining	Listening to Media Playing games Internet Surfing
Assisting Driving	Searching a certain place Searching Nearby Looking up map

After brainstorming the use cases, the actions and operations for accomplished the tasks were considered. The actions and operations are based on the selected concept proposal. The principles for designing the actions and operations are:

1. The first level of use case should not be disturbing by the second level of use cases.
2. Usability consideration

According to the principles, functions are located into functional area to fulfill tasks.

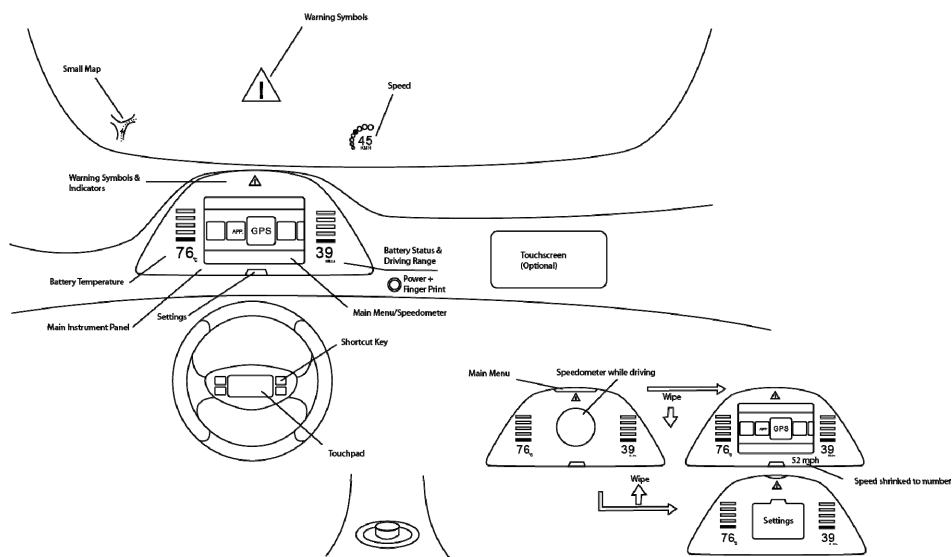


Figure 12 Functional Layout Of Standard User Car And Expert User Car

7.2.2 Functional Hierarchy

After defining the functional layout, the functional hierarchy of HMI was designed (Appendix F). Functional hierarchy is a result that combines user action, operation and HMI feedback. It is used to visualize the operation and feedback map [Figure 13, 14].

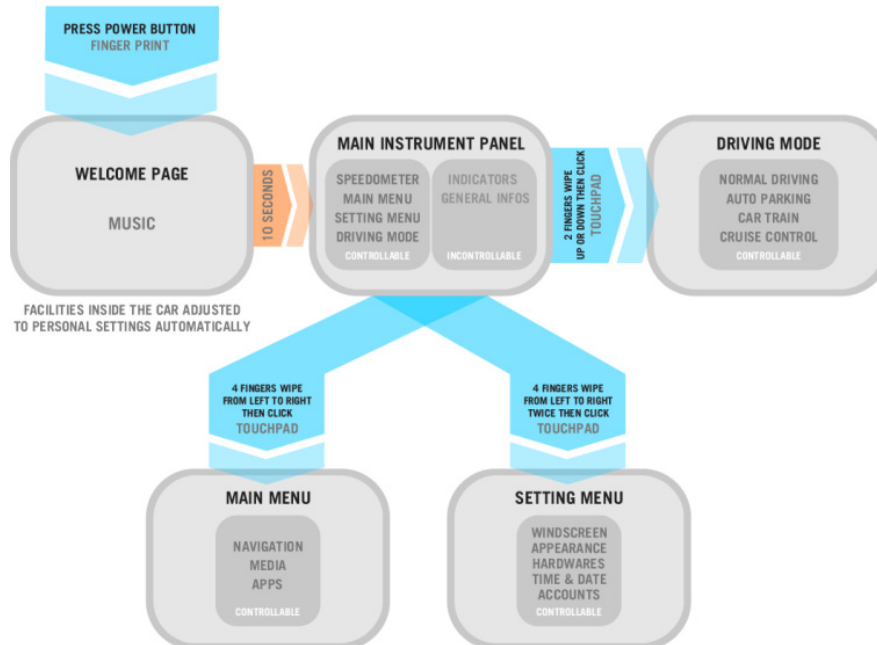


Figure 13 Part of Standard User Car Functional Hierarchy

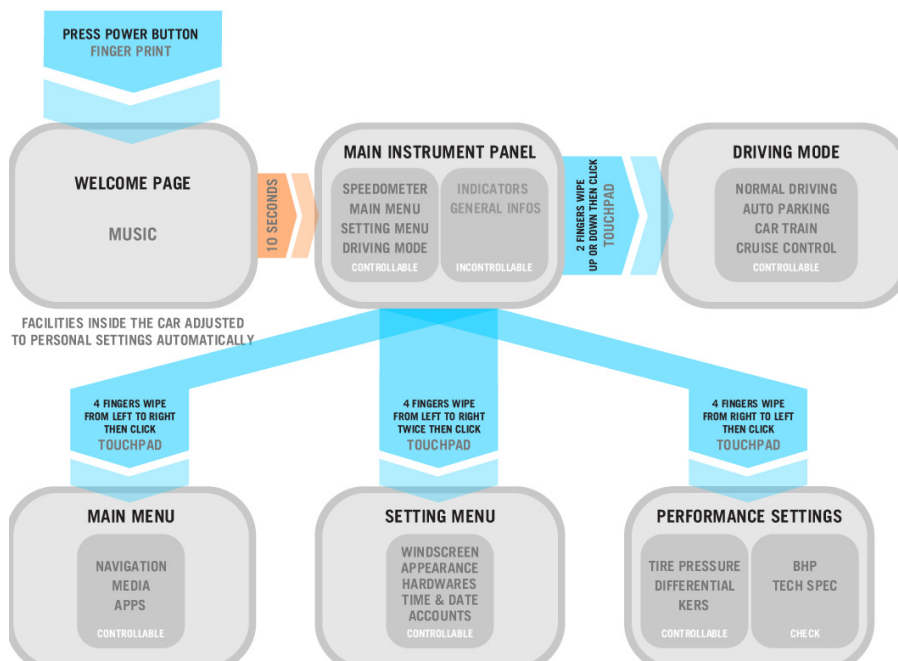


Figure 14 Part of Expert User Car Functional Hierarchy

7.3 Visualization

The visualization process contained three stages. The first stage is mainly developing a visual structure, creating mood board and delivering a wide range of sketches, while in the next style development stage, the general look is created based on the first stage and the function hierarchy structure. In the last visualization stage the whole design is refined by looking into details.

7.3.1 Inspiration Gathering and Sketch

For the inspiration gathering, creating the image board is an efficient method. Based on the results from the user research, more keywords have been concluded. Besides the image board, a bunch of designs that appeared to have similar topic have been found for inspiration as well. After this session, sketches will be delivered by brainstorming, and among these to decide which to develop further more.

7.3.1.1 Image Board

Keywords for the standard user: Simple, Organic, Futuristic, Neat, Intuitive, Light, and Cohesive

Keywords for the expert user: Speed, Aerodynamic, Premium, Retro, Scientific, and Futuristic (Appendix G).

7.3.1.2 Sketches

Standard User

The first brainstorming sketch session is about to have different ideas on styling of several instruments. The second one is to match the results from the first brainstorming and get a whole look to decide which way to go. After these two sessions the results are selected and put together. By comparing these concepts, and consulting from the company, there are some generated thoughts, sketches and opinions coming out as listed below:



Figure 15 The Selected Speedometer Sketch

The speedometer has been selected as such. Because of the electric power system, the ammeter should be shown in the cluster as well, and in this case it has been integrated into the speedometer. The style is neater, which matches with the standard user style keywords. And the flashing blocks which indicates the current speed, looks like part of the Mecel AB logo. It is valuable for the brand identity embedded.

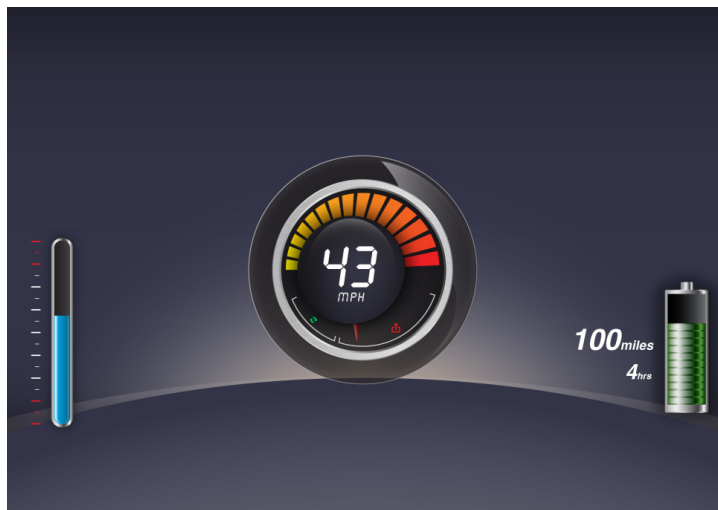


Figure 16 A rough layout to show the place of different instruments on the dashboard for standard user

From Figure 4.8 There is a general image about the position for each instrument on the dashboard, for the standard users. For driving an electric power car, besides the

speed information, the battery temperature and the battery status are equally important to know, according to the system study. Because of this, the battery temperature and the battery status gauges are located to the sides of the speedometer, two obvious positions.

Expert User

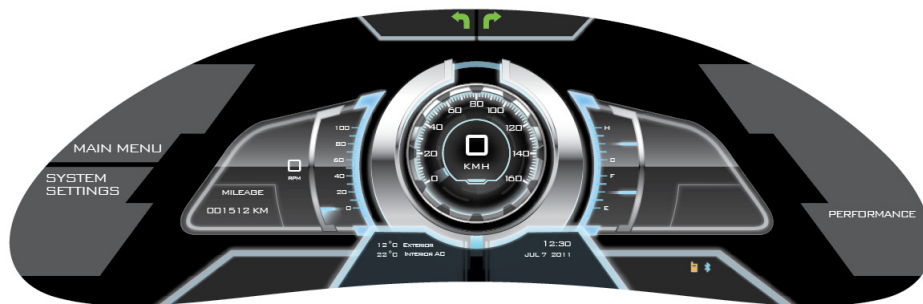


Figure 17 The selected sketch of expert user concept

With experience from the standard user concept development, the expert user concept is much easier getting into the details. The traditional speedometer is set in the center of the dashboard, with other driving information located around. The main menu and system settings are at the left while the performance setting on the right side. What has been added here is the performance menu. The research results suggest that the expert user car has more settings over the driving dynamics, and to separate this from other general applications and settings, the performance menu is at the left side of the dashboard, equally as the main menu and system settings.

7.2.2 Style Development

In the style development stage, the sketches are further examined. The user interfaces of main instrument panel for each concept will be completely organized in this phase; the instruments and secondary menu will be designed.

The style development is mainly based on the brainstorming, sketches and discussions, discussions and consulting from Mecel

The Standard User Concept Development

From the previous sketches, the general structure and the idea about how the speedometer looks like are kept to this stage. Basic required information, such as the warnings and indications, time and date information, is put into the proper position as

well. Every item in the main instrument panel is more detailed compared to them from the sketches.

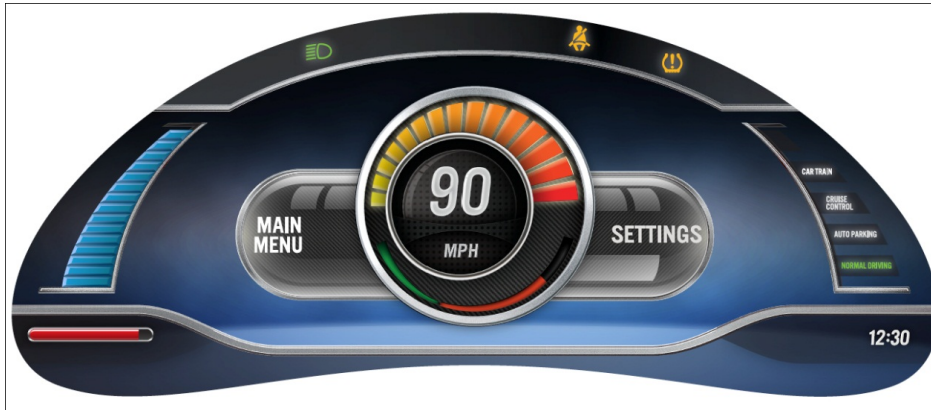


Figure 18 Developed Main Instrument Panel Concept For Standard User

The general position and look are completed: warnings and indications are on the top, with the battery status staying at the left side. The apps, media player and navigation system are integrated into the main menu, while other settings are organized into the settings menu. The lower bar involves less important information: the battery temperature at the left side and the time at the right side.

The Expert User Concept Development

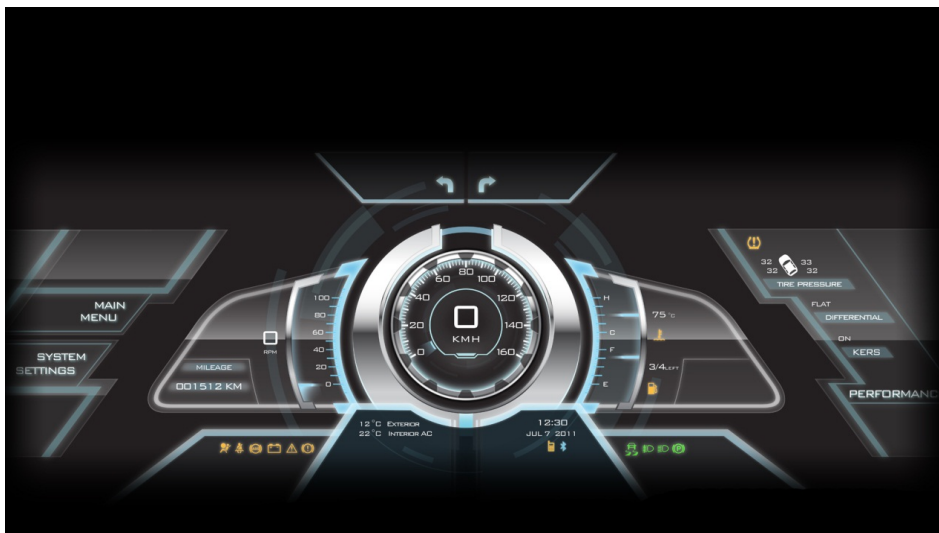


Figure 19 Developed Main Instrument Panel concept for expert user

The instruments and information are set into positions as well as the standard users. Based on the experience and the structure from the standard user development, the development process becomes much smoother.

7.2.3 Detail Design

The detail design phase focused on the missing gadgets and buttons required by each layer of the user interfaces, typefaces and distance in between. The climate control and passenger touch also will be finished after this stage.

Standard User Concept Detail Design And Finalization

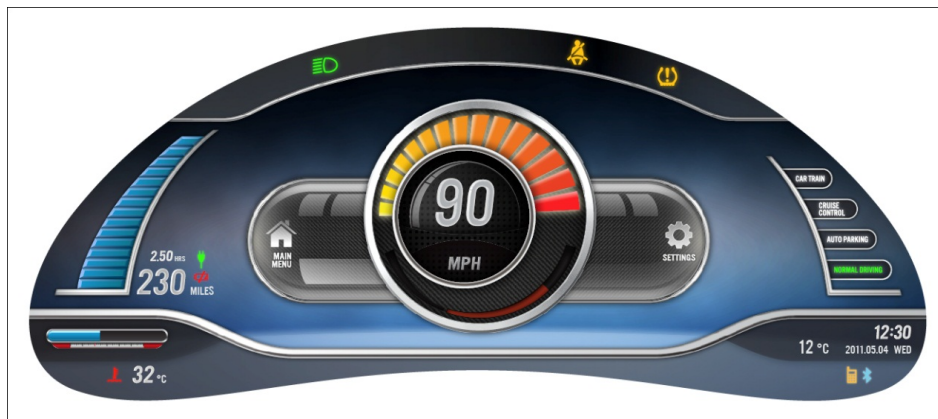


Figure 20 Standard User Concept After Detail Design And Finalization

The instruments in the dashboard are more designed with details after this stage. What has been modified from style development, first is the color correction, warnings and indicators color are changed with higher purity since that makes higher contrast with the background, which means they are more visible to the drivers. Second the main menu and settings titles are changed from text to graphical icons, which allows both remain the same and smaller size.

Expert User Concept Detail Design And Finalization

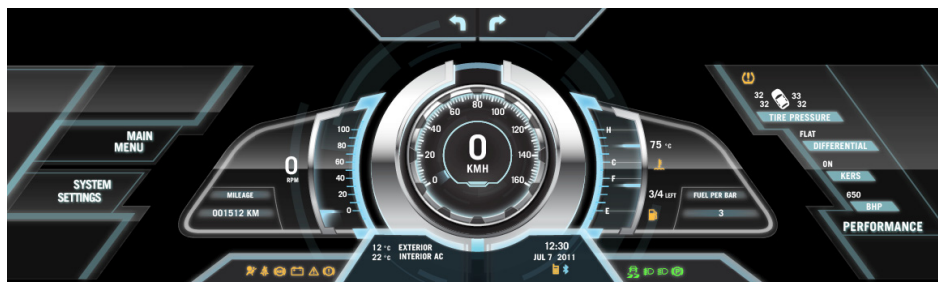


Figure 21 Expert User Concept After Detail Design And Finalization

Compared to the expert user concept after style development, the color correction to warnings and indicators are also been done. Besides this, the typefaces are modified

into trade gothic font, because it makes better recognition. Furthermore, Mecel uses this typeface for a long time, so it cooperates with Mecel brand identity.

