

User Information and Interaction (USI)



Project within FFI: Vehicle and Traffic Safety

Author: Per-Anders Jörgner, Volvo Car Group

Date: 2013-01-28



Content

1. Executive Summary	3
2. Background	3
3. Objectives	3
4. Project Realization	4
5. Results and Deliverables	6
5.1. Structure.....	6
5.2. Examples of Results	6
5.3. Delivery to FFI Goals	12
6. Dissemination and Publications	13
6.1. Knowledge and Results Dissemination	13
6.2. Publications.....	13
7. Conclusions and Future Research	16
8. Participating Parties and Contact Person	16
9. References	17
10. Terminology	17

FFI in short

FFI is a partnership between the Swedish government and automotive industry for joint funding of research, innovation and development concentrating on Climate & Environment and Safety. FFI has R&D activities worth approx. €100 million per year, of which half is governmental funding. The background to the investment is that development within road transportation and Swedish automotive industry has big impact for growth. FFI will contribute to the following main goals: Reducing the environmental impact of transport, reducing the number killed and injured in traffic and Strengthening international competitiveness. Currently there are five collaboration programs: **Vehicle Development, Transport Efficiency, Vehicle and Traffic Safety, Energy & Environment and Sustainable Production Technology.**

For more information: www.vinnova.se/ffi.



1. Executive Summary

The USI project commenced in 2009 and terminated, according to plan, in the end of 2012. All project objectives defined in the application were fulfilled. We believe that USI will contribute to achieving overall FFI objectives from an HMI (Human Machine Interaction) perspective. USI has produced research results in different HMI areas, including: Haptic perception, attention, and effects on secondary tasks and driving performance concepts for in-vehicle text input and reading; Internet use and navigation, green touch points; Open platforms and principles for open application development for in-vehicle information systems, the impact of product digitalization; and Sound and vibration design for information and entertainment. Two PhDs were examined in the project.

2. Background

When the FFI application for USI, was created back in 2009, the following background was depicted (Palo, 2009):

- Safety, usability, styling and comfort are areas highly appreciated among premium car owners today. They make design of interfaces and interactions in modern cars increasingly challenging. From a development perspective there is a growing amount of secondary in-vehicle tasks related to more in-vehicle information systems (IVIS). In order for Volvo Car Corporation to maintain the important safety profile and at the same time utilize the possibilities that expands from the evolving domain more research is needed.
- Many in-vehicle tasks were changing from manual to manual-visual tasks. At that time analysis was made on functions that, compared to IVIS today, can be considered as short manual-visual tasks, e.g. tune the radio. Information, which used to be activated by pressing a button, is now hidden in hierarchical menu structures. The new system designs required extensive manual-visual interaction. The findings were revealed in a study of premium cars with multifunctional control systems. The change towards an indirect manipulation style could be explained by a function driven evolution where functions were added in a menu-based interaction as they became popular.
- The IVIS functions have high demands on flexibility in interaction (on and off board: navigation, radio, mp3, settings, telephone, Internet, etc.). That is why some of the evolving in-vehicle tasks may be utilizing interaction techniques that are not fully compatible with the nature of the task.

3. Objectives

The objectives are described together with comments on the results in section 5.3 (Deliver to FFI-goals) below.

4. Project Realization

The USI project was part of the EFESOS (Environmental Friendly efficient Enjoyable and Safety Optimized Systems) umbrella project. EFESOS is a Vehicle HMI (Human Machine Interaction) research project. The overall ambition is to make driving of future cars more environmental friendly, enjoyable and safer by means of optimized systems. The project is managed by Volvo Car Corporation (VCC) and it is collaboration between VCC and seven other research partners (see logos in Figure 4.1 below). The EFESOS project is divided into three subprojects:

- **USI – User Information and Interaction**
- DRIVI – Driver Information and Interaction
- METOHMI - Methods & Tools Development for HMI



Figure 4.1 EFESOS Partners

The EFESOS project started in 2009 and will continue until December 2013. The project is financed by the industry partners VCC, HiQ and Semcon, and by Swedish agencies as part of the national FFI (Strategic Vehicle Research and Innovation) program, see www.vinnova.se/en/ffi/ (see also picture on front page, page 1).

Of the totally eight research partners in EFESOS the following five partners were active in USI (listed in alphabetical order below):

- HiQ Göteborg AB
- Luleå University of Technology (LTU)
- Semcon AB
- Viktoria Institute
- Volvo Car Corporation (VCC)

USI is the part of EFESOS that had the earliest start and it was also ended around one year before the other parts (see Figure 4.2 below).

