

FFI

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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.**

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1 Executive summary

Driver inattention is one of the biggest factors contributing to crash risk. The recent rapid growth in vehicle HMI functionality as well as in the usage of nomadic devices in vehicles has brought great concerns on causing driver visual distraction. New HMI design guidelines addressing the distraction issue have been introduced and are continuously under development by authorities. There is a high demand to understand the nature of driver distraction and the relation to accidents, how to measure and monitor it, and what HMI designs provide safe interaction.

In SICS, SP1 addressed the HMI design guidelines and validation methods. SP2 focused on improvements of the actual HMI design and provided safe HMI recommendations to future products. HMI performance tests were conducted in simulator and on-road using eye glance measure with an eye tracking device and occlusion method. With these tests the project was able to:

- verify and compare how accurate and feasible the test methods are
- influence NHTSA HMI guidelines development
- integrate testing method in product development process in a cost efficient way
- discover current HMI design problems
- explore the potential of novel solutions
- contribute the safe HMI recommendations in the driver interface requirements

Significant knowledge in safe visual-manual onboard and off board HMI design and evaluation has been built. In the future, auditory-vocal interfaces, gesture and eye gaze HMI control, and more advance head-up displays, will bring new challenges. The current trend toward automated vehicles will also require a deeper understanding of driver state during the transition mode as well as next generation HMI design.

The overall objective of SP3 was to design, develop, and evaluate a safe connectivity platform concept, i.e., the overall design of a set of resources with which to generate services and applications that satisfy state-of-the-art safety standards. Requirements on a safe connectivity platform were formulated as user stories and these were mapped to different platform resources such as APIs, guidelines, tools etc. Cooperation with Automotive Grade Android (AGA) was formed for SP3 to have a platform on which to build safety-related resources. The evaluation of the platform was led by Chalmers, where 172 students had as a task to develop apps to be run on the platform. To control the safety and quality of the apps developed by third party developers to be used in vehicle, it is necessary to have a well-defined approval process. A case study of existing processes at MirrorLink, Apple, and Google has been conducted. The result is a description of these



processes as well as a number of mechanisms and parameters as basis for process development.

In vehicle driver state monitoring camera system has shown more mature performance than a few years ago. It is offered not only on passenger cars but also on commercial vehicles. Such system tracks the driver's head and eye movements using an onboard driver facing camera and estimates driver distraction and drowsiness. SP4 was to benchmark sensor performance. Sensor systems were selected with head and eye gaze tracking and with head and eyelid tracking, respectively. Sensor performance was tested in terms of loss tracking, re-initialization, variance, accuracy, correct on/off road classification and facial feature impact. An algorithm using the data from an eye/head-tracking system to compute the probability that the driver is looking at different area of interest (AOI) was developed. Benefit analysis on integrating such a sensor with safety functions was carried out.

2 Background

Design of safe interaction with electronic equipment is a serious and difficult challenge which has intensified considerably recently. Two main developments have combined in the past few years to create this escalation: (1) research has been showing a much clearer association between driver inattention and crash risk, and (2) there is a growing concern over the driving-compatibility of the ever-increasing functionality available through electronic devices (such as smartphones and intelligent vehicle systems). The safety problem at issue in both these developments centers upon problems related to driver inattention. Driver inattention is very high on the political and scientific agenda and the industry is moving fast to respond to both enable the use of electronic functionality in a safe manner and to reduce driver inattention through safety systems which are capable of monitoring it.

3 Objective

The main objective is to safely deliver connected lifestyle functionality while also improving driver attention.

SP1 and SP2 are to overcome challenges related to driver distraction guidelines and regulation. The following key research questions have been addressed:

- What is the reliability and validity of performance criteria?
 - Single glance duration vs. total glance duration measures
 - Individual vs. group performance criteria and behavior variation
- What is the feasibility of testing procedures?

- Occlusion test feasibility
- Eye glance test efficiency
- Applicability of the eye glance performance testing to other contexts
- What are the practical implications of performance testing on HMI design? Once the results from the performance compliance testing are provided, actual HMI redesign work is needed to improve current HMIs to be compliant. Practical recommendations, or design heuristics have been provided.