8 Evaluation Phase

The process of evaluation phase is shortened compared to the one set in the beginning. The evaluation mainly involves usability examination and technique possibility check, thus the final design could be more reliable.

8.1 Usability Inspection

Because of the purpose of this study, the usability is not possible to be profoundly tested. Thus, the usability evaluation is set to base on several roughly mocked up scene, e.g. displaying the instruments to a 1:1 scale and checking for problems. Also gaining opinions and suggestions by showing the concept to the automotive and software experts in Mecel.

By doing a rough usability evaluation, the graphics has gained some modifications. The outer glow effect has been deleted for some of the text displaying; the font size and space in between has modified larger due to the unclearness of several words; Instruments placement has been reordered as well, such as the warnings and indications in expert user concept are moved to the top of the main instrument panel because of the logic and habit.

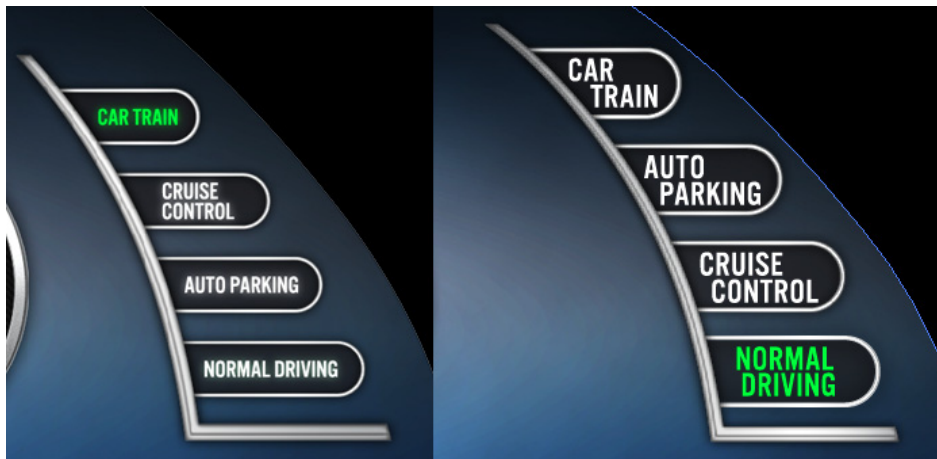


Figure 22 Font size and space between modifications for the driving mode section, the right one is the modified version



Figure 23 Before (bottom) Evaluation and Modified (top) Expert User concepts

Before(bottom) the indications and warnings are at the bottom section, while the modified version(top) has them in the top and bottom section for driving mode. The contrast of the text and the background has been raised in the performance settings as well.

8.2 Technique Check

In this evaluation, the technique check is carried out to make sure that the features applied in concepts are technically possible. By consulting with experts within Mecel, the touchpad will be modified to a lower place on the steering wheel because the central part has the airbag and it will destroy the touchpad while it is activated.

9 Final Design

9.1 Standard User Final Concept

Driving Systems and General Features

Fuel type and fuel capacity: Electricity powered, 230 miles distance to go when fully charged

Highest speed: 90 mph

Transmission: Automatic gearboxes

9.1.1 Standard User Car-Cockpit

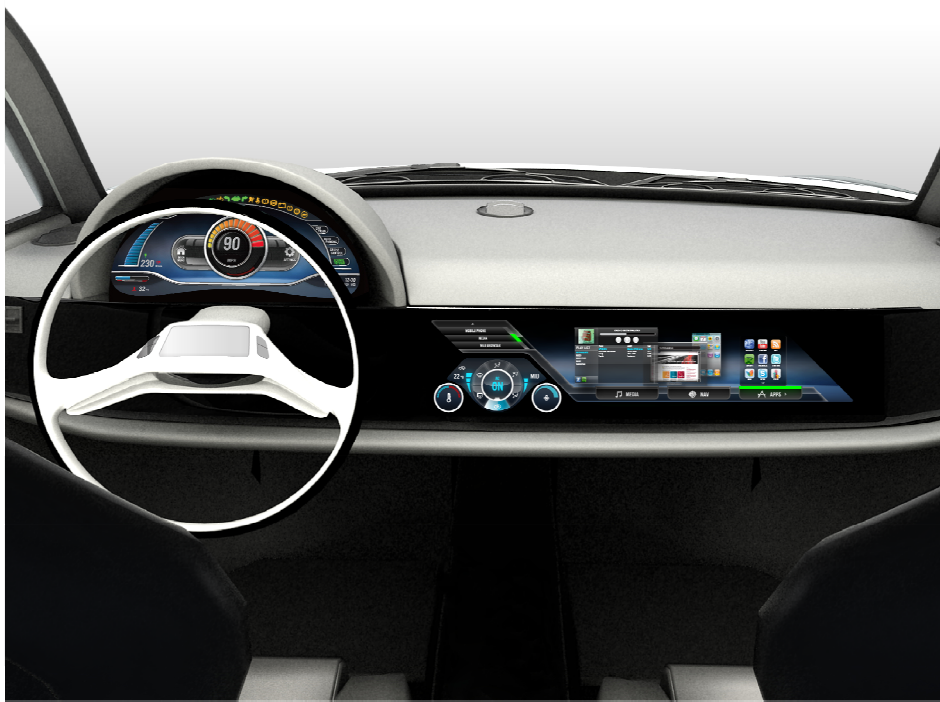


Figure 24 Interior layout of standard user final concept

As shown in figure 5.1, the standard user final concept consists main information sections of main instrument panel, center stack and wind screen instruments. As an electric powered vehicle, the gearshift is altered with the gasoline vehicle. The power button is located on the gearshift; the steering wheel contains a touchpad to control, accompanied with four shortcut keys. The display system covers the main instrument

panels and the passenger touch screen, while the windscreen also contains information to show.

9.1.2 Main Instrument Panel And Touch Pad

The main instrument panel in front of the steering wheel shows all the main driving information and the infotainment for the driver. Push the power button to start the car, the fingerprint system that located on the power button, will automatically recognize who is the driver, and set every facility inside the car to the specific driver's mode. The main instrument panel lights up with a welcome page [figure 25].

The touch pad is the main control unit to the dashboard, by using different finger gestures, different command can be sent by the driver. There are four short cut keys under the touch pad as well, which are direct link to media, navigation, driving mode selection and natural speaking function on/off.

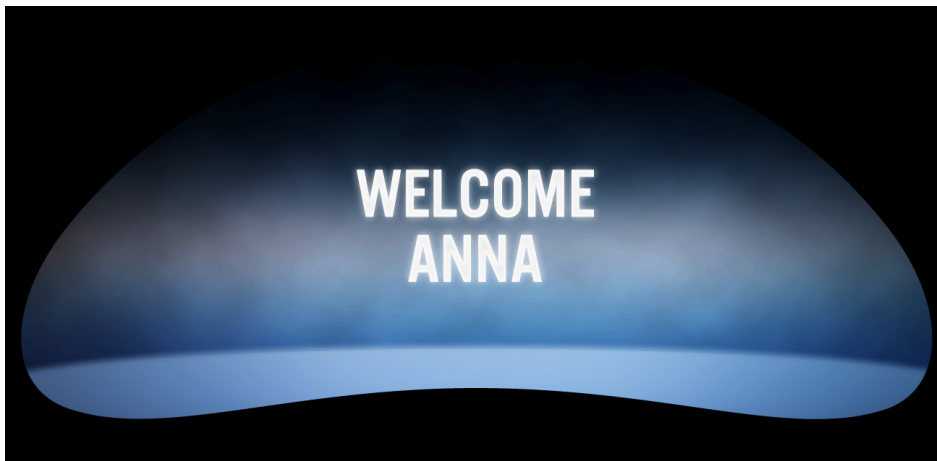


Figure 25 Welcome Page Of Opening For Standard User

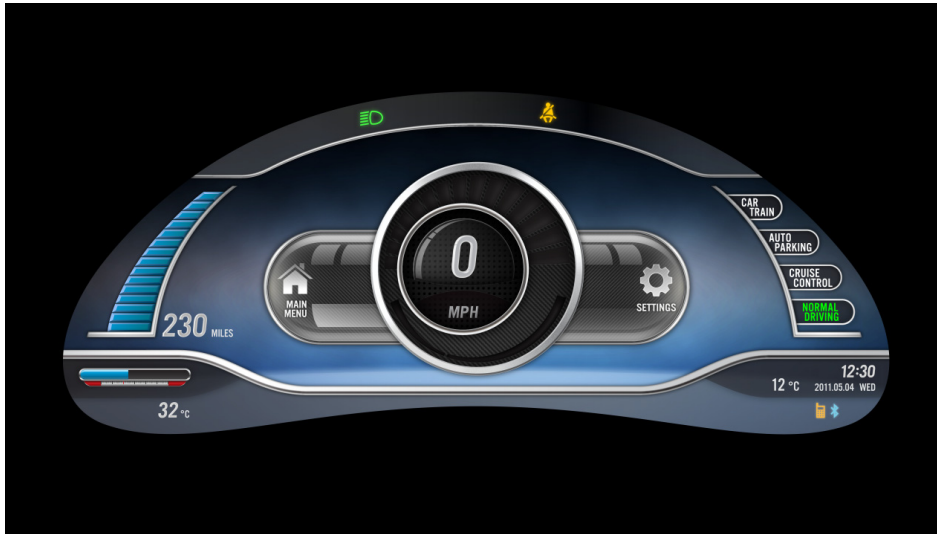


Figure 26 The Main Instrument Panel Of The Standard User With No Speed On
After the welcome page, all the main instruments come afterwards [figure 26]. The speedometer locates in the center of the dashboard, with showing the current speed and the power meter. The two instruments locate both sides are main menu and settings, to switch to them, use four fingers wipe to left/right. To change the driving mode, press short cut key “driving mode”, and use two fingers wiping up and down to select, click to confirm.

Besides the controllable instruments, to the left side is the battery status, showing the current power ability and the distance left to travel. To the left side of the bottom bar there is the thermometer showing the battery temperature, and the right side is basic information including time, date, Bluetooth status and connection status to third party facilities. The top bar shows all the indication and the warnings when it is needed.

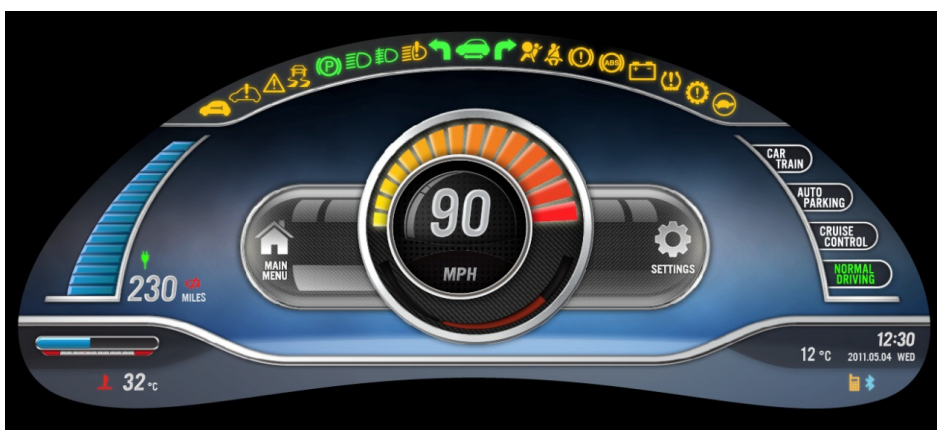


Figure 27 The Main Instrument Panel Of The Standard User With All Indications And Warnings On



Figure 28 Low battery status and abnormal battery temperature

In the Figure 28, when the car is in the low battery status, the blocks will turn to red color, with a low battery sign aside to warn the driver, meanwhile, the car will automatically slow down the speed, with a warning sign on the right top. When the temperature goes abnormally the thermometer will also turn red as a warning sign to the driver.



Figure 29 Driving mode status section and right side of lower information bar

The driving mode section is located at the right side of the dashboard. Besides normal driving and cruise control functions, there is car train, which allows the driver following another car and completely relaxed from driving, and auto parking, which can automatically park the car into right position, being added. The apps except telephone are only available to use when the car is under control of car train and auto parking.

The right side of lower information bar shows some basic information, e.g. the current time and outside temperature, the date of today, and the connection status to the mobile phone and the on/off status of the Bluetooth.

9.1.2.1 Main Menu



Figure 30 The Main Menu User Interface

The main menu is divided into three sections: The navigation, the media and the apps. The navigation and the media are the most widely frequently used applications so they are separated from all the other apps. By choosing the different section, using two fingers wipe up or down on the touch pad.



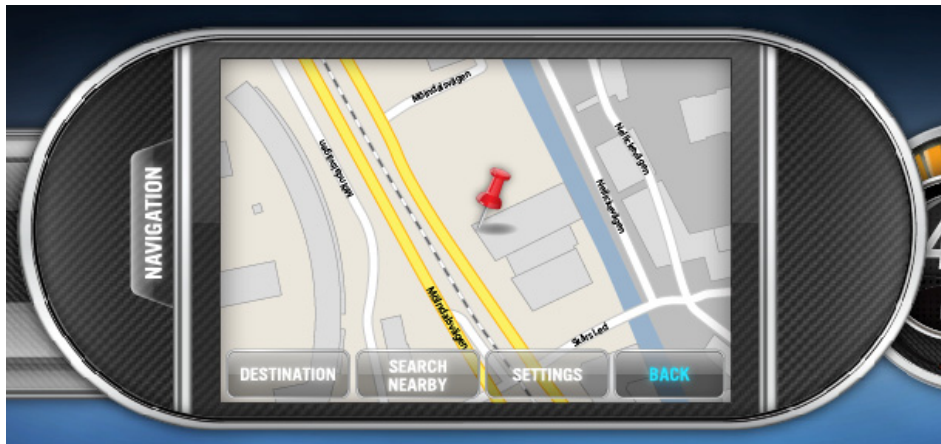


Figure 31 The navigation page user interface

The figure 31 shows the main look for the navigation page. The functions within the navigation section are pretty simple, there are destinations, in which the driver can search the targeted place where to go; in search nearby, various facilities around the current position can be found; the settings menu allows the user for customization.

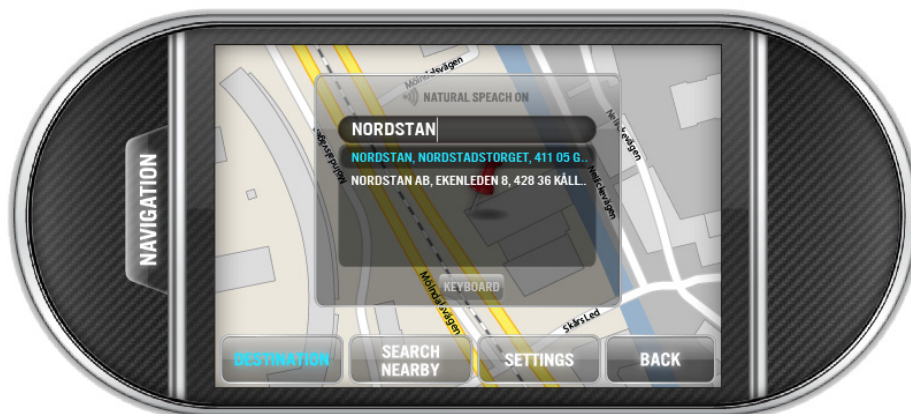


Figure 32 The destination input page

The navigation system are accompanied with naturel speaking function, which means the system becomes smarter to recognize the place or the addresses that the user said and give out the answer more correctly. To set a destination, the user need to make sure the naturel-speaking button is on, and speak the destination's name to the car. The car will process one or more possibilities, then the user can select the answer by wiping two fingers up or down on the touch pad and confirm the answer by clicking or say positive word to the car. If the right destination is not among the list, the user

can let the navigation system search again or directly type in with the keyboard embedded.

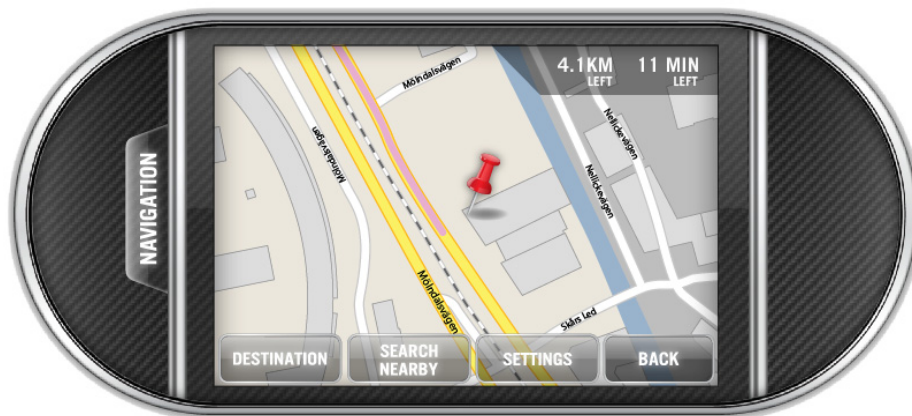


Figure 33 Processed route by the navigation system

After confirming the right destination, the navigation system will process a route, and showing the distance ahead and time left to reach the destination. If there are inconvenient traffic situation on the route, e.g. traffic jam, traffic restriction controlling etc. The navigation system will be automatically updated and tell the driver [Figure 33]. The driver can decide if he or she would like to change the route, the navigation system will reprocess the route after the decision [Figure 34].