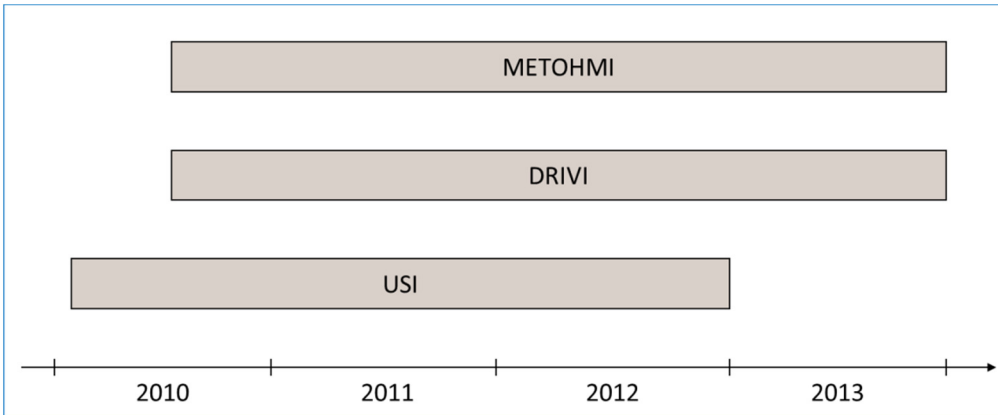


Figure 4.2 EFESOS Overview Time Schedule

Detailed information about the project scope in terms of time, budget and content, the project organization, and way of working is provided in the project steering documents (project plan, time schedule, etc.) and these topics are elaborated on in the technical project report (Jörgner, 2013)

5. Results and Deliverables

5.1. Project Structure

The USI project consisted of six work packages (WPs), which are briefly described below, and more detailed descriptions of the work, including results, is to be found in section 5.2. Involved research project partners are denoted within brackets in the headings below.

- WP1: Efficient Multi-Modal Interaction (LTU, Semcon)
 - Task 1: Driver and passenger studies (LTU)
 - Task 2: Texting and Integrated Nomadic Devices (Semcon)
- WP2: Safe and Green Services for In-vehicle Internet (Semcon)
 - Task 1: In-vehicle Internet and driver distraction (Semcon)
 - Task 2: Constrained web browsing (Semcon)
 - Task 3: Navigation and Location Based Services (Semcon)
 - Task 4: Green Touch Points (Semcon)
- WP3: Open Design Infrastructures (HiQ, Viktoria Institute)
 - Task 1: Platform Strategy and Design (HiQ & Viktoria Institute)
 - Task 2: Application development (HiQ)
- WP4: Sound and vibration design for information and entertainment (LTU, Semcon)
 - Task: Sound and vibration design for information and entertainment (LTU & Semcon)
- WP5: VCC Advanced Engineering and Research (VCC)
 - Tasks 1-5: VCC Advanced Engineering (AE) projects (VCC)
 - Tasks 6-7: Industrial PhD, HMI Systems Engineering and final thesis work (VCC)
- WP6: Concept Cars (VCC)

5.2. Examples of Results

The subsections below provide some good examples of results and achievements from the work packages in USI.

5.2.1. WP1: Efficient Multi-Modal Interaction

LTU has produced a PhD. The thesis investigates haptic perception, attention, and effects on secondary tasks and driving performance for an interaction menu selection interface controlled by an in-vehicle haptic rotary device. The research questions addressed how and why performance would be affected by added haptic information. The causes of selective attention in a visual and haptic menu selection task were also investigated. Three experimental studies complemented with interviews and questionnaires were performed. Two of the studies included a simulated driving task. It could be concluded that an addition of haptic information to a visual menu selection interface could increase

secondary task performance and were preferred with respect to usability issues. However, more complex haptic additions could also confuse the driver.

