AUX
Automotive User Experience

Project within: Electronics, Software and Communication
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Content

Executive summary

The goal of this project has been to improve the competitiveness of the Swedish automotive industry by providing methods and procedures for automotive User Experience (UX) development. Traditionally, usability and safety has been the main focus when designing and evaluating in-car interfaces and experiences. However, these factors are not enough for competitiveness in the 21st century. A comparison can be made to the mobile industry where the Iphone set a shift of UX paradigm; the competitive advantage was the user interface, not the phone's technical features. There has been a need to research the affective aspects of interfaces and experiences in the automotive industry. The objective of this project has been to explore and develop ways to support a product development with UX as a focus.

Part of the work has focused on how to move from a feature oriented design process to an UX driven innovation process and there has been a focus on the capabilities needed in order to be perceived as an automotive company that embraces services and products with the utmost user experience. Organization mirroring physical architecture and capability is not working for digiphysical products and services. Digitalization dynamics require new morphisms to be established. In order to do so, capabilities to uncover future possibilities and challenges are essential. Also, new capabilities are required for implementing new digitilized user experiences based on human values, moral and ethics. In order to meet future challenges, two different complementary strategies need to be considered. Implementing multiple organizational logics concerns organizational structures, while building service design capabilities point at the everyday practices and leadership.

There has also been a focus on methods for the ethnographic study of user experience in cars. For example has Meaningful Incorporation as a design approach for adapting the design process to focus on designing for UX been explored. Meaningful Incorporation is achieved by collecting UX insights as the first step in one's design process. There has also been a focus on UX methods for early design phases. Experience-rich input in early phases of a design process can offer valuable information and inspiration to designers. However, there are methodological challenges linked with efforts to understand future user experiences. Experience encompasses multi-layered and tacit data, such as emotions and value, that are important for commercial success but are difficult to elicit from users for existing products, and even more so for concepts in early design phases. Methods development for early design phases has been explored and methods have also been developed within the project. Additionally, two UX demonstrators have been developed as test cases for method deployment.

The project has given fundamental knowledge in understanding how to explore and develop ways to support a product development with UX as a focus. In addition, new innovative research methods and explorative Human-Machine Interface/ Interaction (HMI) solutions have been developed.

Background

User Experience (UX) is an attribute that takes into account customers' perception of the aesthetics and affection aspects of a user interface as well as the practical aspects [1, Figure 1]. ISO 9241-210 [2] defines UX as "a person's perceptions and responses that result from the use or

anticipated use of a product, system or service". The user experience is formed by a person's perception, cognition, memory, emotion, behaviour and physiology. It is constituted by both an affective aspect as well as a utility aspect. Whereas usability in Human-Machine Interaction (HMI) refers to the customer's ability to understand and execute a task, UX also addresses the emotional aspects. These aspects have become increasingly important for developing competitive products and are key factors for the success or failure for many companies, i.e. in the mobile phone industry. UX design can also be an enabling factor for motivating a customer to use a product in a desired way, i.e. driving safer.

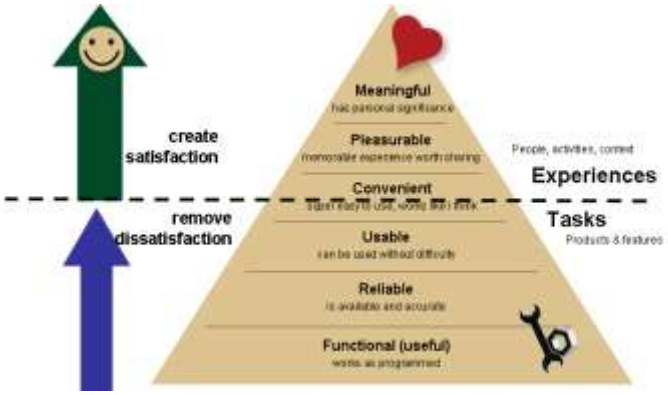

Figure 1: User Experience

In the HMI research area, there has been a shift from usability research towards user experience research in recent years, giving a broader and deeper understanding of the interaction with a product [4]. It is still a research area under development, common methodologies and definitions are scarce. However, there is a common understanding that designing a successful product resides in understanding customers' needs. These needs may differ in different markets. Therefore, the use of ethnographic methods applied to design is central in the UX design field [5].

