FFI

Flexible and Adaptive Driver Information

Project within FFI: Vehicle and Traffic Safety

Authors: Per-Anders Jörgner, Staffan Davidsson, Volvo Car Group

Date: 2013-03-05

Content

1. Executive Summary

The project suggested that the time is currently right to make driver information more direct, better support drivers different goals and to start think beyond tradition and to create a great user experience. The purposes of future driver information and their relations to different functions were therefore investigated.

The next question was what governs adaptability. It was concluded that to support the different goals of driving optimally may the following be considered: Concepts of driving and drivers, which context the driver is in, purpose, mental workload, personal trait, driver state and traffic situation. Which of these that are the most important may not have been answered but it is also concluded that most of them are interrelated.

Adaptability has positive effects on driving. However, problems with adaptability are also discussed. It is concluded that adaptability mainly causes problem similar to what is used to be called automation surprises or automation induced errors. The main solution is to make the driver and the automation to get along together – not to divide work between man and machine. A team building approach is suggested.

Problems with adaptability such as: Mode confusion, function allocation, over and under trust, locus of control, skill degeneration and mental workload ware discussed. These have been described as issues that are needed to be solved in an adaptable driver information system as well as in automation of the driving task.

Prototypes that help drivers to adapt to low demand conditions were developed and tested.

A strong message from this research project is that it is necessary to stop thinking that all contexts, all situations and all drivers are the same and that adaptability may be a way to provide the necessary or wanted information.

2. Background

When the FFI application for this research project was created back in 2009, the following background was depicted in the project description (Palo, 2009):

- The voice of the customer, design trends, and advances in technology within ADAS (Advanced Driver Assistance Systems) and IVIS (In Vehicle Information Systems) are pushing the envelope of cabin design. This is evident by the interior designs and numerous options and features in showrooms today that previously were considered design concepts. Despite the advancements in design, it is clear that packaging of Human Machine Interaction (HMI) devices (displays and controls) needs to take into consideration a multitude of vehicle and human constraints in order for the HMI to be effective and safe. The increasing amount of functions and information available to the driver makes it a delicate task to safely integrate the HMI-systems.

- Driver workload and distraction studies have led to a greater awareness for safety in HMI designs. An HMI that exceeds customer expectations, that is transparent to the user, and that fully supports the users in accomplishing their goals provides a foundation for minimizing driver workload. Not only is the packaging of HMI devices essential to improve safety while interacting with a car. Also regulating the flow of information to a level that will not interfere with the primary task, driving the car, is crucial for the design of safe vehicles.

- Workload management:

    - The number of in-vehicle driver support- and information systems rapidly increases due to market expectations. Lane change aid, adaptive cruise control, forward collision warning, navigation, and mobile phone are all systems that attract the driver's attention. These systems have great potential for enhancing road safety, comfort, and mobility. However too much information can increase workload and cause dangerous situations. There is a need to adopt all this information to specific situations according to driver performance (impairment caused by workload, drowsiness, alcohol, drugs, etc), environment complexity, secondary task complexity, and similar.

- Driver Information:

    - Car driving is a complex task and can be described in many different ways. Car driving can be decomposed into the following categories: To plan the trip, to navigate, to follow the road, to interact with other road users, to interact with the car, to interact with different in car devices. These different subtasks of driving can be classified into the framework developed by Rasmussen, that is, skill based, rule based and knowledge based behaviour. Well practiced tasks, like steering in order to follow the road, may be regarded as skill based processes. Other tasks, like overtaking other vehicles, may be regarded as rule based processes.

    - In order to drive safely a driver need support on the skill based, rule based and knowledge based level. It can be argued that today's cars mainly provide support for skill based and rule based processes of car driving.

    - Relatively few functions in the car of today provide support for the knowledge based processes of car driving, such as trip planning and strategies to meet unexpected events or problems during a trip.

- Another way to put it is that today's system mainly support operational tasks (e.g. Forward Collision Warning) while there are only a few systems providing support for strategic and tactical tasks (e.g. navigation systems).

- The transportation system can be regarded as a complex socio-technical system, containing many different and interacting sub systems. A characteristic property of a complex system is that it is not possible to predict everything that might happen in the system. Accidents on the road, problems associated with the infrastructure, and other unexpected events may be some examples of events that are very hard to predict.