Figure 34 The traffic information updated from the navigation system

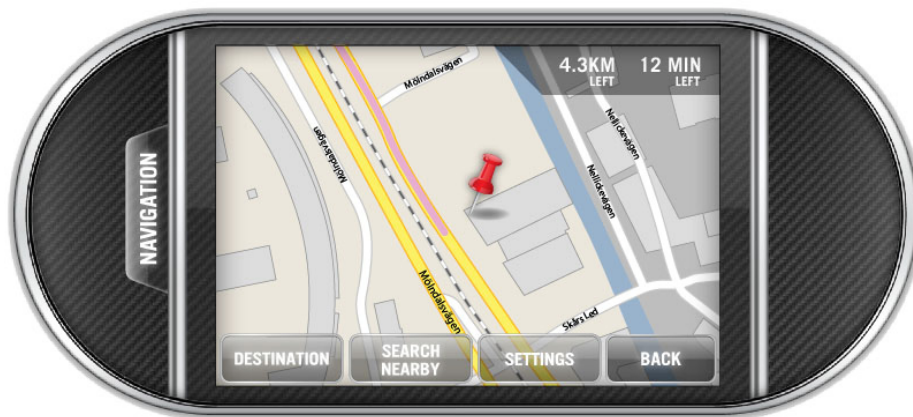


Figure 35 Reprocessed route after the driver's decision from traffic information updated

In search nearby, the driver can search different facilities, e.g. the restaurants, the parking places, etc. like the above, and naturel-speaking input can recognize different target places smartly [Figure 36]. The navigation will show these places in the map around the car's current position [Figure 37]. The system will also show different information for these places, e.g. the rates for the restaurants or the available parking positions situation in a parking place.

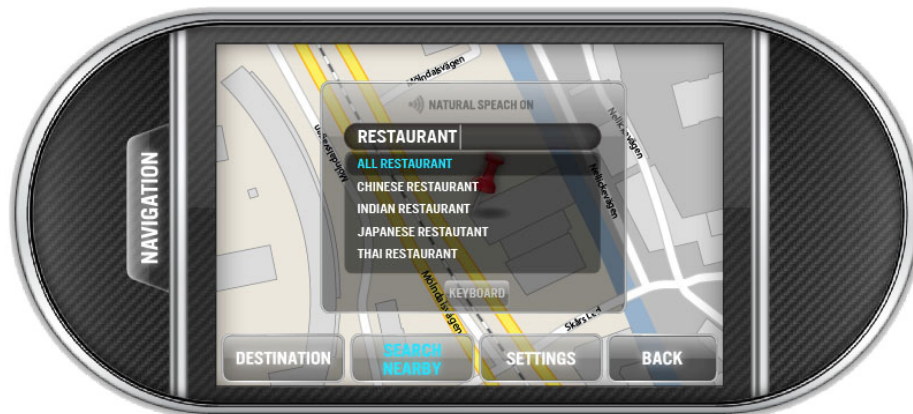


Figure 36 Search restaurants nearby by naturel speaking input



Figure 37 Searching results shown in the navigation map

In setting menu, there are switch for voice guide, map style (2D or 3D), map update and traffic information, for customization [Figure 38].



Figure 38 Navigation settings menu

Media



Figure 39 Media page user interface

The media section combines all the music and radio players and apps together. The user can create playlists not only from the local sources but also the Internet sources and third-party applications. It is also possible to go to these third-party applications' pages by clicking the icons at the left bottom side. The driver can also access to the radio channel and listen to the radio [Figure 40].

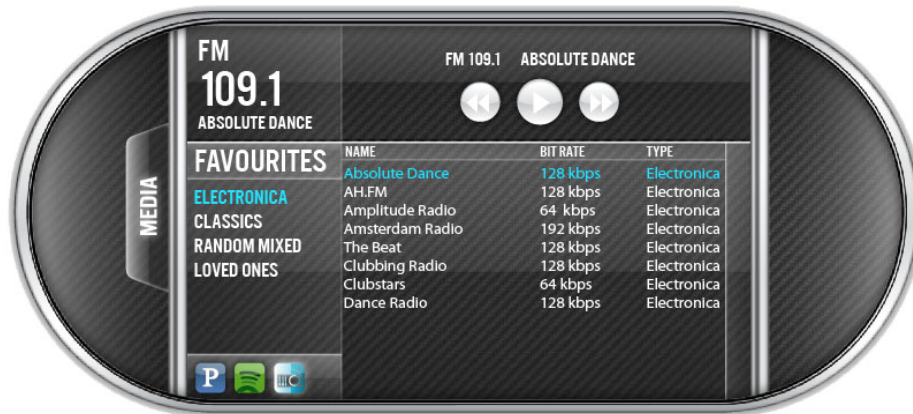


Figure 40 Radio channel in media section

Apps



Figure 41 Apps page user interface

Apps section includes the four basic apps: Telephone, email, Internet and calendar, embedded in the system initially [Figure 41] and other downloadable third-party apps from apps store. Only the telephone function can be activated in all the driving modes. The other apps are only available in car train and auto parking driving modes; otherwise they will turn grey [Figure 42].



Figure 42 Apps page during cruise control or normal driving mode





Figure 43 Four basic apps user interface

9.1.2.2 Settings menu

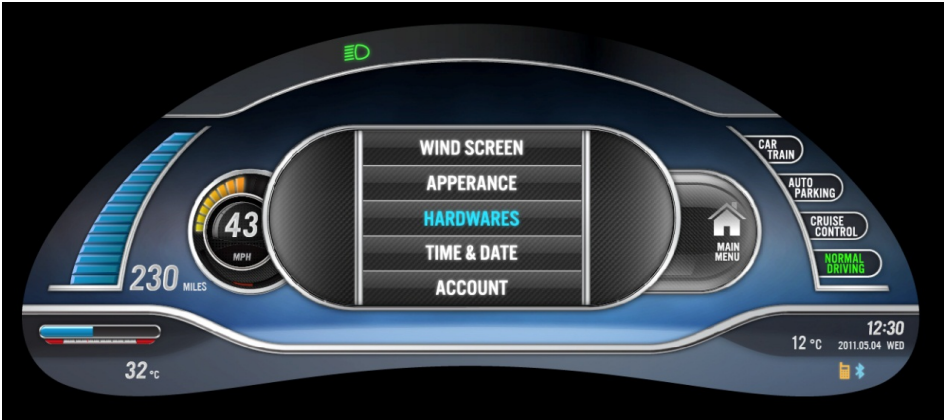


Figure 44 Settings menu user interface

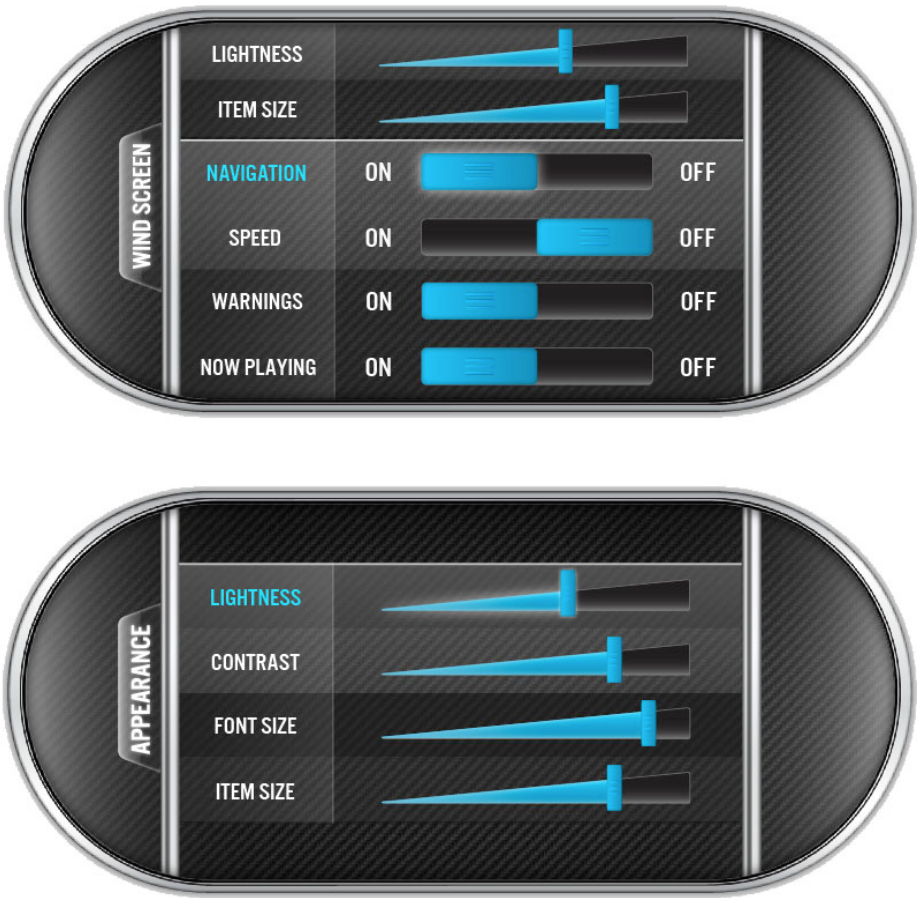




Figure 45 User interface of windscreen, appearance, hardware, time & date and account settings

The settings menu is divided into five sections: windscreen, appearance, hardware, time & date and account. Each of them has several things to be adjusted as shown in the figure 45 when get into the settings menu, use two fingers wiping up and down to select. While getting into the specific menu, the same wipe two fingers and click to select, and use one finger wiping to adjust. While in the account setting, naturel-speaking will recognize the talk and put in the names.

9.1.3. Climate Control And Passenger Touchscreen



Figure 46 General look of the climate control and passenger touchscreen

The climate control and passenger touchscreen are located at the center stack and the passenger front panel. There is part of the passenger touch screen situated in the center stack, together with the climate control. The running apps are shown there, so that both the driver and the passenger can click them and activate them in their window. The driver should click and drag left and the passenger should click and drag right.

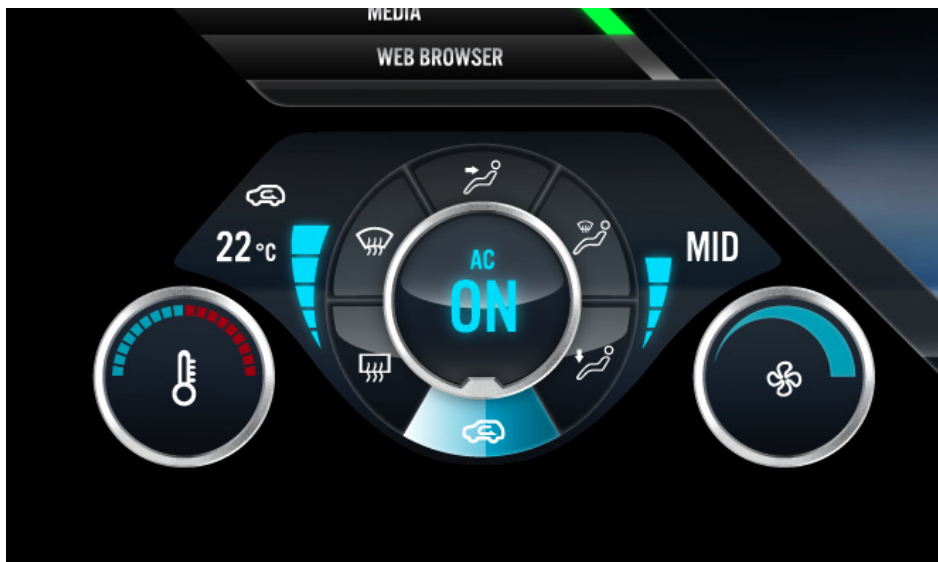


Figure 47 Climate control system user interface

The climate control is right in the middle of the center stack, so that both the driver and the passenger can control it. There are three physical knobs: temperature adjusting knob, wind speed adjusting knob and the mode select & on/off switch. Since climate control is one of the operations that driver will frequently use, easy to reach and operating without watching it turn out to be the main issues. Thus, the three physical knobs are remained. Also on the mode select knob, there is a bulge to indicate which mode is selected, so that the driver can just by touch it to know that.



Figure 48 Passenger touchscreen user interface

The passenger touchscreen have a lower bar [Figure 48], which has all the applications that dashboard main menu has. This allows the passenger to use all the apps as well.

9.2 Expert User Final Concept

Driving Systems and General Features

Fuel Type and Capacity: Gasoline, 80L

Max Speed: 160 mph

Interior Layout



Figure 49 Interior layout of expert user car

Compared to the standard user concept, the interior of expert user is modified on the gearshift because of its gasoline power.

9.2.1 Main Instrument Panel and Touch Pad



Figure 50 Expert user car dashboard user interface

Unlike the electric powered vehicle, the expert user car still remains the instruments belonged to the gasoline vehicles. Main menus and system settings are at the right side to the dashboard while the performance settings is at the left side. General information and driving mode menu are at the bottom side with the warnings and indications located at the top.



Figure 51 Speedometer, tachometer, thermometer and other driving info instruments

For the expert user using, the driving and performance information are more on the screen. Besides the speedometer, the dashboard has information about the mileage, engine RPM, engine temperature, fuel amount and fuel per bar, located aside the speedometer [Figure 51].

Same with the standard user car, the expert user one also has the touch pad to control the dashboard instruments. Four fingers wipe to right once for main menu, wipe to right twice for system setting menu. Wipe to left for performance settings menu. Wipe to top for the driving mode selection.

Figure 52 and figure 53 show all the user interfaces in main menu and system settings, which is mostly the same with the standard users in content.

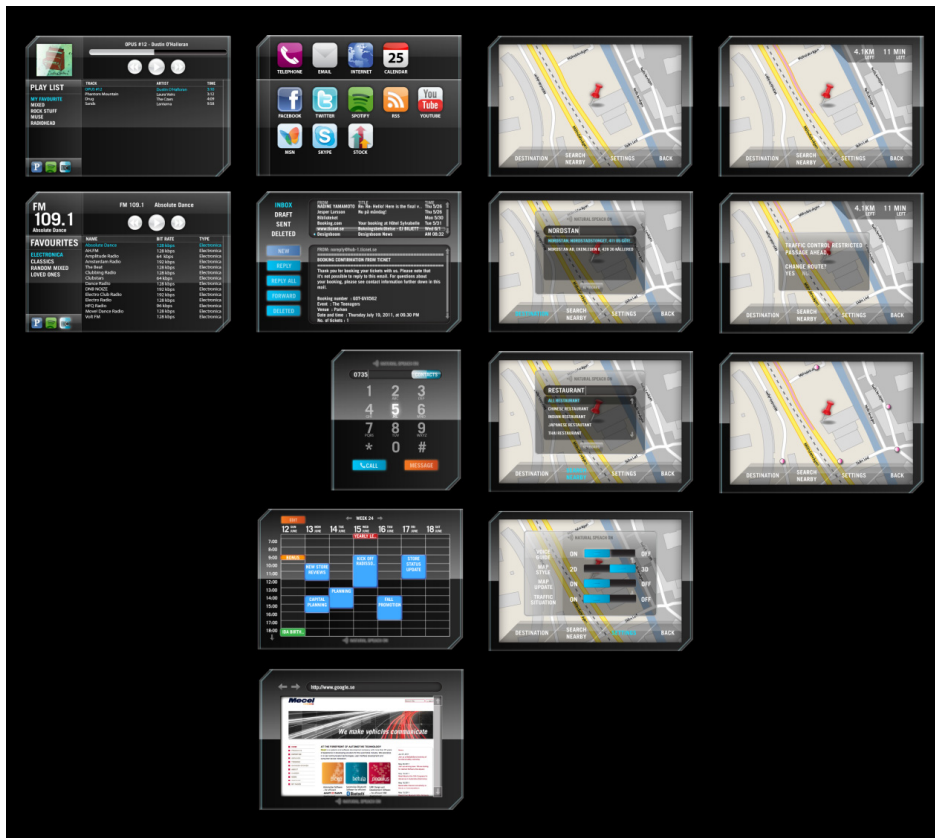


Figure 52 User interface of applications in main menu



Figure 53 User interface of system settings menu items

9.2.2 Climate Control And Passenger Touchscreen

The figures below show how the climate control and passenger touchscreen look. The function layout is the same with the standard user one, while the style goes together with the expert user dashboard design.



Figure 54 Climate control and passenger touchscreen of expert user car

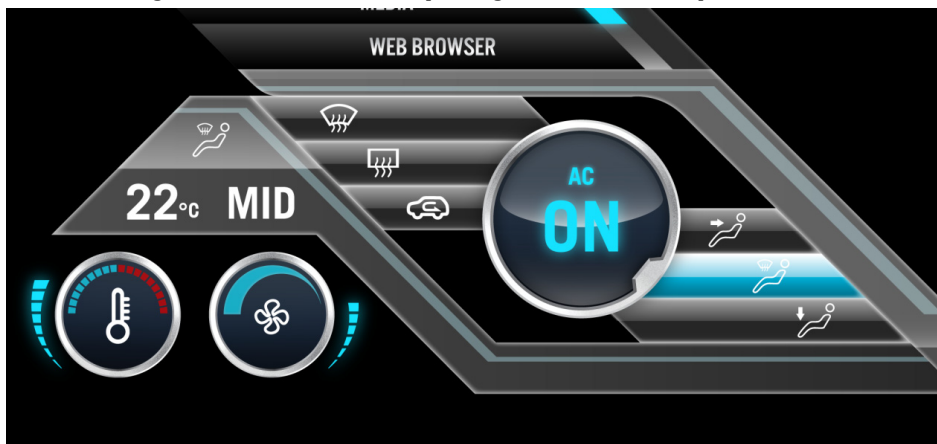


Figure 55 Expert user climate control user interface



Figure 56 Expert user touchscreen user interface

10 Discussion

10.1 Method Discussion

Kommentar [N1]: refine

10.1.1 The HMI Development

The development process is set at the beginning of the project. It is based on authors' knowledge upon product development process. The actual process remains the same but the evaluation phase is shortened. The evaluation phase supposed to include a usability test. Since the purpose of this study are to explore the possibilities of personal vehicle in 2020 and create aesthetic visual materials. The usability evaluation is not practically necessary to fulfill the tasks. Due to the technological and time constraint, the mock-up of HMI and cockpit are not feasible. The usability test is canceled but remains usability inspection and technical check. However, the further development of these HMIs requires comprehensive usability analysis to secure the safety and feasibility.