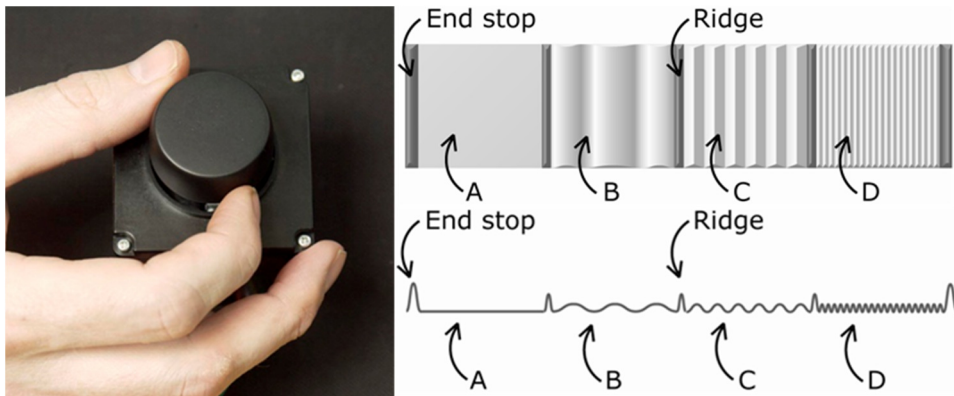


Figure 5.1 Haptic rotary device and visual/haptic ridges

Semcon has evaluated text input by means of touch pad and touch screen devices against criteria such as time to complete the task and standard deviation of lane position. The evaluation was performed in the VCC HMI Usability Lab simulator.



Figure 5.2 Text input concept evaluation in VCC simulator

Based on these experiences, a new innovative concept for text input has been developed (patent pending).

Interesting results are also available regarding reading concept development. Together with students from LTU, Semcon examined whether it would be advantageous to use speed-reading techniques and text “chunking” (dividing the text in smaller units, e.g. four words at a time) to maximize the efficiency when reading a text message, while at the same time minimizing the distracting effect on driving. The typographic aspects of presenting the text message were also explored trying to maximize the possibility to read the text.

Furthermore, an analysis was made on the impact of the “Visual-Manual NHTSA Driver Distraction Guidelines for In-Vehicle Electronic Devices” for the automotive industry in Sweden.

5.2.2. WP2: Safe and Green Services for In-vehicle Internet

Semcon conducted an analysis resulting in a comparison between input methods used for Internet and navigation in different vehicle brands. The result contains information about whether for instance touch screen, joystick and rotary devices are used. There is also a list of main input methods which are used in mobile phones and handheld devices.

Another study compared state-of-the-art navigation systems on the market. Three different navigation systems were tested with hierarchical task analysis (HTA) and cognitive walkthrough (CW). This work resulted in recommendations for which information should be shown on the display of the navigator as well as which guidelines have to be taken into account when designing in-vehicle displays.

In cooperation with Chalmers a Bachelor of Science thesis “Creating a Vision – Identifying Green Touch Points and Encouraging Behaviour Change in Car Use” explored User Experience and the related Vision in Product Design method as a way to improve personal transport interactions. The aim of the project was to identify “green touch points” (see the list below) in car usage and to create a scenario of how to encourage people to make a change in their behaviour. Identified green touch points are:

- Joining a car pool
- Buying a car with the lowest possible emission rate
- Servicing on regular basis
- Using an engine warmer in the winter
- Using environmentally friendly cleaners
- Choosing the right tires
- Cooperation among travelers in e.g. a family
- Carrying out planned trips only
- Leaving the car at home

5.2.3. WP3: Open Design Infrastructures

Researchers from HiQ and Viktoria Institute have investigated the opportunities and challenges of openness in the automotive industry. Open platforms and principles for open application development for in-vehicle information systems, and integration of smartphones and similar devices, were evaluated, industry trends (consumer electronics and automotive) were identified and the future was predicted by means of scenario planning.

The research identified in the project application was approached with following four questions in mind:

- How do other organizations and industries approach open innovation?
- How can we conceptualize and make sense of open innovation in an automotive context?
- What challenges can we expect the automotive industry to face in light of rapid digitalization?
- How should automakers respond to challenges posed by increasing digitalization?

