CHALMERS

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- placement and functionality of a human-machine interface in a truck cab

Master of Science Thesis in the Master Degree Programme, Industrial Design Engineering

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Cover caption:
Rendering showing the final result of an eco-driving advisory system in a truck cab.

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Abstract

The aim of this project, performed on the behalf of Volvo 3P in Göteborg, was to develop a system placed in the truck cab to give advice to the truck driver concerning eco-driving. With tougher environmental legislation in the Swedish society in the future the needs to lower fuel consumption and CO_2-emissions will increase. One way to achieve lower fuel consumption for the Volvo Group is through technological development, and one other is through focusing on product development for the user. The aim for this project was to find the main properties of a system for providing eco-driving feedback to a truck driver, the placement and sensory modalities it should act upon. The eventual realization of this product is in the future of 10-20 years and thus the study has been performed as a conceptual development project.

The base for this study was the conducted literature and user study. 11 drivers, 3 back-office employees, 2 experts within the truck- and/or eco-driving area and 3 truck driver students were interviewed. While interviews were conducted, a number of observations were performed with the truck drivers in their work environment. Solutions were thereafter created based on the found demands of the primary target group. Developed ideas and concepts were evaluated through repeated visits to truck drivers and back-office employees.

The resulting final concept takes a number of properties into account, all affecting eco-driving abilities, for example weather, road condition and brake use. The advisory system has three different placements within and on the truck. The general property of the final concept is that it provides a direct channel of communication to back-office employees as well as real-time eco-driving feedback. The opinions of drivers today have been investigated and creating a futuristic concept adapted to a conservative environment.

Keywords: eco-driving, truck, driver, human-machine interface, display, future, user study

Preface

The development of an eco-driving advisory system for the future is a master thesis that has been performed in cooperation with the commissioning company Volvo 3P during the spring of 2011. The work has been performed by Marie Ingemansson and Nafiseh Mahdavian, students at the Master Degree Programme of Industrial Design Engineering at Chalmers university of technology in Göteborg.

The conditions for the thesis have been that the two students applied for a master thesis proposition developed between Volvo 3P and the Master programme responsible, Ralph Rosenberg at Chalmers. The following work has then been performed in cooperation with coaches at Volvo 3P and Chalmers but with the sole responsibilty placed on the two group members.

We would first like to thank our coaches at Volvo 3P, Nina Theodorsson and David Hellstedt for giving us the opportunity to perform this work and giving us their full support along the way.

We would also like to thank all the drivers, back-office employees, experts within eco-driving and the students at the truck driver education that we have visited, interviewed and in some cases observed during their daily work. Without you letting us visit and pose sometimes difficult questions this work would never have been realized.

Last but not least, we would like to thank our head coach Helena Strömberg at Chalmers for her invaluable advice and support throughout our work, and our examinor Pontus Engelbrektsson for reading and giving advice regarding the report.

Contents

1 Introduction

1.1 Background

The energy consumption and CO_2-emissions of the transport sector stands for 20-25 % and 25-40 % respectively of the total emissions of the Swedish society today and are at this point increasing (STR, 2008). The great challenge of the future is to battle this upward curve for oil dependency – not least for the truck industry. The Volvo Group, as the second largest truck manufacturer in the world has a large responsibility in this. They have a quest to search for a way forward and find user-centered inputs and trends in this area, looking 10-20 years ahead.

One way to lower CO_2-emissions in the future is to develop new fuels. But also a more straight-forward way to lower energy consumption is to lower the amount of fuel used (no matter what type) and this through influencing and educating the driver. Eco-driving is a driving model incorporated in Sweden starting in 1998, a driving concept that builds on the right choice of speed, gears and the utilization of the vehicles kinetic energy to save fuel.

During the interviews, the researchers have discovered that drivers loose skills and knowledge gained during education in eco-driving – to really influence fuel efficiency the driver's behavior has to change and not only momentarily. To promote continuous eco-driving skills an in-cab eco-driving advisory system installed could be of help to the driver. A function in the system for the back-office to communicate information to their trucks out on the road is also of importance to minimize fuel usage.

As truck drivers can be seen as a homogenous group with a traditional culture and great professional pride you have to be aware of the special conditions when implementing eco-driving feedback systems to them. A truck driver is generally individualistic and puts pride in solving problems oneself (Nehls, 1999). To place systems in the environment that affect a truck driver's everyday work is not without conflict. Therefore, an eco-driving/driver system for the future should be designed into a system for advising the driver in the preferred direction and give pro-active advice.

1.2 Aim

The aim of this thesis is to find future incentives and finally a concept, for a lowering of truck fuel consumption through an advisory system for eco-driving. The result should be used with great effectiveness and acceptance from the start by the truck driver and the result should also function well when driver is working together with back office.