Since the thesis topic is futuristic, the development focuses on explore the new features of personal vehicle and decides which features are more likely being applied on personal vehicle in 2020. And therefore, workshops and discussions with experts took up large proportion of entire process. Besides, Mecel specially emphasizes on visually attraction to their customers. The visualization also took up fairly large part of development process. At the beginning of the thesis, the scope and requirement are loosely set, the pre study phase is specially set to define the project and narrow down the scope.

10.1.2 Workshop

Workshop is designed to explore the possibilities of personal vehicle from different perspectives. When design the HMIs, it turned out that workshop is one of the most useful methods. The outcomes of workshops provide numerous feasible features and ideas from technologies and user-centered perspectives. There are several reasons of why workshops contribute most to the project. Firstly, the participants are at their ages of 23 to 29. They are the potential users of personal vehicle in the future. Their opinions upon personal vehicles largely represent the young generation who will be the target user group in 2020. Secondly, the participants mainly divided into two categorized. One group has automotive engineering background while the other has industrial design engineering background. The former provides mostly new technical

features and trends which developers are likely familiar at the beginning of the project. The latter is considered having rich knowledge regarding user-centered design. Their discussions provide a lot of ideas and thoughts from user's perspectives. Thirdly, most of participants are active and talkative. They consistently present their opinions, explain the ideas and discuss in a nature approach. For each workshop, the presentations and discussions are all recorded. Their notes are also kept. When design the HMI, these materials inspire the developers frequently.

10.1.3 System Description

System description is applied to understand the entire automotive system. This is important to the authors, since none of authors has rich driving experience. To investigate the system elements, three cars were studied. The study directly contributes to the design of functional layout, because the project topic is futuristic and conceptual but not inventing a car. Furthermore, to map the relationship of users and the functional units, the authors acknowledge the priority of functional units. It allows authors to locate the functional units into appropriate functional areas.

10.1.4 User interview

The user interviews contribute largely to the personas and scenarios. Through the interviews, the authors acknowledge the actual use context and users. The outcomes from mental models demonstrate how the user interacts with the car. Also, the use cases when driving are provided.

However, besides the inputs to scenarios, user's interviews supposed to contribute to identify user needs. This part is not filled due to the users considering mostly upon the existing driving environments and physical components.

10.1.5 Observation

Observation is designed to understand the actual context of driving. The ideal process should be following a user to record an actual use case. However, when arranging the observations, the time for the two volunteers is unlikely use the car. The activities are actually helping authors. The observation remains on actions level. The observation contribute partly when design functional hierarchy.

10.1.6 Persona, Scenarios and use cases

Personas and scenarios are important outcomes from the research phase. They illustrate the summaries of user study. For this thesis projects, persona and scenarios make designs possible through narrowing down the scope. After persona and scenario set, the use cases are able to be brainstormed.

10.2 General Discussion

As generated in the beginning, the initial purpose of the two HMI designs is clarified: exploring the possibilities of personal vehicles in 2020, with an emphasis on both the function layout and the visualization. Together with the delimitations, it has directed the whole master thesis process. The entire work went successfully in general, according to the purposes and the delimitations.

The Reliability

The purpose of this master thesis is to explore possibilities, which means to give out a suggestion about what is likely to happen in the year of 2020. And this suggestion is mostly based on two facts, the cognitive needs of the user and the technical possibilities in 2020. According to this, the final design is not a concrete answer to the question. It is still a guess, but with exploring and demonstrations. This cannot be guaranteed to happen for sure, since the future is a very uncertain fact: the technology development cannot be predicted exactly; the society and culture progressing is constant, all of these make the future needs are not concretely answered, even though it can be concluded and predicted somehow by the fact of today. In general, several things result an uncertainty to the final results of this study.

The Feasibility

The feasibility of the function layout and the visualized HMI still needs to be examined. The purpose requires the function layout contains features that future needs and technically possible, and the HMI layout to be visually attractive. Thus, the usability issue is considered mostly based on the experiences from the master thesis worker, limitedly from the research. To make the HMIs fully worked, it needs quantity of deepened researches, experiments and evaluations to be finished.

The Supportive Components

The main work of the design phase is the function layout and the visualization of HMI. Objectively, the final design cannot stand solely on these two contents, e.g. the function layout refers to several physical assemblies. So the final design consists several parts are not included in the design purpose, such as physical models of the cockpit layout, the touchpad and shortcut keys on the steering wheel. They are in a

supportive way to explain the functions and the HMIs, but not as part of the design in the results.

The Development Process

As planned in the beginning of the study, the process is planned to have the pre study phase first, about searching future technologies and theoretical studies, as well as setting up a clear purpose of the master thesis and the delimitations. Second for the research phase, with the applications on several methods mentioned before. Then is the design phase, including the function layout design and the visualization. The development process structure is proved to be good in general; it allows the information and results efficiently processed from one stage to the next, while there are still some actual problems existing. In the pre study phase, the setting up of the purpose and delimitations is done too curtly and subjectively. For example, the two user groups are decided due to the very different profiles they have, which may ease to distinguish the two user groups and the results. But the fact is, the expert user group as expected is a rare colony in the society, which makes it is much more difficult to find the ideal expert users to do the research as to support the final design.

Some of the research methods are mainly about the usability issues, while in this case it stands for a second position. The user interviews and the contextual study contributed limited effort to the design development.

In general, the topic of this thesis is a vast one and did not set up a concrete scope at the beginning for a master thesis project. If the time for the entire development process is prolonged, it will be major effective for the final design.

The Master Thesis Topic

The master thesis topic has not been clearly identified in the beginning, for example the targeted users, the scope for the designing objects within this large topic. While it is also time consuming to narrow down the thesis topic, the work that is going to be finished should balance with the time issues as well. As a matter of fact, the master thesis topic could be limited in some way to direct the whole study clearly, e.g. focusing on one user category or a single part of the HMI, which could lead to a more concrete HMI design on every aspect of the purposes

Sustainability Aspect

The final design improved experience and time management of potential users in general. The final designs of HMI are considered as sustainable in a way of supporting future alternative powered vehicle.

11 Conclusions

The final design can be considered that has fulfilled the purpose of this master thesis: exploring the likely future function possibilities and visually attractive HMI, and answering the question of how could the personal vehicle HMI be in the near future. The final design demonstrates the answer of the question. To summary, the personal vehicle HMI will be smarter, intuitive, safer, customizable and aesthetic.

The result of this study receives positive feedback from Mecel AB. At the meantime, there are still reliability issues, which lay in the function hierarchy, the steering wheel layout and the cockpit layout. To further develop them, comprehensive usability analysis is required.

The development process is generally good, but with some issues. Since the initial topic is uncertain and has a very large scope, to minimize the research and design scope becomes very important in this issue. Thus, extending the pre study phase is quite necessary. Besides this, the consideration of methods using is not very accurate, which can be improved when there is more time doing the theoretical study in pre study phase. Also to make the final results more concrete, a detailed and convincing evaluation should be carried out. In general, the study procedure can be maintained with more time put into the pre study and evaluation, this is highly recommended to these kinds of projects.

The whole project is constantly inspiring for both authors, with knowledge study on vehicle technologies and research theories. It is also a highly self-motivated project, with many decisions on processing the thesis development. Unlike usual industrial design project, this study concerns a lot of expanding knowledge. Also the design objects and contents are various and vast, which lets the authors to narrow down the thesis topic by themselves.

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Appendices

Appendix A Market Analysis

Appendix B Workshop Materials

Appendix C System Descriptions

Appendix D Target User Interview

Appendix E Scenarios And Personas

Appendix F Functional Hierarchy

Appendix G Visualization Inspiration Board

Appendix A Market Analysis

1. 1 Standard User Car

Car	Range	Performance	Fuel economy	Bottom Line	Capacity
Nissan Leaf	60 to 110 miles	Speeds up to 90mph, Zero Emission Vehicle (ZEV)	100% electric- no gas required	\$ 32,780	5 P
Wheego LiFe	100 miles	Top speed 60 mph	100% electric- no gas required	\$32,995	2 P
Smart Electric Drive	83 miles	ZEV, better performance than Mercedes A-Class	Electric version of the Mercedes A-Class, battery pack sourced from Tesla Motors	\$44,837	2 P
2011 AVEO 5			35 MPG HWY	\$12,115	5 p
2011 Smart Fortwo Cabriolet			41 MPG HWY	\$17,690	2 p
Mini Cooper		Top speed: 128 mph	37 MPG HWY	\$20,100	4 p
Coda Sedan	90 to 120 miles	Top seed: 80 mph Acceleration is strong in on-road tests, and a zero to 60 time of under 11 seconds is promised.	Electrical	\$44,000	5 p
Think City	125 miles	Top speed: 62 mph, 0 to 30 test: 6 seconds	Electrical	\$35,000	

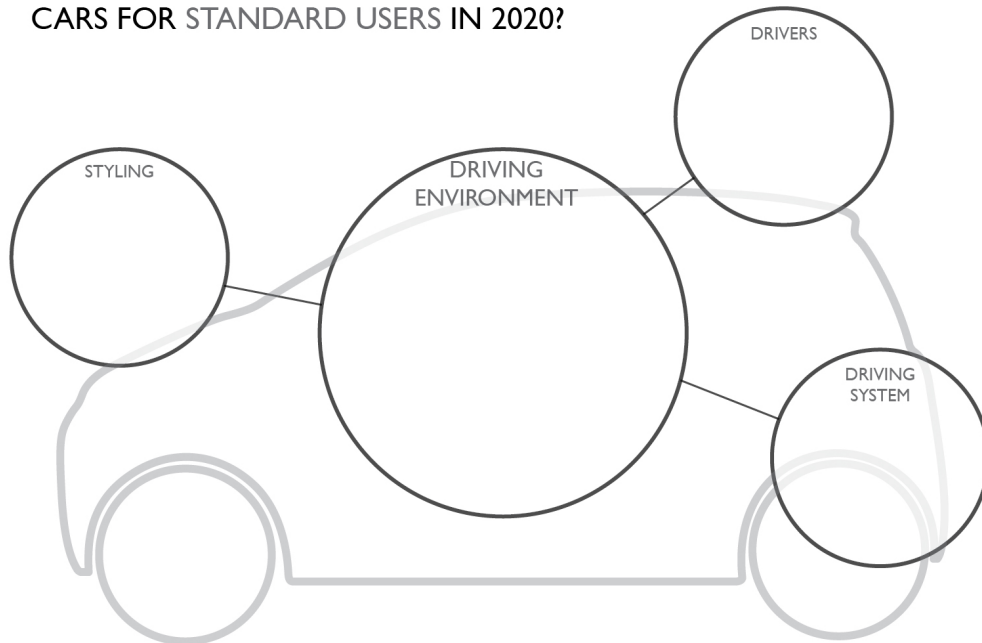
1.2 Expert User Car

Car	Horsepower	Performance	Fuel Consumption	Bottom Line	Capacity
Audi A3 2.0 TFSI® Manual	200 hp @5100-6000 rpm	Top speed:130 mph 0-60MPH 7.1 sec.	MPG: 21 city/ 30 hwy	\$ 27,270	5 P
2011 Acura ZDX	300 hp@6200 rpm		MPG: 16 city/ 23 hwy	\$45,645	5 P
BMW 5 Gran Turismo	300 hp	Top speed: 150 mph 0-60 mph 6.2 sec.	MPG: 30 hwy	\$56,500	5 P
2011 Mazda MAZDASPEED3	263 hp @ 5,500 rpm	Top speed: 155 mph	MPG: 18 city/ 25 hwy	\$23,700	5 p
Porsche Panamera 4S	400 hp @6,500 rpm	Top speed: 175 mph 0-100 km/H 5 sec.	MPG: 16 city/24 hwy	\$93,800	4 p
Honda Accord Crosstour 2WD model	271hp @ 6200		MPG 17 city/25 hwy	\$29,670	5 p
2011 Volvo C30 Geartronic Transmission	227 hp@5000 rpm		MPG 21 city/30 hwy	\$24,600	4 p
2011 Volkswagen Golf TDI Clean Diesel 4-Door	140hp @ 4000	Top speed: 125 mph, 0 to 60 test: 8.6 sec.	MPG 30 city/41 hwy	\$23,885	5 p

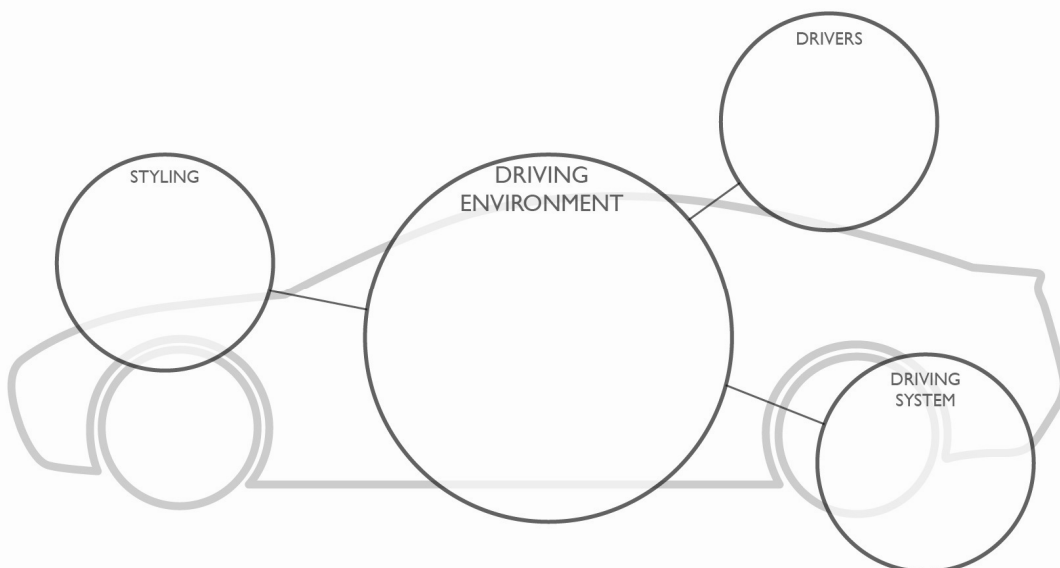
Appendix B Workshop Materials

2.1 Workshop Answering Board

CARS FOR STANDARD USERS IN 2020?



CARS FOR EXPERT USERS IN 2020?



2.2 Workshop Inspiration Board And Mood Boards



2.3 Workshop Answers

2.3.1 Standard Users

Driving Environment	Driving System	Styling	Drivers
Voice Command, Joystick	GPS plus memory to adjust driving route properties	Remake of Old Classic Cars	Richer than today
Programmable Horn Sign	Thinner, more fuel efficient tire	Smaller	Less Teenagers
Memory functions: Recognizing drivers and adjusting, seat, AC, etc.	Gasoline will still be dominate but alternatives will increase in popularity	More Premium	Less Urban Drivers because more developed public transportation
Bigger Interior Space	Methanol Gas	Quality Feel	The Same users as today, but maybe it is hard for old people to use new technology
Instead of analogue gauges, Big Digital Displays Configurable	Hydrogen	Real Materials	Easier for women and people with disabilities to drive
Active Safety System, Warning Interface - Stand out from "Standard" Interface	Hybrid	Bit of Retro	More Casual Drivers, relies more on help system
Connectivity to Cellphone, Mp3. etc.	Electric	More Streamline and Smoother Curves	Older Drivers possible because of new safety features
Internet	Green sources like wind, hydro, solar	Various Styles due to different tastes	Not the owner, leasing
New Information - Battery State, Current Efficiency	Kinetic Energy Recovery Systems (KERS)	More Aerodynamic efficiency for low fuel consumption	Not the owner
Controls For Assistance Function - Auto Parallel Parking	More Hybrids	More or bigger windows	More single car
Instead of Normal Operating, Buttons for radio and AC and etc.	Automatic transmission - electric drive	Compact Style, lower cars	Everyone has his or her car in the family - single seated car
We will have computer touch screen with highly graphical Interface	still long range	Entire Vehicle area can be used for passengers and luggage	Computer car train might be soon for commuters
Have screen and controls as interface on the steering wheels instead of pedals	No hybrids - one well developed system is better	See the A Pillars (More visible area)	Lower age
Satellite Navigation System becomes a standard with traffic jam updates	Down sizing	Moving away from traditional car styling	Profession
Internet Connection becomes standard for Spotify and such	Hybrid/Electric	Aerodynamic	
Night Vision Windscreen	Faster cars with faster	More standardized	

	reaction system	Modules	
Automatic Gearbox	Autonomous		
Warning system on Sides of the Car	More computerized - both cognitively and physically		
Touch Screen - Intuitive while driving?	Family tracking system		
Autopilot	Satire Feedback System. Windscreen is the stimuli		
Entertainment for drivers?	Smart GPS		
Platform, will not need to resemble old ones	Electricity		
Complete Autopilot, no driving at all.	Sunlight		
Active Safety	Induction Energy		
Automatic System - Windscreen wipes, head light settings, Gear box	Automatic Gearbox		
Touch Screen - will soon be outdated?			
Automatic Parking			
Small TV			
Public Transportation consisting of single vehicle			
Voice Controlled systems instead of buttons			
Apps for the car - Virtually reading system			
Program the destination and auto driving			
Having sensor on the ear to control speed			
Office in car, maybe not the best			
Entertainment			
Relax - if you don't want to drive then use public transportation			
Socializing			
Eating			
HUD			
Integrated Wireless Computing			
Turn Down Windows			
Advertising in the car			