To meet increased consumer demand for connected lifestyle, the objective of SP3 is to design, develop, and evaluate a safe connectivity platform concept that are open to offer independent developers significant creative leeway and few constraints in designing applications, at the same time satisfies state-of-the-art safety standards. Certification procedures are designed to secure safe in-vehicle use without reducing the business and innovative potential of the open platform.

SP4 is to evaluate and integrate state-of-the-art on-board driver inattention monitoring camera. Algorithms to detect/classify eyes on/off road will be developed, verified and evaluated with focus on highway driving scenarios.

4 Project realization

4.1 SP1 HMI Guidelines and Validation Processes

SP1 had the objective of investigating issues related to the various HMI guidelines and validation methods that are available. Special focus has been on the “eye glance” and “occlusion” testing methods, how these can be applied in product development and their validity and reliability.

One of the Volvo Group Truck Technology (GTT) research activities within SP1 has been concerned with the eye tracking methodology as applied in a driving simulator mock-up and establishing this method as a part of the product development process. As an example of this line of research, it was found in one experiment that the eye glance metrics were affected by the type of simulator view presented in front of the participants; the typical truck view (high above the road, low dashboard) generated more long glances than the typical car view (low above the road, high dashboard).

Another line of research has investigated the “occlusion” method which is a well-established method particularly suitable for rapid evaluation in an iterative development process and which requires a minimum of preparations and resources. In the occlusion method, the participant wears glasses which automatically switch between being transparent and opaque every 1.5 seconds while performing predefined task in the HMI under study, approximating the behaviour when looking down to operate the HMI while driving. Experiments were conducted to investigate whether the method could be made even more simple by using screen-blanking occlusion integrated in the interface under test (in this case, the interface was a standard smartphone, but could be any visually-



manually operated HMI). It was found that the two methods in principle gave the same results but that there are some methodological caveats that have to be avoided to achieve comparability between the methods. These results were presented at the Enhanced Safety of Vehicles conference 2015 and input has also been provided to the working group dealing with the related ISO standard (ISO 16673).

In a final series of experiments, the two methods, occlusion and eye tracking have been compared in terms of their validity and reliability.

SP1 has also formulated Volvo-internal HMI design guidelines based on findings which have been tested in the courses/competitions held by SP3 (safe connectivity), as have they provided input to GTT's internal HMI requirements and evaluation toolbox.

The main focus for Volvo Car Corporation (VCC) in SP1 has been to understand the impact of the NHTSA driver distraction guidelines on the development of new HMI: s. The NHTSA driver distraction acceptance test has iteratively been used during the development process of new HMI: s and analysed according to the acceptance criteria. A lack of repeatability in the studies raised concerns, so a big scale repeated acceptance test was conducted. The data from this study has been analysed throughoutly and has turned into several publications. Two papers were presented at the Enhanced Safety of Vehicles conference 2015. These papers deal with the lack of repeatability of the test and suggestions on reliability improvements. One paper presented at the Driver Distraction and Inattention conference 2015 described an analysis on better ways to calculate the criteria. In addition, another set of simulator data was used to systematically analyse how individual differences in glance strategies affects the acceptance test. The results of this study show that individual variations in glance strategy exist and that these variations seem to have a non-negligible influence on the NHTSA acceptance test. Overall the work has provided insights on the feasibility of test methods and has played an important role in the correspondence with authorities.

4.2 SP2 Safe HMI designs

SP2 has been focused on conducting distraction evaluations of existing in-vehicle HMI, and on developing and testing novel solutions for how to reduce visual distraction in future products, as well as providing practical recommendations on HMI design and elaborations of guidelines.