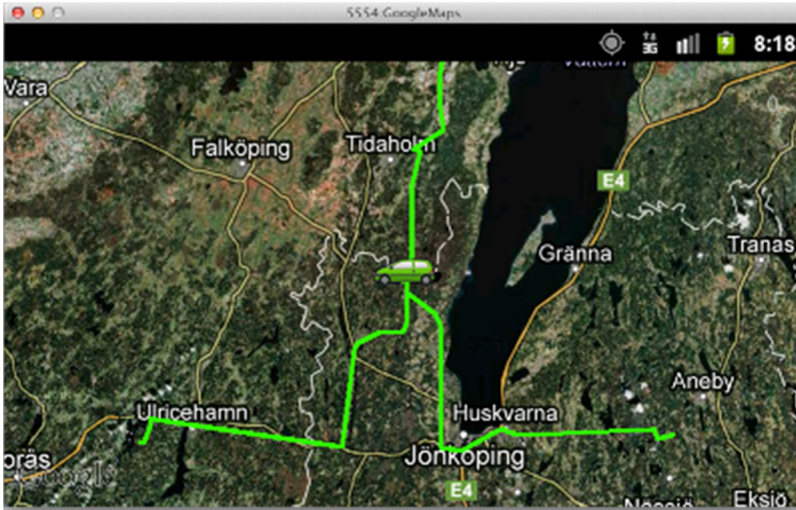


Figure 5.3 Predicted range interval application demonstrator

This research resulted in examination of a PhD, a number of scientific papers and reports, and three demonstrators. The following examples can be given here:

- A scenario planning study was implemented with the Connectivity Hub at Volvo Cars, to improve our understanding of external factors with significant impact on the future design of connected cars. This study made contributions at different levels, but one deliverable worth mentioning is a list of environment variables deemed particularly important for Volvo Cars' capability to "build competitive advantage through connectivity".
- A substantial review of innovation literature to describe and contrast the innovation logic of product innovation and digital innovation was made. This study explicates challenges of innovation management in a context where physical products are increasingly digitized.
- An analysis was made, from the perspective of third party developers, to put light on different barriers for innovation in an upcoming, increasingly open automotive environment. The resulting report identifies and elaborates three resources of particular importance for developers; API design, software development kit, and infrastructure for application distribution. In order to further illustrate the identified concepts, collaboration

was set up with research partners involved in DRIVI WP3 to employ and examine a number of demonstrators (fuel consumption aware speedometer and two applications regarding predicted range interval for electric/hybrid cars, see Figure 5.3).

5.2.4. WP4: Sound and Vibration Design for Information and Entertainment

Researchers from LTU and Semcon used the preconditions developed in project METOHMI to design and evaluate sound and vibrations in a test car interior. Below is an overview of the research results.

In the area Design methodology applied to sound and vibration design three case studies were conducted:

- Development of welcoming sounds/sound logotypes for a Volvo car.
- Development of combined sound and vibration signals for turn instructions from a navigation system.
- Development of sketching tools for combined sound and vibration signals.

Effects on perception of spatial placements of sound signals were analyzed. Secondary task performance was significantly increased when the sound source was located at the same position as the visual task, when compared to not using any sound. The experiment also indicated that driving performance could be increased by presenting driving related sounds in front of the driver.

Technology for synthetic 3D sound was studied. It was shown that loudspeakers placed behind the listener correctly reproduced sound sources in the back hemisphere. Loudspeakers located in front and above the listener gave a high number of front/back confusions for all directions. Sounds with narrow spectral contents were more sensitive to front/back confusions. Loudspeakers placed above the listener resulted in best preference ratings, and loudspeakers placed on the dashboard resulted in lowest preference ratings.