Companies that focus on UX acquire a unique selling position [6]. UX in vehicles is on its way to take the same strides as other consumer products, for example mobile phones and computer games. Just as the amount of functions available for a driver has exploded in the vehicle industry, the number of functions in mobile phones has dramatically increased. But unlike the vehicle industry, the effort put into a high quality UX has been much more dominant in the mobile phone industry. In fact, this is one of the key factors of a mobile phone developer's success, and has contributed to a much higher expectancy on UX from consumers. This is evident in the consumer market in general, and also influences the automotive industry. The automotive UX ambition during the past years has increased radically.

The Swedish parliament introduced the Zero Vision initiative in 1997, an initiative whose aim is to "achieve a highway system with no fatalities or serious injuries in road traffic". There have been immense research efforts in order to achieve this and main focus has been on passive and active safety systems. It is often stressed that over 80% of all accidents can be partly attributed to human error [7]. Moreover, research shows that unhappy drivers are more accident prone and display a more risky and aggressive driving behaviour [8]. These findings underline the importance and the impact user interface can have on driving behaviour. Research provides the tools and knowledge needed for creating positive and pleasurable interfaces that can encourage safer and greener driving.

In resent research utility aspects have been explored, where first and foremost usability and task performance measures have been identified. This project has focused on research on the affective aspects of user's interaction with the vehicle. Usability is no longer enough to keep the customers' satisfied. Also, simply directly applying methods from for example the mobile phone industry is not a feasible solution for the automotive world. In this project, different methods have been explored, adjusted and developed.

Objective

The objective of this project has been to explore and develop ways to support a product development with UX as a focus. The following areas have been emphasised:

- How to move from a feature oriented design process to an UX driven innovation process
- Explore existing and develop new UX metrics and methods suitable for the automotive domain

Project realization

Work package 1: UX driven innovation

The aim of this work package was to present methods for the ethnographic study of user experience in cars and define and exemplify a UX design process through use of design methods and strategies that promote UX design.

Models of User Experience

There are several models and frameworks for User Experience, and they share some common aspects (Table 1).

Table 1: Models and frameworks for User Experience

Author	**Experience Model**	**Aspects of Experience**		
		Initial	With Use	Through Use
Norman	Emotional Design	Visceral	Behavioural	Reflective
Jordan	Pleasurable Design	Physio	Psycho	Socio- Ideo-
McCarthy & Wright	Threads of experience	Sensoral	Emotional Spatio- Temporal	Emotional Compositional
Hazzenzhal	Be-Do	Motor	Do	Be
Desmet & Hekkert	Product experience	Aesthetic	Emotional experience	Emotional & Meaning

The models and frameworks of User Experience in Table 1 have their elements organized in three categories based on how experience unfolds over time, and on a division inspired by Activity theory:

- *Initial Experience:* These elements describe first impressions and experience that arises from these first interactions with the artefact. The materials that the artefact is made of, the user interface elements that the artefact may possess etc., heavily influence this initial experience.
- *Experience With Use:* These elements include the usability of an artefact and other experiences that arise with and by using the artefact.
- *Experience Through Use:* These elements include parts of the experience that arise through use of the artefact. The value and meaning of the artefact is defined here. For example, the freedom and independence that a car affords its owner by enabling visiting remote places, does not stem from the experience with the car, but is a valuable experience that occurs through using the car nonetheless.

The models presented have stark implications regarding how UX research and design should be practiced. The pragmatist stance informs UX work by underlining the importance of **context**. Activity theory places focus on **time**, and the user's ultimate goals instead of only looking at tasks in a vacuum. **Emotions** are a significant aspect of experience that must be considered in UX design. If we are to design for experience, we must understand what motivates users to commence different activities in a deeper level, and then design in order to enable them in their pursuits in all levels of an activity.