- Consequently it seems important to provide car drivers with some support to meet events that involve problem solving or knowledge based behaviour not only reducing workload induced by functional growth within both infotainment and driver information.

- Another interesting motivation for improved driving information is that problem solving not only is limited to safety but also has a need to support green driving, mainly due to carbon footprint. There is also need to support legal, more cost efficient driving. Lately, motives such as Emotional aspects has arouse (e.g. feel of control, security).

3. Objectives

3.1. Defined Project Objectives

The following objectives were defined in the project description of the FFI application (Palo, 2009, chapter 4):

1. The intention of the project is to create guidelines for a dialogue manager that present adaptive driver information. The adaptation of the interfaces is influenced by the current vehicle status, situational conditions, contextual prerequisites, and individuals' status, operator performance, as well as historical behavioral data.

2. The purpose of driving information has been established previously and is to support safe, environment friendly, Efficient, Legal and Enjoyable. This will be further developed.

3. The results from Adaptive Driver Information aims will gradually be utilized in product development at Volvo Cars within the Big Bang BB#7059 and the Advanced Engineering project "Green Coach" etc.

3.2. Outcome

The research work in the project was in accordance with the defined objectives (in section 5.6.5 above):

1. The research work followed the intention to create guidelines for a dialogue manager that present driver information.

2. The project further developed the purpose of driving information.

3. The results from this project were gradually used in VCC Advanced Engineering projects such as Eco-coach, DIAS, HDII, ADHMI and HMI 2.0. The implementation of solutions based on these innovations in real products will happen gradually as new Volvo car models are being launched to the market during this decade.

4. Project Realization

The main intention behind the project was to enable an industrial PhD student to finalize his research work towards PhD.

The project was conducted in a small project organization, consisting of:

- The industrial PhD student (VCC/LTU),
- Academic supervisor (LTU), and
- A part time Project Manager (VCC)

The major results from the project and the methods used are documented in the PhD Thesis (Davidsson, 2013) and its academic papers.

Apart from the activities and objectives, a number of project deliverables were defined in the project description of the FFI application (Palo, 2009, chapter 7). The follow-up on these deliverables is described in the Technical Project Report (Jörgner, 2013). The main deliverable was the creation of the PhD Thesis (Davidsson, 2013) and this deliverable was accomplished.

5. Results and Deliverables

5.1. Delivery to FFI Goals

5.1.1. Defined Contributions to FFI Goals

In the project description of the FFI application (Palo, 2009, chapter 6) it was stated that contributions to FFI objectives may be summarized as:

- Driver Information that enhance… (→ Effect goals)
    - Safety (anticipation, setting goals, work load buffer etc.) → Improved planning capabilities for both daily trips but also long trips that will gain safety.

- Green driving (e.g. Reduced Carbon footprint by green coach, Edutainment or new navigational features) → Reduced carbon footprint, (Research has shown very promising results of green coaches.)
- Enjoy (e.g. improved feeling of control) → Improved Competitiveness
- Efficiency (e.g. Off-car services) → Lower cost for customer and less in-productive time spend.
- Law-abidingness (e.g. inform about unintended violations) → Avoidance of unintended violations.

5.1.2. Outcome

The project's results have contributed to driver information concepts and ideas that enhance safety, green driving, enjoyment, efficiency and law-abidingness. This due to implementation of innovations in this area in VCC Advanced Engineering projects such as Eco-coach, DIAS, HDII and HMI 2.0. The implementation of solutions based on these innovations in real products will happen gradually as new Volvo car models are being launched to the market during this decade.
The general FFI Vehicle and Traffic Safety targets are documented on the FFI web site (www.vinnova.se/en/FFI):

The objectives of the Vehicle and Traffic Safety programme are 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.

We are convinced that the results from this project will contribute to the fulfillment of these objectives from an HMI perspective. Hopefully, this can be verified in the "effects analysis" planned by FFI for the year 2020.

5.2. Project Structure

The Flexible and Adaptive Driver Information project consisted of four 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 below. These work packages were a continuation of one of the work packages within the OPTIVe project.