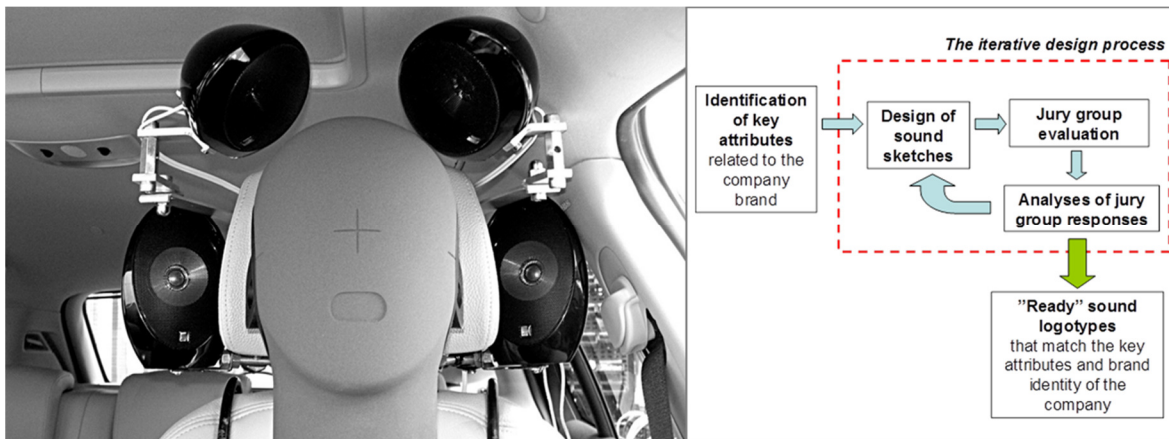


Figure 5.4 Audio experiment (3D) and sound design process overview

Hardware recommendations for audio/tactile infotainment systems were developed. Touchscreens with haptic feedback were studied and evaluated. A system for haptic feedback in a car seat was developed in order to design multi-modal information signals. This system proved very useful for one master thesis, where multi-modal signals for car navigation were studied.

5.2.5. WP5 & WP6: VCC Advanced Engineering, Research and Concept Cars

The results of the different advanced engineering activities in USI WP are, very briefly, summarized below:

- A basis for creation of a safe and harmonic sound experience that connects with the values of VCC brand.
- Interaction concepts for driver and passenger interaction with displays in the cockpit.
- Research results regarding development of HMI solutions for driver support systems towards fully automated driving.
- Enhanced concepts for speech recognition.
- Research results in the areas of driver support system for more fuel-efficient driving, infotainment system architecture and connectivity.

The further use of these results is outside the scope of the USI project. They may, or may not, be implemented in future Volvo cars.

In USI WP6, three concept cars were used for verification and evaluation of HMI concept prototypes and demonstrators developed in other work packages. These concept cars were based on XC60, V70 and S80 cars.



Figure 5.5: Concept You, Frankfurt Motor Show 2011

Additionally, ideas and knowledge gained in USI was used as one input to two public Volvo concept cars. These were Concept Universe, presented at the Shanghai Auto Show



in April 2011, and Concept You, revealed at the Frankfurt Motor Show in September 2011.

5.3. Delivery to FFI Goals

5.3.1. Purpose and Objectives

The purpose and objectives were defined in the FFI application (Palo, 2009). The results are elaborated on and discussed in other USI final reports (Jörgner 2013b; Jörgner 2013c). The financial results are described in USI financial final report (Jörgner 2013c).

To summarize: All objectives were fulfilled in the project. Two tangible objectives can be mentioned here: Two PhDs were examined (objective: 2 PhDs) and ten master theses were produced (objective: at least 4).

5.3.2. FFI Targets

The overall objective of the Vehicle and Traffic Safety program (www.vinnova.se/en/ffi) – *to contribute to the development of Zero Vision vehicles, i.e. vehicles with an optimum combination of active and passive systems to reduce the number of accidents and the consequences of those accidents which nevertheless occur* – was in the USI application (Palo, 2009) refined into a number of targets (sub objectives), divided into three areas (vehicle development, safety and energy & environment). The fulfillment of these targets – they all were fulfilled – is described in the technical project report (Jörgner, 2013a). We believe that USI will contribute to achieving the FFI overall objective above, from an HMI perspective.

5.3.3. Summary and Outlook

All objectives were fulfilled. The results will be used by all partners involved in the project. USI had its focus on HMI for cars. The results can also be applicable in other industries, primarily trucks, buses and construction equipment (hopefully also for trains and airplanes).

6. Dissemination and Publications

6.1. Knowledge and Results Dissemination

Dissemination was made outside as well as inside the domain of project research partners. Externally, dissemination was made through participation in international and national conferences, seminars and similar events. Internally, dissemination was achieved through the EFESOS internal conferences, project meetings, and workshops.

Examples of connections to other research projects include: DRIVI, METOHMI and Non Hit Car & Truck. Drives of change with the potential of accelerating the dissipation of project results are mainly: the continuing high innovation pace in consumer electronics and the rapidly increasing innovation pace in automotive electronics.

6.2. Publications

PhD theses:

- Grane, C. (2012a). Haptic Perception, Attention, and Effects on Performance in a Driving Context - Use of a Haptic Rotary Device in a Menu Selection Task. PhD thesis, Luleå University of Technology, Luleå, Sweden.
- Svahn, F. (2012c). Digital Product Innovation: Building Generative Capability through Architectural Frames. PhD Thesis, Department of Informatics. Umeå: Umeå University.