Methods for the study of UX

While traditional ethnographic methods can capture user experiences in incredible levels of detail, a proper ethnographic study can be extremely time consuming to the point where conducting such studies is simply not feasible in an industrial setting. However, there are methods that adapt principles of ethnography, such as the idea to allow participants to freely express their experiences as opposed to only offering them predetermined answers through questionnaires, and the importance of context, time and emotions. Some examples are: *Future Workshop Scenarios, Interviews, KJ (Affinity Diagramming), Reflexive Photography, and UX Curve.*

UX case studies

A series of studies have been conducted within the frame of the work package with the ultimate result being the concept of *Meaningful Incorporation (MI)*. MI is a design approach for adapting the design process to focus on designing for User Experience. MI is achieved by collecting *User Experience Insight* as the first step in one's design process. User Experience Insight consists of UX data with special attention to the UX aspects of time, emotions, and context. UX Insight is then systematically incorporated into subsequent phases of the design process by using design methods that mandate its use. With Meaningful Incorporation and the utilization of the methods and insights found in the PhD thesis, design professionals can take on UX design without compromising designerly intuition. Instead, Meaningful Incorporation can enhance their process to create solutions that can support desirable User Experiences.

Work package 2: Developing dynamic capabilities in HMI design

This work package has focused on the capabilities needed in order to be perceived as an automotive company that embraces services and products with the utmost user experience. The future is yet to come, and we all are trying to visualize what it will be like. Some patterns are already revealing itself and therefore must be acted upon.

- **From product to service** - In order to keep a competitive edge and to prosper, businesses are continuously challenged to serve a greater range of needs. Meeting everyday customer needs whenever it does or could include the car is important. This means to abandon the concept of the car as the product and instead actively searching for services that enriches existing touch points. This also means creating new services in order to enhance everyday life of the car owner, usually referred to as design thinking. This transfer also highlights the need of making incumbent firms integrate services into their portfolio and service focused companies emerge.
- **Sustainability** - A focus on a long time perspective have revealed itself to be not only a necessity in order to keep the possibility to live and prosper on earth, but also a more profitable way to act. This includes to be long term environmentally friendly in the broad sense, not limited to material/waste handling, energy, water and air, but also stakeholder perspective, leadership, and employees (usually referred to as conscious capitalism) but also including control models and phronetic leadership.
- **Open innovation** - Digitalization comes with severely increased complexity of distributed coordination and control in conjunction with heterogenous resources. This requires new strategies in order to find, or create, a position in an ever evolving ecosystem.
- **Engaged and aware customers and employers** - Customers and employers wants to comply with values that they are emotionally engaged in. Organization needs therefore to directly and simply convey their values throughout all their actions and outputs. This includes finding and maintaining simple and efficient ways of continuous evolvement and embrace value-based rationality to balance the traditional logical and instrumental rationality.

Organization mirroring physical architecture and capability is not working for digiphysical product and services. Digitalization dynamics require new morphisms to be established. In order to do so, capabilities to uncover future possibilities and challenges are essential. Also, new capabilities are required for implementing new digitilized user experiences based on human values, moral and ethics.

In order to continue the journey towards user centric innovation with services in focus, sustainability as a core value, open up innovation processes and apply value-based leadership, the capabilities presented below are fundamental.

- **Agility** - An iterative process with continuous and frequent deliveries and where planning is used to maximize *learning*.
- **Understanding usage and practices -** Focus on usage and continuously asking the question "*why* " to improve the understanding of how people use and practice their daily lives.
- **Capability to design for behaviours -** The aim is to design solutions manifested in digiphysical products and services that guides users to *keep, or change, certain behaviours*.

- **Continuous evaluation in use** - Admitting that user experience cannot be uncovered any other way than exposing a proposals of solutions to *real people in real situations* continuously and iterative.
- **Service innovation** - A mind-set where *relations* between people and their needs and behaviours include both product, service, and other contextual factors.
- **Phronesis** - Underlining that skilled workers with *practical wisdom* and *tacit knowledge* understands how different contextual elements affects each other. This skill needs to be enforced in any process where a specific user experience is the design goal.

In order to meet future challenges, two different complementary strategies need to be considered. Implementing multiple organizational logics concerns organizational structures, while building service design capabilities point at the everyday practices and leadership.