At GTT, SP2 was initiated by an on-road field study in which the current Volvo Truck interfaces were tested using real truck drivers. From the results in this study, the key problems of the current designs were identified and used as a basis for the exploration of novel solutions to the distraction problem. In a series of simulator experiments, various hypotheses on how to reduce the visual demand from in-truck HMI have been tested. In one line of research, visual display characteristics of text presentation have been investigated based on previous research conducted by MIT. Mainly two parameters have been tested: how the fonts used can affect glance behaviour, and also whether the polarity (dark text on light background vs. light text on dark background) has any influence on the number and length of glances required to operate an HMI. Although improving the font seemed to have some effect on glance behaviour, the MIT findings that dark-on-light text



has lower visual demand could not be corroborated. Another line of research has developed and tested various auditory enhancement techniques which allow for, in principle, “blind operation” of both traditional menu interfaces and a novel scribble-type input method. These experiments have shown that brief speech feedback during menu navigation and text entering (commonly referred to as “spearcons”) can significantly reduce visual distraction; In case of menu navigation, the total glance time was reduced by about 50% compared to navigation without speech support. The results from these studies have been very promising, indicating that these improvements can reduce visual distraction significantly with relatively development efforts. A third line of research has been investigating ways to improve visual-manual text input, a task which is very problematic from a distraction point-of-view.

In SP2 VCC has made comparisons between old and new HMI designs and has elaborated with how different HMI object properties (such as size) affect driver distraction. In addition, different ways of interacting has been analysed. For example, it has been shown that using scribble (hand writing) for alphanumeric input during driving is less demanding than using a regular keyboard. This work has served as input to the design guidelines and has also served as input to the on-going projects. A test of a visual-manual task analysis framework was also made. The purpose was to verify the proposed framework in terms of its predictive capabilities of performance metrics in a driving simulator set-up. The theoretical basis for this assumption relies on the fact that different levels of visual-motor activity require different levels of resources. The joint result of the timeline analysis and the driving simulator performance metrics shows that the task analysis framework indeed has some predictive capability on the simulator study.

4.3 SP3 Safe Connectivity

The overall objective of SP3 “is to design, develop, and evaluate a safe connectivity platform concept, i.e., the overall philosophy and design of a set of resources with which to generate derivative infotainment services and applications that satisfy state-of-the-art safety standards.”

The Application Platform

Requirements on a safe connectivity platform were formulated as user stories. These user stories were mapped to different potential platform resources such as APIs, guidelines, tools etc. Cooperation with Automotive Grade Android (AGA)¹ was formed for SP3 to have an app platform to build safety related platform resources on top of. AGA provides means for developing apps on a PC-emulator or a real hardware device, an API for vehicle data access, an API for retrieving state changes in driver distraction, a simulator for vehicle signals, a wiki, and forum.

¹ <https://developer.lindholmen.se/redmine/projects/aga/wiki>

Platform resource added by SICS include a new safety related API, driver distraction assessment tools, HMI and driver distraction guidelines, and a process for OEMs to assess apps to be able to approve or certify them.

Safety API

When it came to the Safety API, we wanted it to have the following properties:

- The concept should be platform agnostic
- The solution should be generic
- Developers should not be concerned about distraction levels.
- The solution should be able to handle future changes in the OEM with minimal or no impact

This solution is not tied to a fixed number of driver distraction levels. In this solution, access is restricted on a functional level rather than on a distraction level. For example, when distraction is high, sound can be disabled.

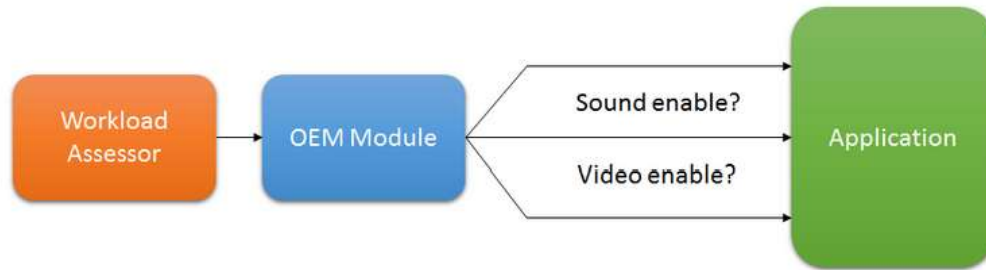


Figure 2. Can-do solution; access is restricted on a functional level rather than on a distraction level

Figure 2, illustrates the overall idea. After getting the distraction level from the workload assessor² the OEM module will set the permissions for example for sound or video to the application. That is the reason this solution is called Can-do solution.