2.3.2 Expert Users

Driving Environment	Driving System	Styling	Drivers
High-Tech Information, including Tire Pressure, Engine Power	Hybrid Systems	More Premium: Quality feel, “real” Materials, Controls & Lights Derived from racing	40s(Midlife Crisis)
Performance Adjustment: Down force, 4WD, Differential Settings	Electrical	Leather and Luxurious Materials	Rich
Adjustable Seat Side Support	Interchangeable Batteries	Wider Wind screen	Male (Mostly)
Simulated Gear Shift (For Single Speed Gearbox)	Fuel Cells	More Steel and Black Material	Rich
Simulated Engine Noise	CVT (Continuously Variable Transmission)	Active aerodynamics “Moving Wings” on body	Educated Drivers
Voice Command	Active Flow Control, to reduce Aerodynamic drag	No Rear View Mirrors	Not necessarily traditional car lovers but also people interested in computer science and such
Less Buttons, Less Functions (Sports Car)	Auto Driving System which will let the driver to rest for some minutes, let the car drive by itself	No Friction Surface	Well trained drivers
Less Buttons, Functions into menu system (Grand Tourer)	Safety System that intervene with your driving (like braking for you to avoid hitting a pedestrian	Smooth or Edgy	Car Train - Communication between expert user
Head-up Display with RPM, Speed etc.	Full Electrical	Adjustable tilted windows	Pleasure Enjoyment Drivers (Motorcycle)
More Intelligent Navigation System	Range Extended - Vehicle	Make your own pattern in head and rear lights, area of LEDs	Personalized, turn the car while you have it
More Information to the Driver about Eco Driving and Safe Driving	Torque Vectoring	Low and wide	Embrace new Tech.
Voice Control for Different functions like say 20 degree temperature, the car does it by itself	Customizable Power Distribution	Old Fashion Car. Basic Car Cues	Want the good old days back
Surround Warning System	KERS. But is there a need to brake?	Individuality, Customizable	Driving out for joy
More Cameras	Diesel	Mass customization	Owner
Steer by Wire	Composites	More Unique cars	Owner
Paddle-Shifting	Adjustability	More Aerodynamic	Part time owner, maybe a limit number of people
More Settings, e.g. Control Over Tire Pressure	Not autonomous	Old School Cars	
Driver aids optional, but many still mechanical feel and mechanical units	Manual Gearbox		

Seats that shapes themselves for every driver	Faster		
entire dashboards customized, access to all data from CAN(Controller Area Network)			
Center Position seat, racing feeling			
Individuality, Customizable			
Head-up Display with 3D Projection			
Internet			
Adjustability - Integration with your own Gadgets			
Want more manual control over: roads, speed, control, feedback, noise			
Louder noise but only inside the car			
Multi mode like JAS			
Driver Focused Aids			
Information about other drivers			
Electrical Steering			
Visual Aids			

Appendix C System Descriptions

3.1 SAAB 93 2.0T System Study

Door & Other Instruments



Figure 3.1 Classification of Instruments for SAAB 93 2.0T Interior

3.1.1 Main Instrument Panel

Center Gauge

- Speedometer: Current/Highest Speed
- Odometer: Overall Distance Travelled
- Trip meter: Temporary Distance Travelled
-

Right Gauge

- Temperature Gauge: Current/Dangerous Temperature of Coolant
- Turbo Gauge: Current/Dangerous Air Volume of Combustion
- Fuel Gauge: Current/Highest/Warning Fuel Amount

Left Gauge

- Tachometer: Current/Dangerous Rotation Speed

Warning Signals

- Antilock Braking Warning
- Low Brake Fluid Level Warning
- Parking Brake Release Warning
- Check Engine Warning
- Low Battery Warning
- Low Tire Pressure Warning

- Low Oil Pressure Warning
- Low Fuel Warning
- Safety Belt Buckle Up Warning
- Airbag Fault Warning

Indicators

- High Beam Indicator
- Front Fog Light Indicator
- Headlight and Parking Light Indicator
- Cruise Control Indicator
- ESP On/Off Indicator

3.1.2 Steering Wheel

Left Control Stalk

- High/Low Beam Control
- Left/Right Turn Signal Control
- Headlight Flasher Control
- Cruise Control

Right Control Stalk

- Windshield Wiper Control: High/Low Speed, Auto, Single Sweep, Off
- Washers Control
- Rear Window Wiper Control

Wheel

- Mechanical Steering Control
- Horn
- Steering Wheel Position Adjustment
- Volume Control
- Forward/Backward Control
- SRC
- Phone call & Hands free Button

3.1.3 Central Control Panel

Central Top Display

- Time/Date
- Passenger Seatbelt Reminder
- Radio Channel
- Telephone/Climate Control Status

Climate Control

- Temperature Control
- Wind Direction & Distribution Control
- Seat Heating (Left & Right)
- Window Heating
- Fan Speed Control
- Recirculation Control
- Hazard Warning

CD Player

- CD Selection Buttons
- CD Import Buttons

Display System

- Radio
- CD
- Navigation
- Address Book
- Telephone
- WAP Browser
- System Settings

Other Instruments

- Dashboard & Central Panel Lightness
- ESP Control

Gear Shift

- Reverse Gear
- Neutral Gear
- Drive Gears: 1-6

Handbrake

Cup Folder

3.1.4 Door & Other Instruments

Window & Door Controls

- Window Switchers
- Rear Window Deactivates
- Door Open

Exterior Rear View Mirror

- Mirror Selection
- Mirror Position Adjustment
- Reversing Position

Steering Wheel Left Side Panel

3.1.5 Interior Rear View Mirror, Ceiling & Driver Seat

Interior Rear View Mirror

- Garage Door Open
- Auto Dimming/Compass ON/OFF
- Compass Bearing

Ceiling Control

- Interior Lighting Control
- Moon roof Control

Driver Seat

- Seat Position Forward/Backward Control
- Backrest Angle Adjustment Knob
- Headrest Height Control

3.2 Volvo V70 2.4 System Study



Figure 3.2 Classification of Instruments for Volvo V70 2.4 Interior

3.2.1 Main Instrument Panel

Left Gauge

- Speedometer: Current/Highest Speed
- Fuel Gauge: Current/Highest/Warning Fuel Amount
- Trip meter: Temporary Distance Travelled

Right Gauge

- Tachometer: Current/Dangerous Rotation Speed
- In-Car Temperature
- Clock
- Parking Indicator

Warning Signals

- Antilock Braking Warning
- Check Engine Warning
- Low Battery Warning
- Low Tire Pressure Warning
- Low Oil Pressure Warning
- Low Fuel Warning
- Airbag Fault Warning
- Fault in the active bending light system
- Generator not charging
- Fault in the brake system

Indicators

- High Beam Indicator
- Front Fog Light Indicator
- Parking brake applied

- Stability system indicator
- Seatbelt reminder
- Left/Right turn signal indicator
- Information Symbol, see text in ID

3.2.2 Steering Wheel

Left Control Stalk

- High/Low Beam Control
- Left/Right Turn Signal Control
- Headlight Flasher Control
- Cruise Control

Right Control Stalk

- Windshield Wiper Control: High/Low Speed, Auto, Single Sweep, Off
- Washers Control
- Rear Window Wiper Control

Wheel

- Horn
- Steering Wheel Position Adjustment
- Cruise control
- Audio controls

3.2.3 Central Control Panel

Audio System Controls

- CD Selection Buttons
- CD Import Buttons
- Internal Audio Source
- External Audio Source
- Sound Setting Knob
- Volume and no/off
- Navigation button

Climate system control

- Ventilated front driver's seat
- Blower

Others

- Stability System on/off button
- SYC Control

Gear Shift

- Automotive gear

Handbrake

Store space

3.2.4 Door & Other Instruments

Window & Door Controls

- Window Switchers
- Rear Window Deactivates
- Door Open

Ceiling Control

- Interior Lighting Control
- Moon roof Control

Driver Seat

- Seat Position Forward/Backward Control
- Backrest Angle Adjustment Knob
- Headrest Height Control

3.3 Nissan LEAF 2011

Door & Other Instruments



Figure 3.3 Classifications of Instruments for Nissan LEAF 2011 Interior

3.3.1 Main Instruments Panel

Top Display Panel

- Speedometer: Current Speed
- Clock
- Outside Temperature
- Indicators: Turn Signals; ECO Indicator
- Master Warning Light: Very Limited Driving Range

Battery Information

- Current Available Battery Charge
- Battery Capacity Level
- Driving Range Left
- Low Fuel Warning and Charging Reminder
- Plug in Charging Indicator

Battery Temperature

- Current Battery Temperature
- Battery Temperature Range
- Too High/Low Temperature Warning

Power Meter

- Regenerative Power Against Charging Power Status

Dot Matrix Display

- Odometer/Twin Trip Odometer
- Trip Computer
- Shift Position Indicator
- Indicator For Timer

Indicators

- High/Low Beam Indicator
- Front Fog Light Indicator
- Electric Parking Brake Indicator
- Power Limitation Indicator
- Ready to Drive Indicator
- Front Passenger Airbag Status Indicator
- Security Indicator
- VDC Off Indicator

Warnings

- 12-Volt Battery Charge Warning
- ABS Warning
- Brake System/Brake Warning
- Electric Power Steering Warning
- Electric Shift Control System Warning
- EV System Warning
- Headlight Warning
- Low Tire Pressure Warning
- Seatbelt Warning
- Airbag Fault Warning
- VDC Warning

3.3.2 Steering Wheel

Left Control Stalk

- Headlight Control
- Turn Signal Control
- Fog light Control

Right Control Stalk

- Wipers Control
- Washer Control

Wheel

- Driving Range Button
- Audio Control
- Hands free Control
- Electric Steering Control
- Cruise Control
- Horn
- Tilting Steering Wheel Lever

3.3.3 Central Control Panel

Climate Control

- AC ON/OFF
- AC Timer
- Temperature Control
- Defroster Control
- Manual Air Flow Control
- Fresh Air Intake Control
- Fan Speed Control
- Air Recirculation Control

Center Display Control

- Navigation
- Vehicle Information And Settings
- Hands free Phone System
- Audio System

Gear Shift

- Reverse Gear

- Parking Gear
- Neutral Gear
- Driving Gear

Other Instruments

- Power Outlet
- USB/iPod Connector
- Auxiliary Input Jack
- Passenger Airbag Status Light
- Hazard Warnings
- Power Button

3.3.4 Door and Other Instruments

Window and Door Controls

- Window Switch
- Door Lock Switch
- Exterior Rear View Mirror Remote Control

Steering Wheel Left Side Panel

- Instrument Brightness Control
- Trip Switch
- VDC Off Switch
- Headlight Aiming Control
- VSP Off Switch
- Immediate Charge Switch

Appendix D Target User Interview

4.1 Interviews

Interviewee A

Profile

Male, Mid-age, Mecel staff

How long have you been driving?

22 years, since 1988

How many hours will you drive per week?

Now it is about one hour

In which situations you will drive your car rather than use public transportation or other vehicles?

I will drive when I want to get to nature, like drive to sea, nature places that Public transportation cannot reach.

Will you drive your car from home to work place? How long does it take?

I don't drive to workplace. I walk. I live quite close.

Are you satisfied with the cars you drive?

Yes. I like my car. It is Toyota bought in 1996.

Name 3 things you like and hate the most about your cars.

I do not need to repair, inexpensive (car itself and fuel-economy), fun driving experience.
Things don't like: too noisy, not very comfortable (suspension too stiff), old car the steel getting rust.

Are there any functions or facilities you never or seldom use?

Cup folder

Can you describe your worst driving experience? (Road condition, weather condition, event, car condition, time, people)

When snow. The screen get dirty, hard to see through. Or the dust.

What is the main reason you think about this happened? Or what do you think you can do to your car to prevent such situation?

A good windscreen wiper

Are there any new techs you like or dislike?

Dislike: Some safety features are too much, like seatbelt warning.

Like: car is getting safer, better for the environment, and fuel-economy

Your prefer cars when you want to buy a new one.

Volkswagen Passat, Golf, or Volvo v70. I want feel sporty, practical.

Are you following the car news? How do you think today's vehicle technology?

Yes, I read through the news from magazines and so on. I think the good thing from today's technology is the car is getting safer and better for environment, fuel economy. The things I don't like probably is the over considered safety that sometimes makes you feel annoying.

Interviewee B

Profile

Male, Around 28, Master student in Chalmers

How long have you been driving?

8 years, since I was 18

Do you own a car now?

No, not anymore.

What is the last time you drive?

Last week, like two days ago. I drive a lot actually, cars from friends or parents. So I have access to cars whenever I need one.

How many hours will you drive per week?

I guess not many, 5-10 hours per week.

In which situations you will drive your car rather than use public transportation or other vehicles?

In situation that it's more convenient to use a car, like some places which don't have good connection to public transportation. Or go shopping with a lot of stuffs. Or driving for work.

Will you drive from home to school?

No, mostly not.

Which car have you been driving?

My parents have a Jaguar, which I have driven a lot. Also Honda and Volvo. Sometimes I go test drive, in that cases I choose to drive cars have more fun and sporty feelings.

Which is your dream car?

The most extreme one would be Lamborghini; otherwise to be realistic I would like Audi. They have good features and pretty futuristic as well.

Are you satisfied with the cars you drive?

Not very much. Maybe because you own them so they eventually break down. Like I had a SAAB, it's ok in general but still have a lot of problems.

Name 3 things you like the most?

Everything is at their place when you are in the driving position. The designs and also the convenience.

Is there anything you really hate about your car?

I think the flower stand above dashboard in the new Beetles of Volkswagen is really stupid.

Are there any functions or facilities you never or seldom use? What are they?

CD Player and Cruise control.

Can you describe your worst driving experience?

In Lisbon, it's a totally new city; we are close to accident all the time. Another time is in Bolivia, drive a Jeep on a mountain road, which is very narrow with the other side of cliff. That's quite scary.

For the Lisbon one, what is the main reason for the bad situation?

Inexperienced with the traffic, driving culture, everything in the city.

What do you think will help for that situation?

GPS or larger car maybe.

Interviewee C

Profile

Male, Around 24, Master student in Gothenburg University

How long have you been driving?

5 years, since I was 19

How many hours will you drive per week?

Not that often in Gothenburg. About half an hour per week if has to count. In Umeå, where I'm from, I drive for 2-3 hours per week.

In which situations you will drive your car rather than use public transportation or other vehicles?

When I was working at that period, like I have been working for a security company, during that time I drove to work a lot.

Will you drive you car from home to work place? How long does it take?

Yes, and about 20 minutes.

Which car are you driving?

I have never owned a car. I have driven my parents' cars, a Chrysler Voyager from 1994, a pick up and a KIA from 2004.

Which you have driven the most?

Then it will be the KIA one.

Are you satisfied with the cars you drive?

Yes.

Name 3 things you like the most about KIA?

It is quiet, and it has some very useful functions like you can fix the speed if you want to. And the rear warning system and the automatically windscreen wipers.

Is there anything you really hate about your car?

Nothing particularly hate about.

What car would you like to buy? Or is there any dream car for you?

Actually I haven't really thought about that. I'm not quite following this particular area. But maybe BMW? I don't know.

When did you buy your car?

2 years ago

Are there any functions or facilities you never or seldom use? What are they?

The rear windscreen wipers maybe? I seldom use them, but I think there are some reasons for them to be there. And I have never used a GPRS

Can you describe your worst driving experience?

I think I don't like to drive in Gothenburg city. The road signs here always confused me. While in Umeå, the big snow and the unpredictable reindear can be the trouble.

What functions do you think can be developed in the future?

Like the car can tell you what's the closest parking place.

Interviewee D

Profile

Male, Around 26, Master student in Gothenburg University

How long have you been driving?

7 years, since when I was 18

How many hours will you drive per week? <5 h, 5h~10h, 10+ h

One hour a day before, but now it's much less.

In which situations you will drive your car rather than use public transportation or other vehicles?

I prefer driving the car than public transportation most of the time, if I had to define; driving is better for long range, while public transportation is better for inner city.

Will you drive you car from home to work place? How long does it take?

Mostly to school, to workplace or other activities.

How long does it take from home to school/work place?

Usually 20 to 30 minutes.

Which cars have you been driving?

First it was a Volvo actually, an older model. Then it's an Opal, which I have driven for 1 and half years. Then I have been using my parents' SAAB a lot,

Which one you are satisfied with the most?

The Opal, maybe it's new model

What are the things you like about the Opal one?

It was quiet; I didn't get much disturbance from the outside and the engine. Also it was comfortable driving. Also the driving experience, which is important. I feel like the extra features are unnecessary for me.

What are the things you don't like about the Opal car?

Some electronica failures, which I don't think they supposed to happen on a new car. Stuff on the steering, like can't adjust the volume for the stereo.

Are there any functions or facilities you never or seldom use?

I don't adjust the seat that much maybe.

Can you describe your worst driving experience? (Road condition, weather condition, event, car condition, time, people)

Actually that's with the Opal, I got hit two times in a minute while I was driving car out from the parking lot.

Where is it?

It's in Gothenburg

What is the main reason you think about this happened? Or what do you think you can do to your car to prevent such situation?

Some censor detection to warn you there's something coming

Are you following the car news? How do you think today's vehicle technology?