- Implementing multiple organizational logics
    - Big bang (disruptive, fast but risky and difficult)
        - Top level big bang
        - Total make over
    - Evolving (incremental, slow but safe)
- Building service design capabilities and change of focus
    - Transparency
    - Value leadership
    - Phronetic infusion

Work Package 3: User Experience Metrics

The aim of this work package was to define a methodology for UX design-evaluation with appropriate customers in appropriate test environments (desktop, simulator, field, etc). A focus has been on the early design process.

Experience-rich input in early phases of a design process can offer valuable information and inspiration to designers. However, there are methodological challenges linked with efforts to understand future user experiences. Experience encompasses multi-layered and tacit data, such as emotions and value, that are important for commercial success but are difficult to elicit from users for existing products, and even more so for concepts in early design phases. At early design phases, the inevitably incomplete representations of product and use context influences the outcomes. It is typically easier to elicit usability-related aspects, meaning that other aspects of experience may be insufficiently addressed. The contribution of this work package is an approach for eliciting rich UX data in early design phases, building on six studies. This work package employs in-vehicle user experience as a study case, but results are however presented on a methodological level that can also be of use to other interactive products. The overall research questions have been: *What signifies in-vehicle UX? How can UX data be elicited for input to novel in-vehicle concepts in early design phases?* Firstly, the *analysis* phase of the design process was addressed, where a multi-method approach was employed to study current in-vehicle UX. UX is an umbrella term that has proven difficult to describe and conceptualise in studies. Therefore, the aim of the first study was to better understand what signifies the specific case of in-vehicle UX. Secondly, how to approach and understand user expectations on future autonomous cars was addressed in the two following studies, in order to address prospective research of novel systems. A method addressing research on user expectations was developed

– Setting the Stage for Autonomous Cars. Thirdly, *ideation* was addressed in a series of workshops, containing generative and creative efforts for ideating future interactive in-vehicle systems. Methods such as enactment, small-scale scenarios, Wizard of Oz, a lofi driving simulator and the developed Setting the Stage for Autonomous Cars method were used. The final studies address concept *evaluation*, and comparatively explore the effects of choosing different product representations (storyboard and interactive prototype) and study contexts (Virtual Reality and in the field) in early UX evaluation. Based on the outcomes of the studies, an approach is proposed – the CARE approach – for enabling richer and more in-depth UX data in early design phases. This approach suggests that there is a need to *Contextualise* the researched experience (conveying the intended use situation and sentisising the participants to experience), enabling the participant to *Act* (enabling interaction even at the stages of very lo-fi concepts), supporting *Reflection* on the experience (enhanced by generative elements in the methods, such as drawing concepts and enacting use) and enabling the participant to *Express* the experience (in more ways than by just relying on words). Furthermore, the thesis presents findings regarding what signifies in-vehicle UX, for example whole-body, multi-sensory interactions, the importance of the temporal stage of use, the social and multi-device context, and the changing relationship between user and car with increased automation. The results emphasise the importance of addressing the multisensory use situation in each design phase and for participants to express experiences, not only in words but also through enactment and generative techniques.

Work Package 4/5: UX demonstrators

The two work packages aimed to be test cases for method deployment. It resulted in two UX demonstrators: the quickStart and the Information Load Control.

UX demonstrator 1 – the quickStart

The aim of this UX demonstrator was to test a technical solution that can take keyless drive one step further – skip the START-button:

- The engine starts when driver presses brake pedal and grabs the gear shifter
- The engine stops when driver releases gear shifter i P-position or operates P-brake

A solution was implemented in a car and tested on some participants. Technical solution:

- A new switch, hidden in the gear shifter knob, is activated when grabbing the knob. The switch initiates start of engine if brake pedal is pressed and other conditions are met.
- During driving, the switch has no function.
- When selecting PARK position and hand is released, ignition is turned off.
- The switch and an indicator LED is connected to existing CEM module, no further components are added.
- The current START/STOP switch is kept as is, and can be used in parallel

UX demonstrator 2 - the Information Load Control

The UX Demonstrator 2, named the Information Load Control (ILC), is an in-car information and entertainment platform, based on a touch screen.