- WP0: Method Development.
    - Method development for context vs. function. A continuation of a previous work.
    - Assessment of Situation awareness: The original method developed by Endsley must be modified in order to be used for cars and a previous study where context and functionality was matched will be utilized.
- WP1: Development of a Context Activity Template
    - A continuation of a previous study will be performed. The Work Domain Analysis and the Context Activity template are finalized with prioritizations.
- WP2 Development of Prototype
    - An Ecological interface design approach will be utilized

  - When needed also a User-Centered design approach will be used.
- WP3 Studies (simulator tests, interviews)
  - Evaluation of the prototype.

5.3. WP0: Method Development

In the project description (Palo, 2009) it was stated that:

- In this work package methods will be developed.
- Method development for context vs. function. A continuation of a previous work.
- Assessment of Situation awareness: The original method developed by Endsley must be modified in order to be used for cars and a previous study where context and functionality was matched will be utilized.

In WP0 the following activities were performed:

- A method to interview people about information in contexts was developed. In a thesis work was the same functionality used to study if it is possible to get quantitative data that is similar with the more qualitative data gathered by the more time consuming interviews.
- Endsley's method Situation Awareness Global Assessment Technique was not utilized since it had some major shortcomings (Driving is mainly automated and unaware).

5.4. WP1: Development of a Context Activity Template

In the project description (Palo, 2009) it was stated that:

- A continuation of a previous study will be performed. The Work Domain Analysis and the Context Activity template are finalized with prioritizations.

In WP1 the following activities were performed:

- A Work Domain Analysis matrix with abstract functions on one axis and the contexts on the other was created. The study made was a between subject design which makes it possible to later add contexts.

5.5. WP2: Development of Prototype

In the project description (Palo, 2009) it was stated that:

- An Ecological interface design approach will be utilized
- When needed also a User-Centered design approach will be used.

In WP2 the following activities were performed:

- The prototypes developed were rather limited due to lack of external resources. However, the following prototypes were developed:
  1. One prototype based on voice message was created for the collaboration with Brunel University
  2. App for iPhone that worked on road 40 outside Gothenburg
  3. Simulator interface to increase mental demand on the driver during monotony. Based on the app.

5.6. WP3: Studies (simulator tests, interviews)

In the project description (Palo, 2009) it was stated that:

- Evaluation of the prototype.

In WP3 the following activities were performed:

- Prototype 1 was used in the Brunel study (Young, Birrell and Davidsson, 2011).
- Prototype 2 was used as a basis for Prototype 3.
- Prototype 3 was used in study that took place in the VCC HMI simulator 2011. The result from the study was submitted 2012.

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, within the HMI research community including VCC and its research partners in different projects, dissemination was achieved through the EFESOS internal conferences, project meetings, and workshops.

The project participated in the following external conferences:

- ITS world 2009 Stockholm: PhD student visited.
- IEA 2009 Beijing: PhD student visited and presented.
- HCII 2009 San Diego: PhD student visited and presented.
- 2nd International Conference Automotive Cockpit HMI, 28th-30th September 2011 in Darmstadt, Germany: PhD student acted as workshop leader on HMI for automated vehicles.
- IEA 2012 Recife: Two papers by PhD student were presented by the project manager.
- 3rd International Conference Automotive Cockpit HMI, 24th-26th September 2012 in Bonn, Germany: PhD student acted as workshop leader on HMI for electrical vehicles.

Examples of connections to other research projects include: DRIVI, METOHMI and Non Hit Car & Truck. Drivers 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

6.2.1. PhD and Licentiate Theses

- Licentiate Thesis (Davidsson, 2009).
- PhD Thesis (Davidsson, 2013).

6.2.2. Papers

- Work Domain Analysis of Driver Information (Davidsson et al, 2009).
- Applying the Team Player Approach on Car Design (Davidsson & Alm, 2009)
- Importance of human computer interaction and work domain understanding (Alvarado Mendoza & Davidsson, 2010).
- Importance of human computer interaction and work domain understanding (Davidsson et al, 2011)

- Countermeasure Drowsiness by Design - Using Common Behaviour (Davidsson, 2012).
- Towards a model to interpret driver behaviour in terms of mismatch between real world complexity and invested effort (Broström & Davidsson, 2012).
- What do whom need and want when and why Davidsson & Alm, 2012).

6.2.3. Master Thesis

- Adaptive driver information – A quantitative study (Borg & Murphy, 2011).