Scientific papers:

- Broström, R., Bengtsson, P., Axelsson, J. (2010). Correlation between safety assessments in the driver-car interaction design process, *Applied Ergonomics*, Volume 42, Issue 4, *Applied Ergonomics and Transportation Safety*, pp. 575-582.
- Broström, R., Davidsson, S. (2012). Towards a model to interpret driver behaviour in terms of mismatch between real world complexity and invested effort, IEA 2012 conference, Recife, Brazil, February 2012.
- Ghazawneh, A., Henfridsson, O. (2010). Governing Third-Party Development through Platform Boundary Resources, *Int. Conf. on Information Systems*, St Louis, USA.
- Grane, C. (2012b). Methodological considerations when adding new measures to the lane change test. NES 2012 conference, Stockholm Saltsjöbaden, August 2012.
- Grane, C., & Bengtsson, P. (2012a). Haptic addition to a visual menu selection interface controlled by an in-vehicle rotary device. *Advances in Human-Computer Interaction*, 2012, 12 pages. doi:10.1155/2012/787469.
- Grane, C., & Bengtsson, P. (2012b). Driving performance during visual and haptic menu selection with in-vehicle rotary device. Manuscript resubmitted for publication.

- Grane, C., & Bengtsson, P. (submitted 2012c). Selective haptic attention and selective use of haptic information when interacting with visual-haptic interface during simulated driving. Manuscript submitted for publication.
- Henfridsson, O., Mathiassen, L., Svahn, F. (2012). Managing Technological Change in the Digital Age: The Role of Architectural Frames, submitted to international journal.
- Hylving, L., Selander, L. (2012). Under the Guise of Openness: Exploring Digital Innovation in User Interface Design, ECIS 2012, Barcelona, Spain.
- Lundkvist, A., Nykänen, A., Johnsson, R. (2011). 3D-sound in car compartments based on loudspeaker reproduction using crosstalk cancellation. In proceedings of the 130th AES Convention, London, UK.
- Mohlin, P., Arvidsson, I., Svensson, J (2012). Real-Time Manipulation and Spatial Location of Auditory Icons as Tools to Decrease the Workload of a Driver. NES 2012 conference, Stockholm Saltsjöbaden, Sweden, August 2012.
- Nätterlund, K., Sundin, A., Romell, I., Gustavsson, M. (2011). On Attitudes towards Green Touch Points in the Use of In- and Off Vehicle Internet. VDI conference Electronics in Vehicles, Baden-Baden, Germany, October 2011.
- Rydström, A., Broström, R. (2012). Developing in-car user interfaces with emphasis on user experience. NES 2012 conference, Stockholm Saltsjöbaden, Sweden, August 2012.
- Rydström, A., Broström, R., Bengtsson, P. (2011). A comparison of two contemporary types of in-car multifunctional interfaces. Applied Ergonomics journal 09/2011.
- Selander, L., Henfridsson, O., and Svahn, F. (2012). Capability Search and Redeem across Digital Ecosystems, submitted to international journal.
- Selander, L., Henfridsson, O., Svahn, F. (2010). Transforming Ecosystem Relationships in Digital Innovation, Int. Conf. on Information Systems, St Louis, USA.
- Sundin, A., Patten, C.J.D., Bergmark, M., Hedberg, A., Iraeus, I.-M., Pettersson, I (2012). Methodical aspects of text testing in a driving simulator. IEA 2012 conference, Recife, Brazil, February 2012.
- Svahn, F., Henfridsson, O. (2012). The Dual Regimes of Digital Innovation Management, HICSS-45, Grand Wailea, Hawaii: IEEE Computer Society.
- Svensson, J., Kleiven, S., Mohlin, P., Mannegren, M (2012). Designing multimodal stimuli for in-vehicle information systems. NES 2012 conference, Stockholm Saltsjöbaden, Sweden, August 2012.

Master theses:

- Arasa Gaspar, A. (2011). Design and evaluation of haptic feedback for in-vehicle touch screens. Chalmers University of Technology (CTH) Master of Science Thesis, 2012.
- Borg, J., Murphy, A. (2011). Adaptive driver information – A quantitative study. Luleå University of Technology (LTU) Master of Science Thesis, 2011.
- Chang, B., Marshall, D. (2012). Development of an In-Vehicle User Interface for Traffic Information Presentation. Chalmers University of Technology (CTH) Master of Science Thesis, 2012.