App assessment tools

The objective was to provide tools to the 3rd party developers, to be used during their app development iterations, which would help them, develop safer apps. We investigated several different known methods and tools, together with the expertise in SP1 and SP2, for example Keystroke Level Model (KLM), and Distract-R, but finally implemented an Occlusion Service Application (OSA) which follows the NHTSA Visual Manual distraction guideline's methodology.

The OSA blanked the screen of the android device at a configurable frequency (1.5 sec open, 1.5 sec shut) but allowed for button pushes while blanked. The tool was validated by SP2 by comparing test results with occlusion goggles.

² Workload assessor is the concept module which we consider responsible to determine the workload (distraction) level based on its inputs.



To further aid developers to be able to carry out Human Factors testing in a standardized way, and to provide results for the approval process (described below), SP3 also developed a Test Leader App. The purpose of this app was to guide the developers through testing and collect their data for analysis. The first version of this Test Leader app, which was provided to the students at the end of their development, only allowed for development testing, and did not support ISO 16673-2007. The second version of Test Leader app will now guide developers to more easily follow ISO 16673-2007.

Guidelines

SP3 was responsible for taking HMI Requirements and Guidelines provided by SP1 and SP2 and packaging them for developers. After looking at several choices, we decided to include the HMI Guidelines in a local copy of the Android Developer's Design Guideline site by adding "Driving Safety" tabs in the Table of Contents (TOC). The idea was to eventually be able to hyperlink throughout the site and seamlessly integrate information that was relevant to driving safety. We also found it relevant to add information on driver distraction, with the intention to get the developers in the "driving safety" mindset.

The Approval Process

The OEM is losing some control when letting third party developers develop apps for their platform. To maintain some level of control it is necessary to have a well-defined process which can give some predictability in regards to quality.

A case study of existing processes at MirrorLink, Apple and Google has been conducted. These processes have some drawbacks in term of cost & UI constraints. An alternative process has been explored: This process requires the developer to test the app towards the OEM safety criteria while the manufacturer would limit its testing to only spot-check. The complete description of this process was made in the Thesis report "An App Approval Process for Commercial Vehicles" (Andreas Lindmark – Chalmers University)

Evaluation methods

An action design research team was formed to transform existing organizational and technological resources into platform resources when seeking to enter the ecosystem around Google's Android. In addition to researchers and Volvo personnel the team also was represented by the car maker VCC and a consultant firm, with substantial experience in vehicle connectivity.

On the one hand, Volvo and other OEM's need to develop new platform concepts to deal with digitalization and leverage connectivity. Such new concepts cannot be implemented without major organizational changes. We decided to set up our study as an action design research project (ADR) to concurrently generate prescriptive knowledge on platform design and address the problem situation encountered in the organizational setting.

Data Collection

The ADR team was embedded in Volvo's ordinary operations and followed the firm's different moves at a close distance. The study started early 2013 and ended before summer 2015. The ADR team has been deeply engaged in problem solving and collaborative meetings across the whole period. Our main data resources derive from such events. Notes were taken in each project meeting, by researchers. 21 meetings have



been recorded. At an early stage the team decided to follow the agile work processes of scrum. Each so called sprint generated a list of actions, making up an important data source in this study. Actions and decisions were then described and registered in an online database. The database contains 55 individual actions and 150 decisions. To assess and follow up the consequences of the ADR team's work we have also made 8 interviews, within Volvo. In addition, we have made 38 interviews with external developers..

When starting to think about the organizational interventions of the AGA resources on the Android community, the ADR team identified a need to complement and extend. As an example, we developed a complementary Safety API, providing real-time information of preferred interaction modalities. In practice, that would offer guidance for application developer in selecting interaction sources, such as video, images, sound, and text. 172 Chalmers students worked with application development in Android, particularly focused on the platform resources provided by the Volvo ADR team. The students were given the broad assignment to "create innovative and original software applications within the area of safe connectivity". The output was presented to a jury, evaluating applications on the basis of well-defined criteria such as safety, innovation and creativity and business potential and pairwise comparison, using IBM Focal Point.