Yes, I read through the news from magazines and so on. I think the good thing from today's technology is the car is getting safer and better for environment, fuel economy. The things I don't like probably is the over considered safety, which sometimes makes you, feel annoying.

Interviewee E

Profile

Female, Mid-age, Mecel staff

How long have you been driving?

I started driving since 89 so it would have been 22 years.

How many hours will you drive per week? <5 h, 5h~10h, 10+ h

Right now it's 5-10 hours, previous years it has been a bit more.

Will you drive your car from home to work place? How long will it take?

Yes, Primarily to workplace, then to customers and to shopping. And it takes 20 to 30 minutes depending on the traffic.

In which situations you will drive your car rather than use public transportation or other vehicles?

Usually driving cars rather than public transportation, because the connections from where we live aren't very good to them. The only situation is for the experience such as taking my daughter so she can ride a bus or tram. But we tend to drive everywhere.

Are you satisfied with the cars you drive now?

Yes, the Audi A3, it's a good car for what I use for.

Could you name 3 things you like the most about your car?

I prefer that it's a quick little car, so it's fun to drive, and I love it has an SD card slot, where you can put music on, so I have like hundreds of hours of music and paper reads. And it apparently a well-made car, like the door shut well and it's reliable,

Have met any problems when you drive your car?

One thing I don't like is that I have to turn the headlights on manually. Most cars lately are automatic. And I don't like it for a long trip, it doesn't have six gears, so the engine is very noisy when it's on highways. Mostly because it's a city car.

Are there any functions or facilities you never or seldom use?

There's a tire pressure monitor I don't really use them, and I don't use the radio really often, because I have the SD card for the music. I haven't used the USB input either because I have SD for music.

What's the worried things happened during driving?

Sometimes like the distractions like playing cellphones, trying to dial a number to someone, and like distractions from my daughter, she is screaming sometimes, also some other drivers scared me a lot, they are unpredictable, like turning into and stopping in front of you, that's probably the biggest worry.

Can you describe your worst driving experience?

I drove for a business trip in Sao Paolo and that was very scary. And Brussels, because the traffic patterns are very different and the car was very different from what I was used to, and the way people were driving was very scary, just pull in front of you without any notice. It's a bit scary to drive in a new city, like now I have navigation system, if I don't have them, it's tricky because you have to concentrate on your driving and figure out where you are going.

What's the car you drove then?

It was a Brazilian, Gm Chevrolet car.

What do you think you can do to your car to prevent such situation?

If the cellphone have better interface, like big buttons, voice recognitions, for easing the use.

How do you like the touch screen?

I don't like the touch screen for it, because it distracts a lot of your attention. There is a touch

screen in my husband's car and I hate it.

What does that touch screen contain?

Like navigation, you need to hit the digits to enter the destination, and it's frustrated to make it right. The keyboard is on the screen. it feels good to use touch screen when sitting at home, but when you are driving, the car is bumping up and down it's not good to use it.

Have thought about to give your daughter something in the car to calm her down when she's screaming or something else?

I have an iPad for her to watch movies, and something like that works well.

Would you do something else during driving?

Mainly do phone calls, I tend to use that time for work or keep in touch with friends and family.

Would you like having some entertainment facilities in your car besides music player? like gaming stuff?

I don't have much interests into that, and I'm not sure if I want them for my daughter either, we try to limit the video games and TV for her, I could give her my iPad for a while to play in the car is ok, but to spend money on a play station probably not. I would rather like her to read.

What would you do when you are in a traffic jam?

Sometimes I pick up a book and read if I can't reach somebody by phone.

What's the longest time you have been trapped in a traffic jam?

2 or 3 hours in Germany.

Have you got that situation in Gothenburg?

No, longest like 20 to 30 minutes.

Interviewee F

Profile

Female, Around 28, Master student in Chalmers

How long have you been driving?

10 years

How many hours will you drive per week?

40 mins* 3or 4

In which situations you will drive your car rather than use public transportation or other vehicles?

I live in outskirts of Gothenburg, when I need to go to downtown buy something or go to school.

Will you drive your car from school to work place? How long does it take?

Yes, sometimes. 30 mins.

Which car are you driving now?

Renault Megane, I used to drive Renault Laguna.

Are you satisfied with the cars you drive?

Yes, but it will be better to have a higher motor volume. It is more comfortable to drive with powerful engine.

Name 3 things you like most about your cars (not need belong to one specific car)

1. Dashboard is neat and organized. I don't like many buttons. They distracted me. Compared with Volvo, the Renault uses a lot of rolling-button.
2. Steering wheel. I would like to do a lot of things on my steering wheel. Like control radio, wipers, and light even making a phone call.
3. I like to have well organized storing space on the dashboard, so I can put things to a certain place. It will be easier for me to use them. Don't have to search for them.

Are there any features or functions that you hate?

I don't like drive "green" car which the engine is less powerful, say, Volvo S60. I have driven Fuel-version S60; I can feel it was not powerful. I also drive diesel-version S60. I can feel their differences. The powerful car brought me highly sense of security.

Are there any functions or facilities you never or seldom use?

Except I don't know how to turn on the head light

Can you describe your worst driving experience? (Road condition, weather condition, event, car condition, time, people)

Due to the heavy snow, I drove in a narrow street when I turned to a corner, I scratched a SAAB.

What is the main reason you think about this happened?

The street is too narrow and road is slippery.

What do you think you can do to your car to prevent such situation?

I don't think so, even if there is warning. I knew there are some safety features nowadays, but I don't think I would spend my money on them. My car has this warning system that when I reversed, but I never use. It is annoying. I don't have to use it at all.

Will you do something else when you drive?

Listen music or make phone call.

When you trapped in the traffic jam, what you will do?

Listen to the music and wait.

Interviewee G

Profile

Male, Mid-age, Mecel staff

How long have you been driving?

About 13 years

How many hours will you drive per week?

Maybe 7 hours, one hour a day.

In which situations you will drive your car rather than use public transportation or other vehicles?

Almost every situations I drive my car recently. I used to take public transportation, but now I am too lazy and I have driven too much.

Will you drive you car from home to work place? How long does it take?

Yes, usually to day care, to store, to many different places. About 20 minutes.

Which car are you driving?

Volvo 940, 15 years old

Are you satisfied with the cars you drive?

Yes.

Name 3 things you like and hate the most about your cars (not need belong to one specific car)

It is cheap, to buy and maintain. It is a big car. And has large space to store.

Are you satisfied the driving environment, the interior part of your car?

Yes, more or less. I used to work at Volvo car; I saw a lot of the newest cars. I know there is much better driving environment in these new cars, but my car is ok.

When did you buy your car?

2 years ago

Is there anything you really hate about your car?

Not really, no.

Are there any functions or facilities you never or seldom use? What are they?

Yes, I think so, but I don't know. Parking lights I never used.

Can you describe your worst driving experience? (Road condition, weather condition, event, car condition, time, people)

It was when I was new employee at Volvo car. I had a test car that I was driving. It is really rainy and wet day. I was going into big water. There are a lot of water and the car stopped. I drive into the water and cannot get out, so I stand that for almost five hours. They could not come and pull me away, so the car was broken. Eventually it has to be scraped the entire car, so I ruined a new car. I was the new employee to this company, so that wasn't good.

What were you doing during those five hours?

Sitting and waiting.

Did you try to connect with the company?

Yes, but they could not come until after five hours.

What is the main reason you think about this happened? Is it the rain?

The water penetrates the engine, water inside the engine. And they could not fix it so they scrape the entire car

Interviewee H

Profile

Male, Senior, Pensioner

How long have you been driving?

Since 1969, that is 32 years

How many hours will you drive per week? <5 h, 5h~10h, 10+ h

I drive at least one time; usually 2 times per week, I just use my car for shopping. The driving takes 15mins.

In which situations you will drive your car rather than use public transportation or other vehicles?

I need to buy things that heavy and big, because I live in uphill house. For example, go to IKEA.

Are you satisfied with the cars you drive?

Yes, because checking center, which is very serious, proved it. They check everything; they lift the car to check brakes, gases, and engine. My car is 20 years old, but it is the best.

Can you say something you like about your car?

Yes, it is a special car. It is old Volvo; it was the first Volvo to have the automatic things, like window opening by buttons. It is the first electronic Volvo it is this car. It is 20 years old but very nice to drive. It has front-wheel drive, not just rear-wheel driven. It is very nice to drive when you climb the hill.

Name 3 things you hate the most about your cars (not need belong to one specific car)

In winter time, it takes 15 minutes to take off the snow. But it always starts.

Are there any functions or facilities you never or seldom use?

I never use the radio, there it is electronic system you can check air pressure, brakes pressure but I never use when it works. If there is something wrong with the car, there will be signal show on the dashboard, so I don have to check them.

Can you describe your worst driving experience? (Road condition, weather condition, event, car condition, time, people)

When I was in San Francisco, my wife and I rented an automatic car, no gears. I am not used that, I drive from the renting company to the place I live. The road is up and down. It stops at the downhill. I came out the car, it was very nervous very hot. I was sweating. I had to start to drive, I tried to put down the gear, but there is no gear. Then another thing, we have to drive through Paris. I have been drive to Italy with my car; it was fast car, Renault. Then I came to Paris. You have to drive through the Paris. You cannot drive around. There were 6 lanes but not many signs and instructions; it took one hour to drive through the Paris. In Roma, the Italian don't care much about the rules. But it was funny.

What is the main reason you think about the worst situation happened?

It was I was not used to drive automatic gear system. Other countries, I don't know what happened, some people drive like mad men.

What do you think you can prevent such situation?

I will be better prepared for the automatic gear car.

Would you like something new features on your car?

No, I don't need GPS. I knew the city. If I drive to other cities, it is easy to prepare.

Will you do something else when you drive?

No, in my situation, I only drive for short distance.

Will you like some futuristic features in your car, like your car drive for you?

No, I don't even like automatic gear system. It was so fun to drive with mechanical gear system, you can feel it. It is part of art of driving. Driving car is fun; if you just sit in the car you just like passage. It is nearly a sport. That is the whole pleasure of driving. Driving represents freedom.

Interviewee I

Profile

Male, Mid-age, Mecel staff

How long have you been driving?

21 years and I have motorcycle-driving license for 14 years.

How many hours will you drive per week?

Right now it is not that much, I will say an hour a week.

Will you drive your car from home to work place? How long does it take?

No, I live too close. It is more pleasure to drive to shopping center or the place my parents living, outside the town. I used to drive a lot for the previous job; I work for testing and developing navigation system, especially for Volvo. Let say both privately and work maybe 30 000-40 000K.M.

How do you go to work from your home?

Bicycle

In which situations you will drive your car rather than use public transportation or other vehicles?

I will see I will drive my car to shopping center that outside the town or out of the down town, not just my city, I mean, it is just more convenient to use public transportation or take my bicycle in the city. It is usually quicker if you consider parking.

What is your car now?

It is a PEUGEOT 307 it is a medium size car.

Are you satisfied with the cars you drive?

Yes, the size is pretty ok for me. I don't need a premium car. It is not a sport car, but I can always drive my motorcycle when I want to experience sporty. Not in the winter time, unfortunately.

Name 3 things you like and hate the most about your cars (not need belong to one specific car)

it is not too much or too little. The price and size are balanced for me. They work great for me. From pervious driving point of view, one thing quite satisfied me is that there is buttons behind the driving steer, one is volume. The radio buttons. Something else about other control. I don't remember. When you turn the steering wheel they are not moving, you don have to find them. Volvo and SAAB don't have this function they are buttons on the front side of the wheel. I have to find them. Even I am quite experienced driver, I still need to look where are the buttons are. And it doesn't consume much petrol, which I think it is good.

Is there anything you hate about your car?

Not really, of course with the higher price car it will have more equipment. And my car doesn't feel very exclusive. But I don't need that exclusive feeling; It doesn't worth for the money. I don't want to pay much money for it. Now it is getting old now, when it was new, it is better from safety point of view.

Are there any functions or facilities you never or seldom use?

I used the radio, AC; I think I use them there. Glove compartment has cooling in it, I seldom use. The warming you can put your thing in it to keep it warm in winter. But I seldom use the cooling.

Can you describe your worst driving experience? (Road condition, weather condition, event, car condition, time, people)

When I went to Paris one time, I drove around the downtown area in Paris in a Monday afternoon to test the navigation system, and it's usually rush hour at that time in Paris.

What is the main reason you think about this happened?

Obviously, when we go to the major city, trapped in traffic jam that is stressful. One I drive to down town Paris to pick up a colleague. It was a Monday afternoon. I drive into the traffic rush hour. I used the navigation system, that we usually do in downtown area. It was rush hour. It takes me around 40 minutes to drive. That is not very pleased, but I am not unhappy yet. I am normally not scared of trapping in the traffic jam.

What do you think you can do to your car to prevent such situation?

One thing came to me, if the navigation system. If I have a good navigation system.

Could you define "good navigation system"?

1. The map has to be updated. Two times every year usually
2. Very clear instruction from voice and display. Like distance came first from actual action in instruction.
3. You have to get used to use navigation system. I am more used to listen to the voice instructions.

Do you think there is some more information should be on navigation system?

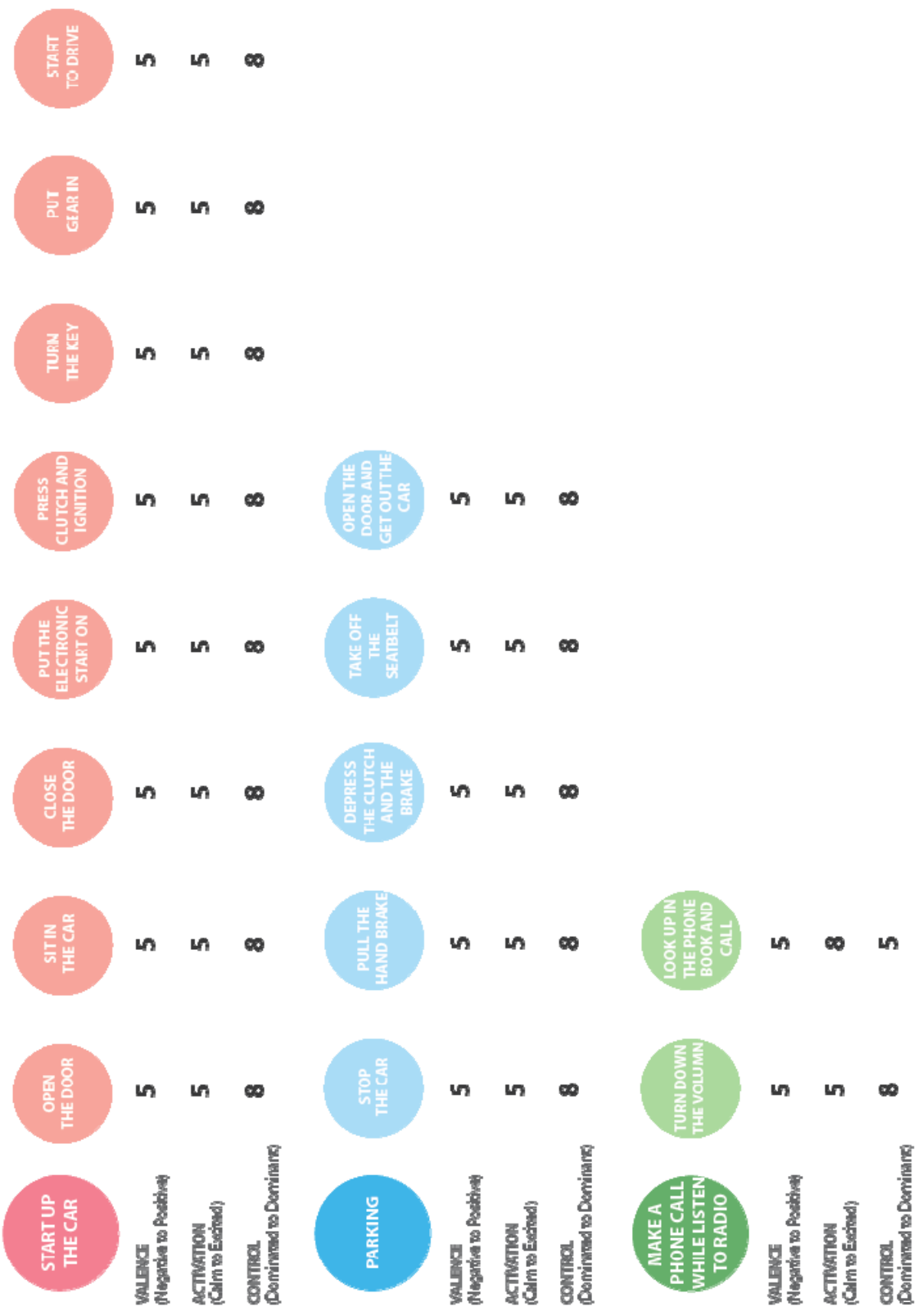
1. Parking space available
2. Accurate Traffic information, which lane has accident etc.
3. Point out a best parking place for you