- Duan, L. (2009). Culture Differences Analysis – A Comparison between Chinese Drivers and Swedish Drivers on Driving Behaviors. Chalmers University of Technology (CTH) Master of Science Thesis, 2009.
- Jonsson, S. (2011). Driver's exposure to distractions from visual in-vehicle secondary tasks – Measuring eye-movements and working memory capacity. Linköping University (LiU) Master Thesis, 2011.
- Kjellberg, E. (2012). Creation of Method and Early Evaluation Package with Focus on Safety and Multimodal Evaluation for Text Input while Driving. Luleå University of Technology (LTU) Master of Science Thesis, 2012.
- Larsson, M., Sondell, I. (2011). Creating a Vision – Identifying Green Touch Points and Encouraging Behaviour Change in Car Use. Chalmers University of Technology (CTH) Bachelor of Science Thesis, 2011.
- Mankila, J. (2012). Technology acceptance of personalizable in-vehicle systems. Luleå University of Technology (LTU) Master of Science Thesis, 2012.
- Mannegren, M. (2012). Designing Multimodal Stimuli for Driving Events. Chalmers University of Technology (CTH) Master of Science Thesis, 2012.
- Rahman, M. (2011). Generating Driving Scenarios from Real World Video Records. Chalmers University of Technology (CTH) Master of Science Thesis, 2011.

7. Conclusions and Future Research

The project has been executed according to plan from a cost, time, content, resource and delivery perspective and the objectives have been fulfilled. The benefits of the project for the different partners are very good according to an evaluation performed by the project's steering & management team (Jörgner, 2013a). The project has also contributed to the further development of a Swedish Eco system, involving OEMs, suppliers, academies and institutes, in the area of HMI and Interaction Design.

The idea to have this project, USI, integrated with other research projects in the same area (DRIVI and METOHMI) within the EFESOS umbrella project has been fruitful. More and deeper contacts were achieved between researchers from the different partner organizations. The concept having internal conferences, twice yearly, was successful. This enabled the researchers to present results and intermediate results, to get valuable feedback from colleagues, and to exchange information and knowledge. The external conferences with main focus, the IEA 2012 at Recife, Brazil (www.iea2012.org) and NES 2012 at Stockholm Saltsjöbaden (www.nes2012.se), were also successful, each with six accepted papers from the project. The mix of PhD students, senior researchers, other researchers and engineers in the project was good.

Future research in this area, within the FFI programs, is achieved through the continuation of DRIVI and METOHMI, two smaller successor projects were started in 2012, and a number of new applications have been made for projects that will start in 2013 or later.

8. Participating Parties and Contact Person

HiQ Göteborg AB

- (WP3) Anders Bengtsson, anders.bengtsson2@hiq.se, 0734-481247
- (WP3) Mohsen Nosratinia, mohsen.nosratinia@hiq.se, 0709-734920

Luleå University of Technology

- (WP1) Peter Bengtsson, peter.bengtsson@ltu.se, 0920-492474
- (WP4) Anders Ågren, anders.agren@ltu.se, 070-5757092

Semcon AB

- (WP1-WP2) Anders Sundin, anders.sundin@semcon.com, 0733-989635
- (WP4) Peter Mohlin, peter.mohlin@semcon.com, 0704-210601

Viktorias Institute

- (WP3) Fredrik Svahn, fredrik.svahn@viktorias.se, 0730-401188
- (WP3) Lena Hylving, lena.hylving@viktorias.se, 0761-302188

Volvo Car Corporation

- (Project Manager) Per-Anders Jörgner, pjorgnel@volvocars.com, 0701-839152
- (WP5-WP6) Patrik Palo, patrik.palo@volvocars.com, 031-597997

9. References

- Jörgner, P.-A. (2013a), USI Technical Report (confidential final report), Volvo Car Corporation, 2013.
- Jörgner, P.-A. (2013b), USI Slutrapport Måluppfyllelse, Volvo Car Corporation, 2013.
- Jörgner, P.-A. (2013c), USI Ekonomisk slutredovisning, Volvo Car Corporation, 2013.
- Palo, P. (2009a), FFI Project Description for USI – User Information and Interaction, Version 1. Volvo Car Corporation, 2009-07-09.

10. Terminology

API	Application Programming Interface
DRIVI	Driver Information and Interaction
EFESOS	Environmental Friendly efficient Enjoyable and Safety Optimized Systems
IVIS	In-vehicle Information Systems
LTU	Luleå University of Technology
METOHMI	Methods and Tools Development for HMI
PhD	Doctor of Philosophy
USI	User Information and Interaction
VCC	Volvo Car Corporation
WP	Work Package