4.4 SP4 Driver Inattention Monitoring

The Driver Alert System (DAS) is currently available at VCC and AB Volvo. This system uses lane position information, yaw rate and steering wheel angle. Another way of monitoring driver state is vision based. An on-board camera system which monitors the driver face and tracks head and eye movement can estimate driver distraction and drowsiness. Such systems were not able to demonstrate acceptable performance. Based on recent development by suppliers, there is reason to believe that new sensors that are coming to the market in the next years now meet automotive requirements.

The first part of SP4 was to benchmark sensor performance. Two sensor systems were selected at VCC and AB Volvo. One with head and eye gaze tracking and the other with head and eyelid tracking were installed in front of the cluster in a car and a truck respectively. Sensor test plan was defined to evaluate the performance in terms of loss tracking, re-initialization, variance, accuracy, correct on/off road classification and facial feature impact. 20 test participants for each sensor system were driving on the selected highway section for 15-20 minutes and performing a number of tasks. The tasks were either a glance at different areas of interest (AOI) such as on-road, rear view mirror, speedometer and center console, or finding a radio channel. Camera video which was annotated in order to provide ground truth and sensor output were logged for first performance analysis and later algorithm evaluation.

An algorithm using the data from an eye/head-tracking system to compute the probability that the driver is looking at different AOI was developed. The key question here is determine if the driver is looking on-road, if not, which AOI the driver is looking at. The driver could be distracted by a radio task or a cell phone task, which can be indicated by



corresponding AOI. There are two versions of the algorithm, since the two sensor systems have different output and performance. When eye gaze is not available, a head to gaze mapping is included. Moreover, the eyelid closure signal is used for the gaze pitch angle estimation.

The aim of the algorithm evaluation is to assess the correct classification of AOI and to compare different solutions based on with and without eye gaze. Part of evaluation is done by measures such as sensitivity, specificity, and accuracy etc., which are done based on different classifications such as false/correct/missed detection and correct rejection. Depending on the application, timing of detection especially for off road glances might be a crucial factor. Hence the algorithm delay, which is dependent to the filter parameters, is another evaluation criterion.

One other way to evaluate the different algorithms is to calculate the expected costs to the different possible misclassifications. There are different applications that can assign these costs, but the most known one is to evaluate the improvement that can be done in tuning the timing of the forward collision warning knowing the driver state in the last 0.5 second and the effect of it on driver's reaction time.

5 Results and deliverables

5.1 Delivery to FFI-goals

The challenge to design safe interaction with electronic equipment in vehicles is serious. Research has shown driver inattention plays a great role in traffic accident. Recently inattention is associated with a large growth in on-board/off-board electronic functionality. The SICS project aimed to safely deliver connected functionality while also improving driver attention. The project contributed to the following sub-program goals:

- Analysis, knowledge and enabling technologies
- Basic safety features of vehicles
- Driver support and related interface between drivers and vehicles, and interfaces with other road users
- Intelligent and collision avoidance systems, and vehicles

SP1 and SP2 have provided findings from performance testing using NHTSA distraction guidelines. These findings have been communicated with NHTSA in order to influence HMI guidelines development and performance testing. The integration of the performance testing in to product development process using simulator, eye tracker and occlusion tool were under iteration development in a cost efficient way.

Within SP3, different methods & tools to test Apps have been evaluated according to distraction guidelines provided by SP1-2. Collaboration between SP1-2 and SP3 helped secure the transfer of knowledge in safe APP development for vehicle application.



Knowledge and expertise have been built on the resources & components required within the Automotive Android Platform.

. APP approval process and evaluation method were developed to promote safety in APP development and provide the possibility to certificate APP's for safe use in vehicle.

In SP4, the sensor system evaluation results have been positive to understand the best performance and the limitation in order to integrate a robust on-board driver inattention monitoring system for car and truck applications. A roadmap toward monitoring driver distraction and inattention and integration with mitigation safety functionality is getting clearer based on the industrial technology knowledge. The competence development in distraction and inattention detection and prevention secure the leading position in this industrial area.