4.2 SAM

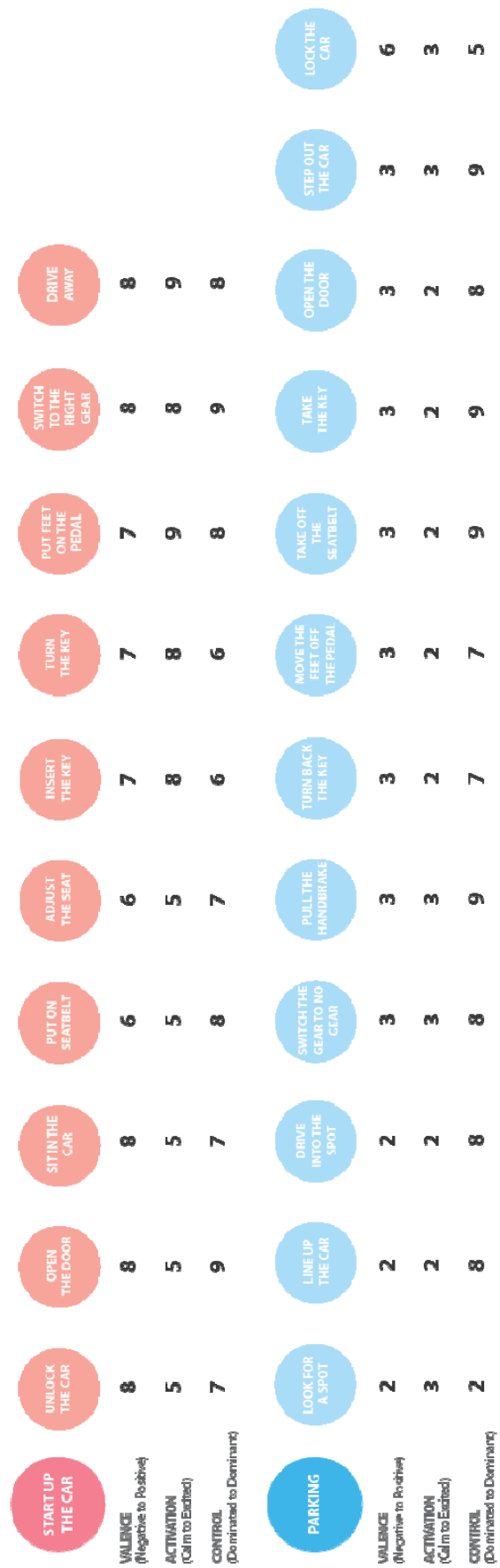
Interviewee A

START UP THE CAR	GET IN AND SIT DOWN	PUT THE SEATBELTS ON	PUT THE CLUTCH AND IGNITION ON	TURN THE KEY	RELEASE THE HANDBRAKE	DRIVE AWAY
VALENCE (Negative to Positive)	7	7	8	8	7	8
ACTIVATION (Calm to Excited)	5	5	7	7	6	8
CONTROL (Dominated to Dominant)	7	8	8	8	6	8
PARKING IN THE CITY	LOOK FOR A PLACE TO PARK	MOVE THE CAR INTO PARKING SPACE	APPLY HANDBRAKE	STOP THE ENGINE	REMOVE THE SEATBELT AND GET OUT	
VALENCE (Negative to Positive)	2	6	8	8	8	
ACTIVATION (Calm to Excited)	5	5	5	5	5	
CONTROL (Dominated to Dominant)	3	6	7	7	7	
PARKING AT HOME	MOVE THE CAR INTO PARKING SPACE	APPLY HANDBRAKE	STOP THE ENGINE	REMOVE THE SEATBELT AND GET OUT		
VALENCE (Negative to Positive)	5	6	6	6		
ACTIVATION (Calm to Excited)	4	4	4	4		
CONTROL (Dominated to Dominant)	5	6	6	6		
RECEIVE A PHONE CALL	SEARCH THE PHONE FROM SOMEWHERE	HOLD THE PHONE AND ANSWERING		MAKE A PHONE CALL	SEARCH THE PHONE FROM SOMEWHERE	SEARCH THE PHONE BOOK AND CALL
VALENCE (Negative to Positive)	2	7		VALENCE (Negative to Positive)	2	6
ACTIVATION (Calm to Excited)	7	4		ACTIVATION (Calm to Excited)	7	4
CONTROL (Dominated to Dominant)	2	6		CONTROL (Dominated to Dominant)	2	5
SEND SMS	SEARCH THE PHONE FROM SOMEWHERE	FIND SMS APPLICATION	ENTER MESSAGE	SEND		
VALENCE (Negative to Positive)	3	4	4	7		
ACTIVATION (Calm to Excited)	6	6	5	4		
CONTROL (Dominated to Dominant)	2	3	3	6		

Interviewee B



Interviewee C



Interviewee D

	START UP THE CAR	WALK TO THE CAR	OPEN THE DOOR WITH THE KEY	SIT IN THE CAR	PUT THE KEY IN THE LOCK	START THE ENGINE	PUT ON THE GEAR	DRIVE BACK AND TURN	DRIVE AWAY
VALENCE (Negative to Positive)		6	6	8	8	8	8	5	9
ACTIVATION (Calm to Excited)		4	4	4	5	6	7	4	6
CONTROL (Dominated to Dominant)		7	6	8	9	7	7	7	8
	PARKING	DRIVE TO THE PARKING PLACE	PUT OFF THE ENGINE	OPEN THE DOOR AND GO OUT					
VALENCE (Negative to Positive)		5	8	8					
ACTIVATION (Calm to Excited)		5	4	6					
CONTROL (Dominated to Dominant)		3	7	5					

Interviewee E

START UP THE CAR	USE REMOTE TO UNLOCK THE CAR	OPEN DRIVER'S DOOR	PUT ON SAFETY BELT	PRESS DOWN CLUTCH PEDEL	RELEASE BRAKE PEDAL	TURN THE KEY	LOOK AROUND AND READY TO GO	
VALENCE (Negative to Positive)	7	7	5	5	5	7	8	
ACTIVATION (Calm to Excited)	7	7	5	5	5	7	8	
CONTROL (Dominated to Dominant)	8	8	6	5	6	8	8	
PARKING AT CURBSIDE	DRIVE AROUND TO CHECK THE SPOT	POSITION THE CAR TO PARK	TURN IGNITION OFF	TAKE OUT THE KEY	RELEASE SEATBELT	OPEN THE DOOR	STEP OUT AND CLOSE THE DOOR	LOCK THE CAR
VALENCE (Negative to Positive)	4	6	5	5	5	5	5	5
ACTIVATION (Calm to Excited)	5	6	5	5	5	5	5	5
CONTROL (Dominated to Dominant)	4	7	6	6	6	6	6	6
PARKING AT HOME	DRIVE INTO THE YARD	POSITION THE CAR TO PARK	TURN IGNITION OFF	TAKE OUT THE KEY	RELEASE SEATBELT	OPEN THE DOOR	STEP OUT AND CLOSE THE DOOR	LOCK THE CAR
VALENCE (Negative to Positive)	6	6	5	5	5	5	5	5
ACTIVATION (Calm to Excited)	6	6	5	5	5	5	5	5
CONTROL (Dominated to Dominant)	7	7	6	6	6	6	6	6
MAKE A PHONE CALL	GET THE PHONE FROM POCKET	UNLOCK THE PHONE	FIND THE NUMBER	DIAL THE NUMBER	HOLD THE PHONE AND CALL			
VALENCE (Negative to Positive)	3	5	4	5	2			
ACTIVATION (Calm to Excited)	4	5	4	5	4			
CONTROL (Dominated to Dominant)	3	6	4	5	2			

Interviewee F

START UP THE CAR	OPEN THE DOOR AND GET IN THE CAR	PUT THE FOOT ON THE CLUTCH	PUT ON THE RIGHT GEAR	TURN ON THE ENGINE	SLOWLY RELEASE THE CLUTCH AND FORWARD THE GAS
VALENCE (Negative to Positive)	7	7	7	8	8
ACTIVATION (Calm to Excited)	3	4	6	5	7
CONTROL (Dominated to Dominant)	7	6	8	7	8
PARKING	FIND PLACE AND PLAN THE PARKING	PLACE THE CAR INTO THE SPOT	TURN OFF THE ENGINE AND GET OUT		
VALENCE (Negative to Positive)	3	5	6		
ACTIVATION (Calm to Excited)	7	3	3/4		
CONTROL (Dominated to Dominant)	2/3	3	5		
MAKE A PHONE CALL	JUDGE THE CASE IF IT'S OK TO DO THAT	TAKE THE PHONE AND MAKE THE CALL			
VALENCE (Negative to Positive)	5	5			
ACTIVATION (Calm to Excited)	8	8			
CONTROL (Dominated to Dominant)	6	4			

Interviewee G

START UP THE CAR	OPEN THE DOOR GET INTO THE CAR	ADJUST THE SEAT(IF DRIVE OTHER'S CAR)	PUT THE KEY INTO STEERING WHEEL	TURN ON MUSIC AND PUT CELL AT A CERTAIN PLACE	READY TO DRIVE	
VALENCE (Negative to Positive)	7	3	8	7	7	
ACTIVATION (Calm to Excited)	5	4	7	7	7	
CONTROL (Dominated to Dominant)	9	5	8	7	7	
PARKING IN THE CITY	LOOK FOR A SPOT	DRIVE TO THE SPOT	ADJUST TO GET INTO THE SPOT	TURN OFF THE CAR	GRAP THE CELL TURN OFF MUSIC	GET OUTTHE CAR SET ALARM
VALENCE (Negative to Positive)	3	7	5	4	1	5
ACTIVATION (Calm to Excited)	2	3	6	2	1	5
CONTROL (Dominated to Dominant)	4	8	5	8	9	8
PARKING AT HOME (POSITIVE)	PAKING THE CAR	TURN OFF THE CAR	TURN OFF MUSIC	GET OUT THE CAR		
VALENCE (Negative to Positive)	6	5	3	6		
ACTIVATION (Calm to Excited)	3	1	2	5		
CONTROL (Dominated to Dominant)	9	9	9	8		
MAKE A PHONE CALL	GRAP THE PHONE	FIND THE RIGHT NUMBER	PUT BACK THE PHONE CONNECTED HANDS-FREE			
VALENCE (Negative to Positive)	3	3	6			
ACTIVATION (Calm to Excited)	7	6	3			
CONTROL (Dominated to Dominant)	4	4	6			

Interviewee H

START UP THE CAR	USE REMOTE TO UNLOCK THE CAR	BUCKLE DAUGHTER IN THE CAR	GO AROUND AND OPEN THE DOOR	SIT IN THE CAR	PUT THE CLUTCH ON	PUT IGNITION ON	RADIO/ MUSIC COME	DRIVING	PUT SEATBELT ON
VALENCE (Negative to Positive)	8	5	6	4	5	5	7	6	6
ACTIVATION (Calm to Excited)	5	7	3	5	5	5	5	7	4
CONTROL (Dominated to Dominant)	8	5	6	5	6	5	2	8	6
PARKING IN THE CITY	LOOK FOR A SPOT	POSITION THE CAR TO PARK	CHECK TRAFFIC OR PEDESTRIAN AROUND	ADJUST THE POSITION	TAKE OFF THE SEATBELT	STOP THE CAR	CHECK TRAFFIC OR PEDESTRIAN OUTSIDE	REMOVE KEYS	
VALENCE (Negative to Positive)	1	4	5	6	5	5	3	5	
ACTIVATION (Calm to Excited)	8	6	6	6	3	4	6	4	
CONTROL (Dominated to Dominant)	1	4	3	6	5	7	3	7	
PARKING AT HOME	PUT THROUGH THE GATE	PULL IN AND TURN AROUND	BACK TO SPOT	TAKE OFF SEATBELT	STOP THE CAR	REMOVE KEYS	GO OUT		
VALENCE (Negative to Positive)	4	7	7	5	5	5	8		
ACTIVATION (Calm to Excited)	7	7	7	3	4	4	5		
CONTROL (Dominated to Dominant)	4	8	8	5	7	7	8		
MAKE A PHONE CALL (DAUGHTER SCREAM)	DISCONNECT HANDS-FREE	USE THE PHONE AND DIAL THE NUMBER	LOOK AT THE SCREEN	CALM THE DAUGHTER DOWN	PRESS CALL	DO THE CALL AND HOLD THE PHONE			
VALENCE (Negative to Positive)	3	2	2	5	3	1			
ACTIVATION (Calm to Excited)	4	6	7	2	7	7			
CONTROL (Dominated to Dominant)	7	6	2	1	3	2			

Interviewee I

	START UP THE CAR	OPEN THE DOOR	PUT ON THE KEY	ADJUST THE MIRROR	TURN ON THE ENGINE	ADJUST THE AIR CONDITION	ADJUST MUSIC VOLUME	PUT ON THE GEAR	PUT OFF THE HAND BRAKE	DRIVE AWAY
VALENCE (Negative to Positive)	5	5	5	5	5	5	5	5	5	5
ACTIVATION (Calm to Excited)	5	5	5	5	5	5	5	5	5	5
CONTROL (Dominated to Dominant)	9	9	9	9	9	9	9	9	9	9
	PARKING	LOOK FOR A PLACE	DRIVE TO THE SPOT	LOOK AT THE MIRROR TO BACK UP THE CAR	TURN BACK THE GEAR	PUT UP THE HAND BRAKE	TURN OFF THE ENGINE	TAKE THE KEY AND LOOK AT THE MIRROR	GET BAG, GO OUT AND CLOSE THE DOOR	
VALENCE (Negative to Positive)	5	5	5	5	5	5	5	5	5	
ACTIVATION (Calm to Excited)	7	5	5	5	5	5	5	5	5	
CONTROL (Dominated to Dominant)	9	9	3	9	9	9	9	9	9	
	MAKE A PHONE CALL	TAKE OUT HANDS-FREE	CHECK THE TRAFFIC SITUATION	QUICKLY DIAL THE NUMBER	CHECK OUTSIDE AGAIN	MAKE THE PHONE CALL				
VALENCE (Negative to Positive)	5	5	5	5	5	5				
ACTIVATION (Calm to Excited)	8	5	5	5	5	5				
CONTROL (Dominated to Dominant)	9	9	9	9	9	9				

Appendix E Scenarios And Personas

5.1 Standard User

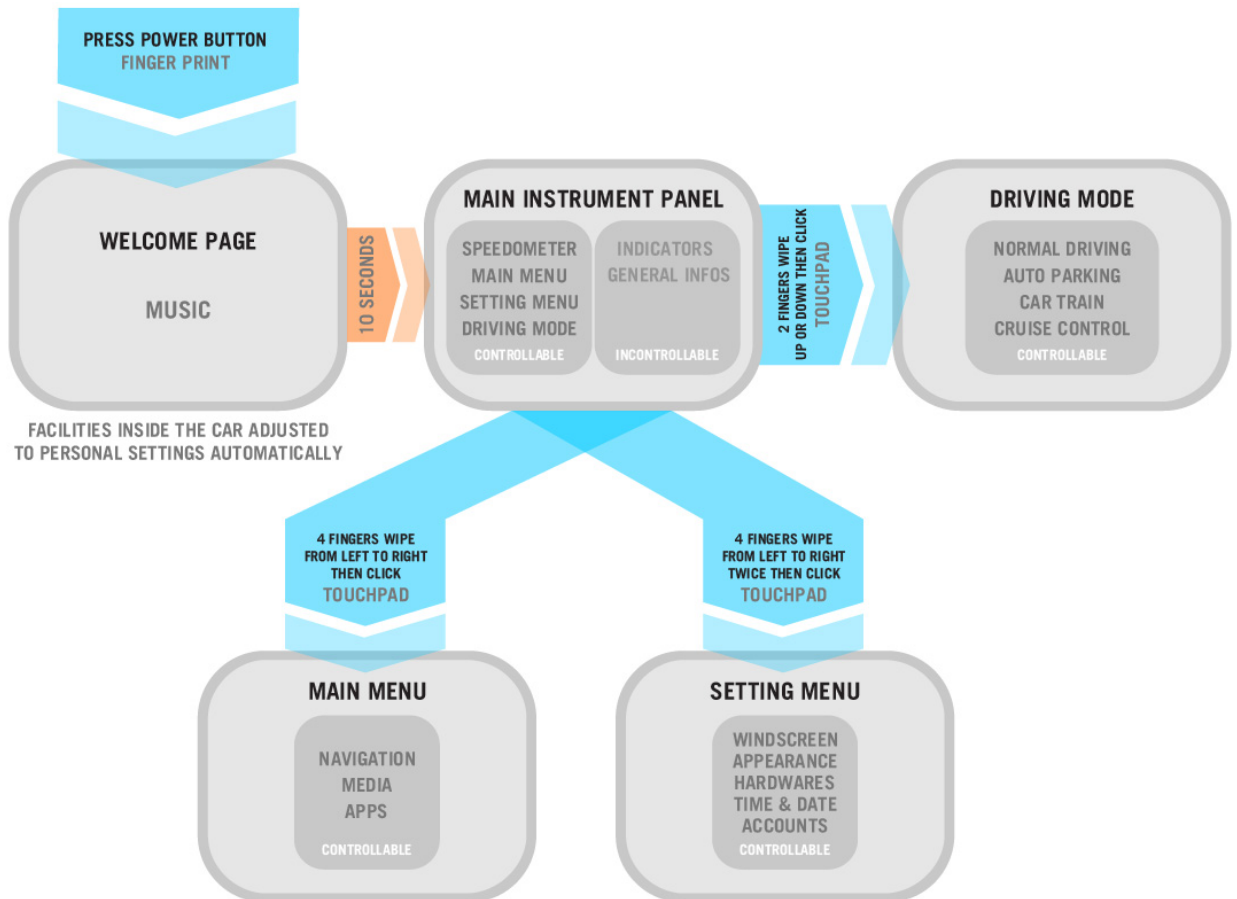
Personas	Scenarios
A: 27, Male, Single. Freshman working in a technical consulting company located in Korsvägen. Lives in Högsbo, usually go to work by public transportation, sometimes go to work by bicycle if it's good weather.	Mostly drive car to shopping and to friends' home. Sometimes drive to parents' house in Kinna, or to other companies in town for work.
B: 36, Female, Married. Work in a company located in downtown, Brunnsparken, as a Human Resources Manager. Lives in Mölndal. Have a child. The family owns two cars, the other is combi.	Mostly drive car to work, and to shopping. Sometimes drive her child to school while on the way to work.