7. Conclusions and Future Research

The main conclusions and recommendations from this research work are contained in the PhD Thesis (Davidsson, 2013). Below is an extract from that document.

When designing dialogue managers:

- Do also consider low mental demand not only high.
- Support, not suppress drivers.
- Design for different personalities. Do not only forbid, block or ignore poor behavior. It is possible to design for personal traits that are often involved in accidents.
- Avoid automation induced problem by using the team player approach. Let driver and vehicle collaborate in automation.
- Further research is needed and following topics should be investigated:
    - Would it be possible to, by driving characteristics, understand personal traits?
    - How can cars better be designed for personal trait common in accidents?

The project's results have contributed to driver information concepts and ideas that enhance safety, green driving, enjoyment, efficiency and law-abidingness. This due to implementation of innovations in this area in VCC Advanced Engineering projects. The implementation of solutions based on these innovations in real products will happen gradually as new Volvo car models are being launched to the market during this decade.

Further research in this area will be performed in new research projects (FFI and other) with VCC as one of the project partners.

8. Participating Parties and Contact Person

Industrial PhD Student:

- Staffan Davidsson, VCC, staffan.davidsson@volvocars.com, 031-599824

Supervisor:

- Håkan Alm, professor, LTU, hakan-alm@ltu.se, 0703-242936

Project Manager:

- Per-Anders Jörgner, VCC, per.jorgner@volvocars.com, 0701-839152

9. References

- Borg, J., Murphy, A. (2011). Adaptive driver information – A quantitative study. Luleå University of Technology (LTU) Master of Science Thesis, 2011.
- Davidsson, S., Alm, H., Birrell, S, & Young, M. (2009). Work Domain Analysis of Driver Information. In Proc. International Ergonomics Association 2009 Conference. Beijing, China.
- Davidsson, S. & Alm, H. (2009). Applying the Team Player Approach on Car Design. Human Computer Interaction International 2009, Conference Proceeding. San Diego, USA.
- **Davidsson, S (2009). Licentiate Thesis,** Adaptive Driver Information - The Way Forward?
  Luleå University of Technology (LTU), Dept. of Human Work Sciences, Division of Engineering Psychology, 2009.
- Alvarado Mendoza, P., Davidsson, S. (2010). Importance of human computer interaction and work domain understanding. European conference in human centered design for intelligent transportation systems, Pages: 1-7.
- Young, M., Birrell, S., Davidsson, S. (2011). Task pre-loading: designing adaptive systems to counteract mental under load. Ergonomics and Human Factors Conference in UK, April 2011.
- Davidsson S. (2012). Countermeasure Drowsiness by Design - Using Common Behaviour.
  The 18th World Congress on Ergonomics - IEA 2012, February 12-16, 2012, in Recife, Brazil.
- Broström R., Davidsson S. (2012). Towards a model to interpret driver behaviour in terms of mismatch between real world complexity and invested effort. The 18th World Congress on Ergonomics - IEA 2012, February 12-16, 2012, in Recife, Brazil.
- Davidsson, S. & Alm, H. (2012). What do whom need and want when and why. Submitted to Applied Ergonomics Special Issue on Transport Safety.
- **Davidsson, S. (2013). PhD Thesis,** What Do Drivers Need and Want When and Why? Luleå University of Technology (LTU), Dept. of Human Work Sciences, Division of Engineering Psychology, 2013.
- Palo, P. (2009). FFI2009+ Project Description for Flexible and Adaptive Driver Information. Volvo Car Corporation, Revised 2009-05-12.

10. Terminology

ADAS	Advanced Driver Assistance Systems
ADHMI	Autonomous Driving HMI
DIAS	HMI for Driver Interaction and Active Safety
DRIVI	Driver Information and Interaction

EFESOS	Environmental Friendly efficient Enjoyable and Safety Optimized Systems
HDII	HMI for Driver Interaction and Infotainment
HMI	Human Machine Interaction
IVIS	In-vehicle Information Systems
LTU	Luleå University of Technology
METOHMI	Methods and Tools Development for HMI
OPTIVe	OPTimized system Integration for safe interaction in Vehicles
PhD	Doctor of Philosophy
VCC	Volvo Car Corporation
WP	Work Package