5.2 Deliverables

SP1-2

- Victor, T.: On-road study of the FH HMI using NHTSA Distraction Guidelines. (Internal report)Wege, C., Larsson, P., Rydström, A.; Safe connectivity recommendations. Volvo GTT/ Volvo Cars: 2014 (Internal Report)
- Rydström, A. & Åhl, J. (2015). VCC lockout guideline. (Internal report)
- Broström, R, & Hallila, R, Mikael Ljung Aust. (2014). Keyboard or handwriting for alphanumeric input? (Internal report)
- Rydström, A., Åhl, J. & Filskov, S. (2014). HMI design principles. (Internal report)

SP3

- A. Mohagheghzadeh, Exploring Key Factors in Successful Governance of Multi-sided Platform, project report, Chalmers University of Technology, 2014
- F. Svahn, Managing External Innovation: An Assessment of Capabilities and Measures, project report, Chalmers University of Technology, 2014

SP4

- Johansson, M., Landfors, P., Driver state monitoring camera system test protocol project internal document, Volvo GTT/ Volvo Cars: 2013 (Internal Report)
- Johansson, M., Backhouse, A., Sensor data analysis results project internal report, Volvo GTT/ Volvo Cars: 2014 (Internal Report)
- Lundgren, M., On-line on/off road classification algorithm, Chalmers: 2014 (Software)
- Lundgren, M., On/off road classification algorithm description document Chalmers: 2014 (Internal report)
- Backhouse, A., Esfahani, H., Zhong, H., McKelvey, T., Realization and evaluation project internal report, Volvo Cars/ Volvo GTT/ Chalmers: 2014 (Internal Report).

6 Dissemination and publications

6.1 Knowledge and results dissemination

All SPs have transferred knowledge built in this project to continuation projects and contributed to the project roadmap within Volvo and Volvo cars. SP1-2 provided findings from performance testing into internal HMI distraction guidelines and integrated test methods into product development process. The experiments on different design and test results transferred into next generation product development to secure Volvo's leading position in the HMI design. VCC communicated the findings with NHTSA in order to influence HMI guidelines development and performance testing. A number of papers were presented at the Enhanced Safety of Vehicles Conference in Göteborg as well as a SICS simulator demo at the Volvo booth. SP3 organized a course at Chalmers and let students design safe APP using the AGA platform and safety API. More than 180 students participated in the competition as the main part of the platform evaluation. Unfortunately no student teams used the Safety API to develop their app. How to package this resource to APP developer was studied. SP4 investigated a number of head and eye tracking sensor systems for car and truck applications and communicated requirements to several sensor suppliers including Swedish ones. Future research project applications in the driver state monitoring area are under development.

6.2 Publications

Publications 2014-2015:

- Master Thesis on “Framework to evaluate in-vehicle applications regarding Safety”, written by a student in the HiQ SP3 team, to be published in January 2015 at Tampere University in Finland (<http://www.uta.fi/english/>).
- A. Mohagheghzadeh, Governing External Innovation. Lessons from: Apple's iOS and Google's Android, the 37th Information Systems Research Seminar in Scandinavia, 2014.
- F. Svahn, R. Lindgren, L. Mathiassen, Applying Options Thinking to Shape Generativity in Digital Innovation: An Action Research into Connected Cars, forthcoming, Hawaii International Conference on System Sciences (IEEE) 2015.
- A. Mohagheghzadeh and F. Svahn, Resource Transformation in Platform Envelopment, Research-in-progress paper, European Conference on Information Systems 2015.
- Larsson, P., Niemand, M.: Using Sound to Reduce Visual Distraction from In-vehicle Human-Machine Interfaces. *Traffic Inj Prev.* 2015 Jun; 16 Suppl 1:S25-30.