5.2 Expert User

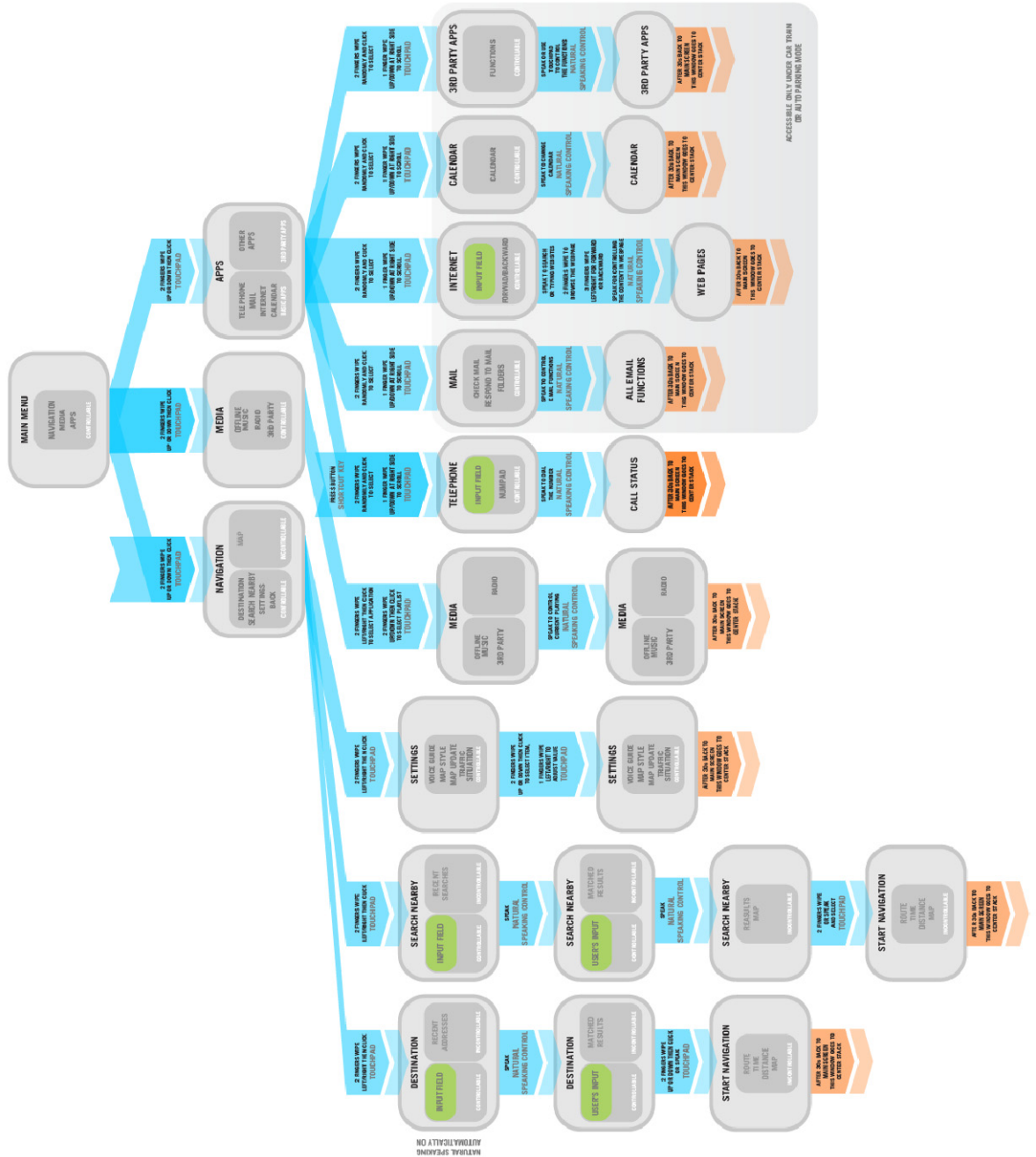
Personas	Scenarios
C: 40, Male, Married. Work in Automotive Industry as an engineer. The company is in Torslanda, and lives in Partille. Has 2 children.	Usually drive cars to work every week. Sometimes drive the car for a family trip for a bit long range.
D: 35, Male, Have a girlfriend. Works as a Marketing Manager in a company located in Central Business District. Lives in an apartment in Linneplasten. Loves cars very much.	Mostly drive car to work and to shopping. Sometimes for a trip with friends or to parents' house.

Appendix F Functional Hierarchy

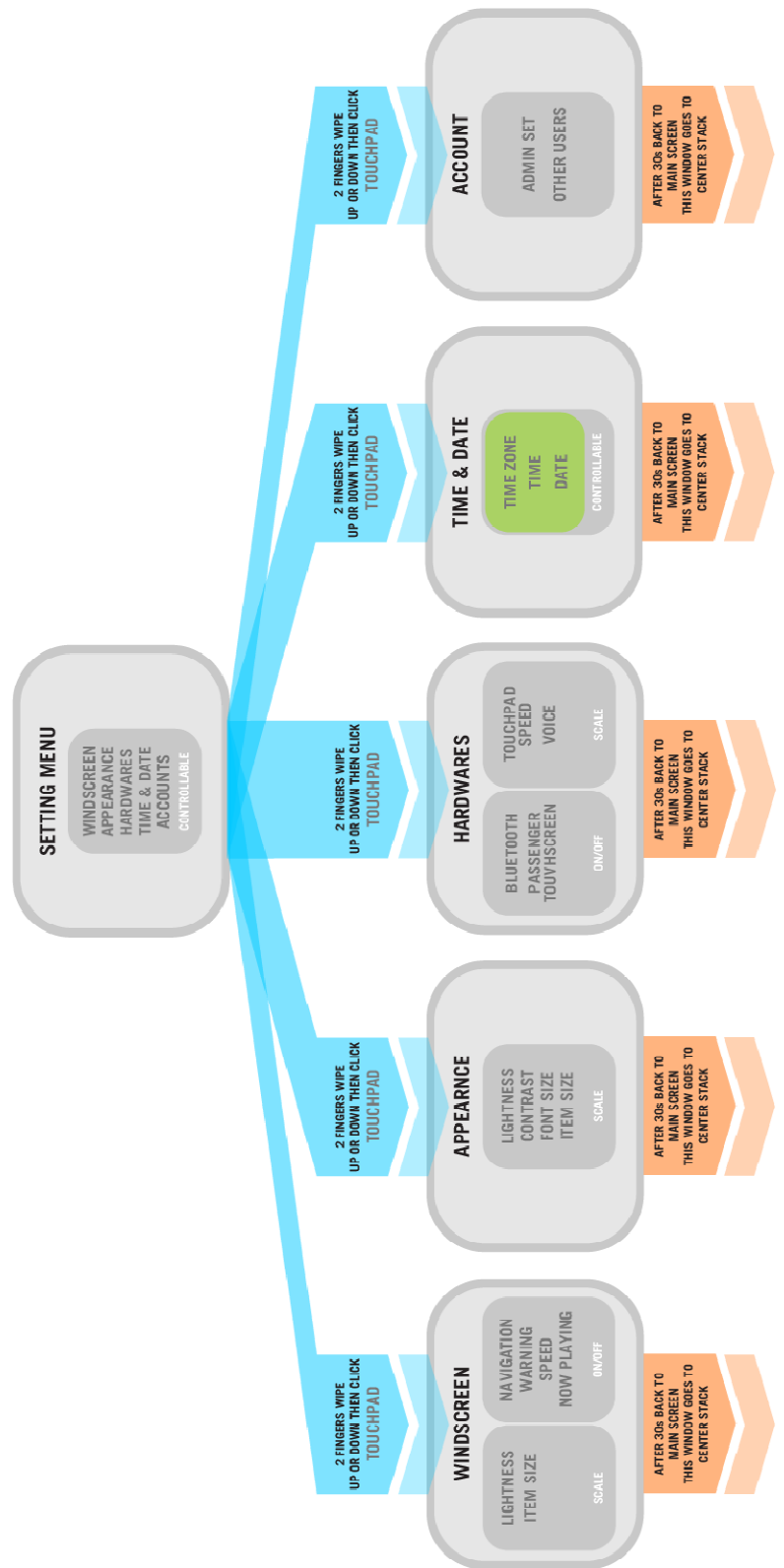
Main Instrument Panel-Standard User Concept



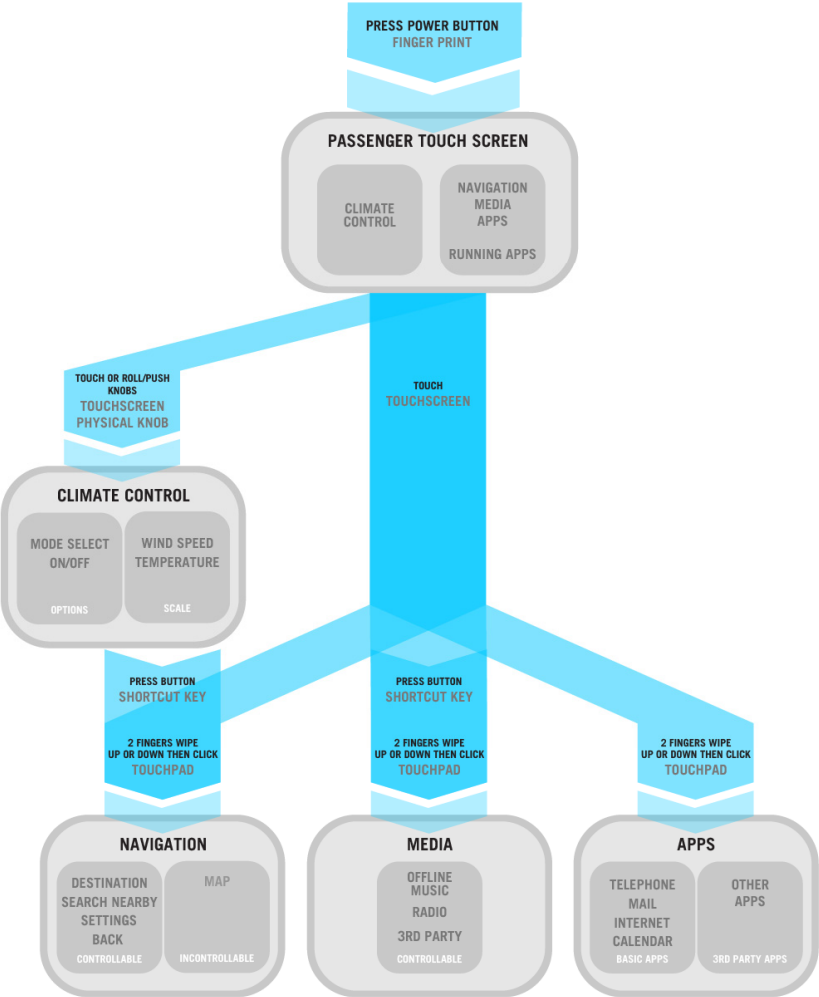
Main Instrument Panel-Main Menu-Standard User Concept



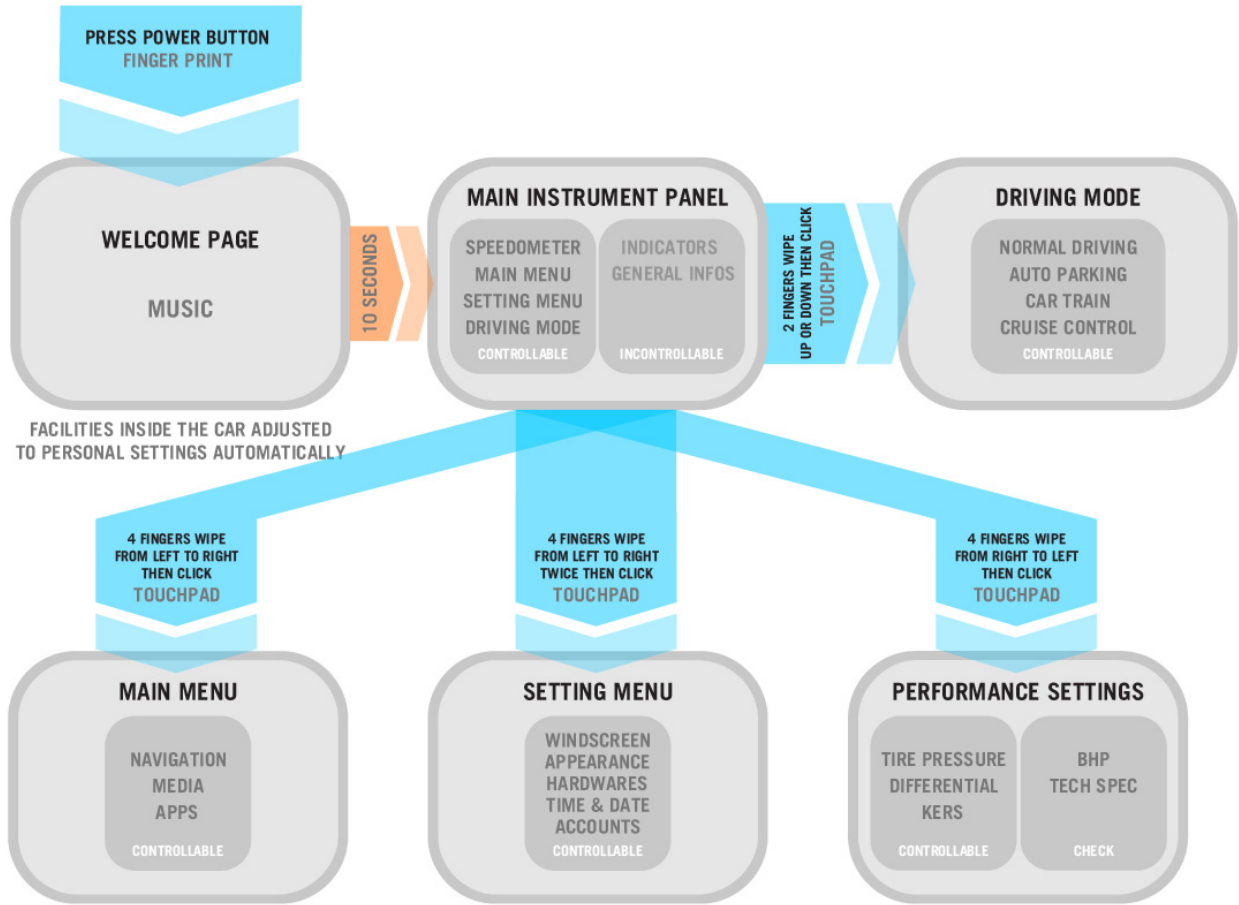
Main Instrument Panel-Setting Menu- Standard User Concept



Passenger Touch Screen-Standard User Concept

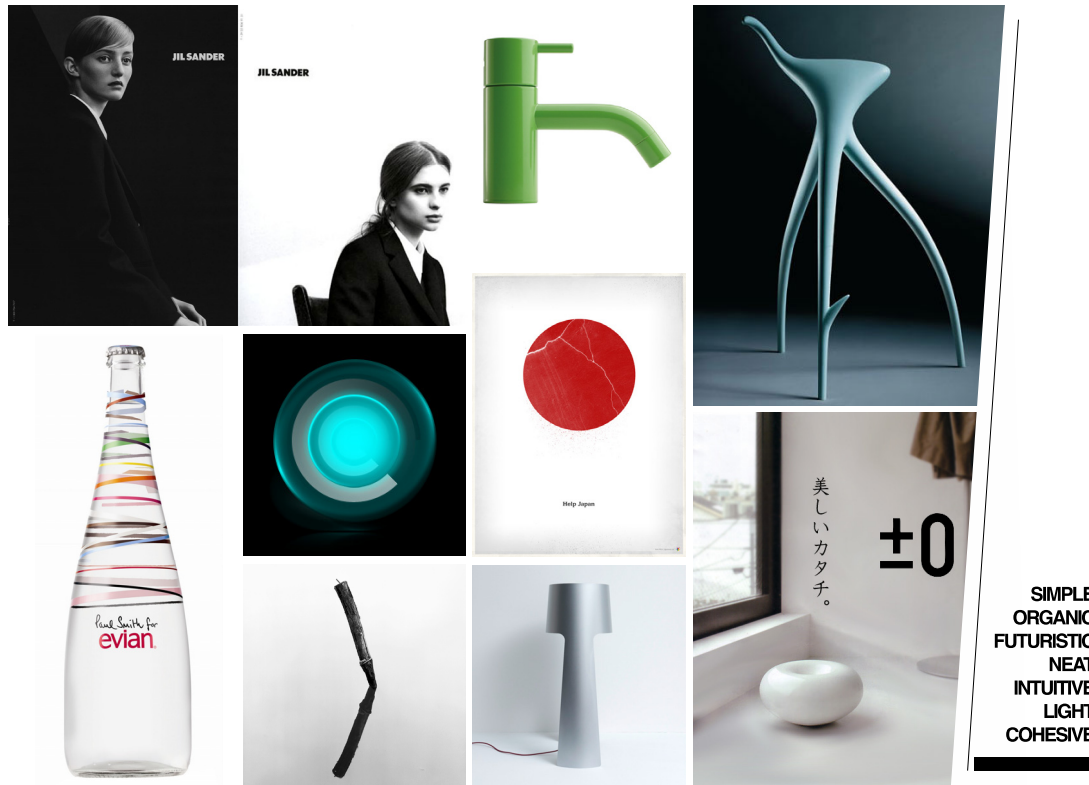


Main Instrument Panel-Expert User Concept



Appendix G Image Board

7.1 Standard User



7.2 Expert User