The highly developed Android platform was chosen as a development platform for the project. Scrum as a way of work was used during the development, with daily stand-ups, sprint planning, scrum board, backlog grooming and technical refinement, spring review and demo with stakeholders. The scrum board was chosen to be a physical board. The reason behind that was that the development team wanted to be able to show the stakeholders a concrete and understandable overview of the work. A persona was also developed - "A CEO or Business manager, with a career and career priorities". What she needed was a way to simplify what she does on the way to work. With an application in the centre of the car (and presuming that the car is autonomous) she saw many things that could be shown there every morning when leaving for work. Examples from the interview were Calendar, Meetings, Phone, Mail, and Navigation. The researchers of the project wanted to have people's opinion on how the application looked and felt. A field test was conducted at the end of the project, but with some time for changing potential major mistakes in the design or functionality.

The work resulted in a prototype where the design of the implementation was made in such a way that the developers were able to add and remove functionality easily for demonstration purposes. The aim was to design an application that is easy to read, understand and use. Additionally, it needs to have relatively high customization abilities to make sure every instance of the application is appealing to the specific user, much due to requirements about personalization. A "Zen-controller", a knob, was implemented, which could be used to regulate the "Zen-level" of the application. The functionality of the controller included decreasing and increasing the information flow by turning the knob left for increase zen (decrease amount of information), and right to decrease zen (increase the amount of information). Clicking the whole knob would mute, or unmute, any information that was currently in the application. Also the application bars in the display was passible to customize.

Results and deliverables

The project has contributed to the overall FFI targets:

- Increase research and innovation capacity in Sweden. The work has contributed to knowledge regarding metrics and methods for a User Experience (UX) focused HMI design process. The work has helped Volvo Cars in transforming to a UX way of work, which is a competitive advantage. Chalmers, inUse, HiQ and RISE Viktoria will utilize the competence gained in this project to remain competent partners in research within this area. Participation in forward thinking research projects is vital for Chalmers, inUse, HiQ and RISE Viktorias ability to attract and retain talented researchers.
- Develop competitive and internationally connected research and innovation clusters in Sweden.
- Promote cooperation between industry, universities and institutes. In addition, the project has contributed to the establishment of new international collaborations.

The project has supported two areas of the FFI collaboration program "Vehicle Development":

- Vehicle electrics and electronics
- Methods and tools for vehicle development. AUX has included research and ideation activities as well as development of tools and processes for design and evaluation, which have already been successfully applied in other ongoing research and development projects.

Dissemination and publications

Knowledge and results dissemination

Seminars and workshops have been held among the project partners with the aim of enabling for discussions, knowledge transfer, as well as concept and study ideation. Presentations of thesis work have invited parties outside the project. In addition, presentations at the conferences have been conducted, for example at:

- The 2018 CHI Conference on Human Factors in Computing Systems
- The 2015 HCIII International Conference of Design, User Experience, and Usability
- DRS2018 (Design Research Society)
- The 2017 Conference on Designing Interactive Systems (DIS)
- The International Conference on Interfaces and Human Computer Interaction 2017 – Part of the Multi Conference on Computer Science and Information Systems 2017
- The 9th Nordic Conference on Human-Computer Interaction
- D and E 2016: 10th International Conference on Design and Emotion
- The 2014 European Conference on Human Centered Design for Intelligent Transport Systems
- The 2014 NordCode Conference
- Automotive user interfaces in the age of automation, Dagstuhl Seminar 16262. Schloss Dagstuhl-Leibniz-Zentrum fuer Informatik.

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Conclusions and future research

The objective of this project has been to explore and develop ways to support a product development with UX as a focus. The project has given fundamental knowledge in understanding how to move from a feature oriented design process to an UX driven innovation process. New innovative UX metrics and research methods suitable for the automotive domain have been developed.

Related work within the area of research methods for UX is continued in, for instance, FFI HEAD (Human Expectations and Experiences of Autonomous Driving) and FFI TIC (Trust in Intelligent Cars).

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