- Jernberg, C., Larsson, P.: Comparison between Occlusion Methods for Measuring Distraction Caused by Smartphone Interaction. Proceedings of the 24th Enhanced Safety of Vehicles Conference, Göteborg, Sweden, June 8-11, 2015.
- Niemand, M.: Using sonic interaction in driver-vehicle interfaces to reduce visual distraction. Örebro University, School of Science and Technology, 2014.
- Broström, R., Bengtsson, P., & Ljung Aust, M. (2015). Individual glance strategies and their effect on the NHTSA Visual Manual Distraction test. Accepted for publication in Transportation Research part F: Traffic Psychology and Behaviour.
- Ljung Aust, M., Rydström, A., Broström, R., & Victor, T. (2015). Better ways to calculate pass/fail criteria for the eye glance measurement using driving simulator test. Proceedings of the 4th International Conference on Driver Distraction and Inattention. Sydney, Australia, November 10-11, 2015.
- Rydström, A., Ljung Aust, M., Broström, R., & Victor, T. (2015). Repeatability of the NHTSA visual-manual guidelines assessment procedure. Proceedings of the 24th Enhanced Safety of Vehicles Conference. Göteborg, Sweden, June 8-11, 2015.
- Ljung Aust, M., Rydström, A., Broström, R., & Victor, T. (2015). Improving the reliability of the eye glance measurement using driving simulator test. Proceedings of the 24th Enhanced Safety of Vehicles Conference. Göteborg, Sweden, June 8-11, 2015.

Expected publications 2015-

- A. Mohagheghzadeh and F. Svahn, Resource Transformation in Platform Envelopment, full paper to be submitted to Journal of Information Technology or Journal of Strategic Information Systems.
- A. Mohagheghzadeh and F. Svahn, Transforming Organizational Resource into Platform Boundary Resources, Submitted into ECIS Conference (November 2015) Notification of acceptance will be in Jan 2016.
- Lundgren M., Hammarstrand L., McKelvey T. Driver Gaze Zone Estimation Using Bayesian Filtering and Gaussian Processes, Submitted to IEEE Transactions on Intelligent Transportation Systems, May 2015.
- Larsson, P., Engström, J., Wege, C.: Virtual eye height and display position influences visual distraction measures in simulated driving conditions. In preparation.
- Theodorsson, N., Jernberg, C., Larsson, P.: The effect of typeface and text polarity on visual distraction in commercial vehicles. In preparation.
- Theodorsson, N., Larsson, P., Jernberg, C.: Efficient text input methods for in-vehicle Human Machine Interfaces. In preparation.

7 Conclusions and future research

The SICS project provided findings in safe HMI design, distraction guidelines, safe connectivity, performance testing and driver state monitoring applications. In SP1, the most common methods for measuring visual distraction, including occlusion and eye tracking, and the related criteria have been thoroughly investigated. SP1 has also given a better understanding on how different test conditions affect the visual behavior of test participants. It has been shown that there is variability in visual behavior among test participants that can have an impact of the test results. The feasibility of different eye glance methods, both formative and summative, has been studied. The eye glance tests have given valuable insights that have been communicated with authorities. In SP2, some of the design aspects contributing to improved driver attention have been established and documented in the HMI design guidelines which have been used in the development of new HMI: s. However this field is almost limitless especially considering the rapid development of new interaction technologies. A likely future development would be to investigate what distraction is and how it can be measured and reduced when vehicles become more and more automated.

The prototype of Safety API was provided as one of the available resources that the students could use to develop safe APP in the coding contest at Chalmers University. The reasons why the students preferred to use the AGA driver distraction signals instead of the Safety API needs to be further investigated. To sum up it is suggested to repackage this resource in a way that can be more self-explanatory and easy to use. The third party developer should be aware of the value and functionality of each platform resource. A tutorial video that can elaborate the affordances of the resource in addition to an example could make it easier for developers to use it and not to find it as a barrier. The next phase is to integrate this platform into an Automotive Infotainment Unit. The main objective is to evaluate the compatibility of this platform with the Android framework. There are also plans to release the Safety API as Open Source on the Automotive Grade Android site, but that would require more development of the code and more thorough testing.

SP4 provided the understanding of state of art sensor performance. Then sensor technology has reached certain maturity level and is coming into the automotive market now. Especially the driver distraction estimation based on head and eye-lid tracking is going to be the first step. Eye gaze tracking, fatigue management and more features are under development and requires more investigation. In parallel to the sensor technology development, SP4 also gave valuable insights on the development needed for future functions in car and truck having such a driver monitoring camera system, The Next step is to further explore the functional performance, the implementation possibility and feature benefit in terms of safety, convenience and automation.

FFI

8 Participating parties and contact person



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