1.3 Research questions

What will be the needs and requirements of an eco-driving advisory system in the future?

How is an eco-driving advisory system for trucks, best designed to be easily and best accepted by users in different working areas, with safety in mind?

How is an eco-driving advisory system for trucks, best designed to be best accepted/appreciated by both the experienced and new users, with safety in mind?

Are there any conflicts between the needs of these groups of drivers?

How is an eco-driving advisory system for trucks, best designed to be best accepted/appreciated by the users in the long run compared to the short run?

Are there any conflicts between the needs of immediate acceptance and long-run acceptance?

What are the different needs for eco-driving information exchange between the On-board area and Back Office?

1.4 Delimitations

This project is a part of the SET-project within Volvo (SET = Safe and Efficient Transportation), which is a development project within Volvo focusing on product development 10-20 years into the future.

The information base for this thesis is taken from the Swedish truck market, where emphasis has not been on a specific truck area but instead to try to create a complete picture of the truck drivers needs, within this area, in Sweden today. Long-haulage truck work, where the driver is away from home for several weeks or days at a time, has not been studied. To find a concept for the future using information found today off course put limitations on the result.

The system for eco-driving coaching will be situated inside the truck cab and affecting the driver pre-trip, during trip and post-trip. The final concept will be presented in digital 2D-sketches.

1.5 Work division

Because of differences in language abilities, work responsibility has been divided. The user study has been one of the researchers' responsibility while literature studies have been the other's responsibility.

2 Transportation

Here general information regarding the truck driver, truck market and Volvo trucks will be presented. It is provided to give readers not generally accustomed to the world of road transportation a foundation for further reading.

2.1 The Truck driver and the law

There were between 50 000 and 70 000 professional drivers working in Sweden in August 2005, the number is hard to predict because of the fluctuating share of foreign drivers. Of the total amount of drivers, one study has shown that about 2,5 % of the total amounts of professional drivers in Sweden were female. If including all people working within the haulage industry the share of women was in May 2005 around 7,5 % (SOU, 2005). The truck industry is a male industry where female drivers are tolerated but not more (Nehls, 1999).

There are many laws regulating the driving of trucks on Swedish roads. One is the law of drive- and resting times, regulating that a driver is only allowed to drive for a maximum of 9 hours a day, with either one break of at least 45 minutes, alternatively two breaks of 15 and 30 minutes respectively. A driver is not allowed to drive for a longer time than 4,5 hours in one run (The European parliament and the council of the European Union, 2006). A built-in trip computer in the truck cab monitors and records drive times automatically. The trip computer is analyzed by the traffic police if, or when, the truck driver is stopped by the wayside. If starting to drive one minute in advance compared to what the trip computer stipulates, the truck driver or the owner company will have to pay a fee of at the most 10 000 and 200 000 SEK respectively (The Swedish ministry of economy, 2004).

2.2 Different truck types and areas

A truck is generally defined as a type of vehicle designed to freight goods. This report is focused on the heavy trucks defined as having a total weight exceeding 16 tonnes. A truck freighting goods in Sweden today could weigh in the range of 20 to 60 tonnes, the first could be an example of a truck without any load and the second being a fully loaded truck. 60 tonnes and 25.25 meters is the maximum total weight and length respectively that is legal for a truck in Sweden. That is heavier and longer than a European truck is otherwise allowed to be (18 meters), this because of the longer transport distances in Sweden. Weight and size depend to a great extent on the type of work the truck is intended for and consequently the truck type (The Swedish transport agency, 2010). Today for example even longer timber transports are being tested by Volvo trucks to acquire greater environmental efficiency (Volvo Trucks Europe Division, 2011).

Different areas for trucks which have been in focus during this project are long haulage, construction work, timber and bulk transport, distribution work and garbage handling. They will be further described below. The different fields of work puts different demands on the truck and therefore different truck types have been developed.

Picture 1: Towing engine/truck tractor that combines with a semi-trailer to create a semi-trailer truck. Photo: M. Ingemansson, Publication approved by Volvo Group

The first truck area is long haulage where goods could be transported in-between countries, or cities within a country; a truck driver might have to stay away from home for several nights or weeks. The trucks travel on larger roads and focus is set on comfort in the truck cab and fuel efficiency. Within long haulage a so called towing engine, or truck tractor, might be utilized see Picture 1, transporting so called semi-trailers between destinations, see Picture 2. So called full trailers with front wheel axles as well might also be connected to the truck tractor. Within long haulage maximum loading abilities are essential. Volvo models used within this type of work today are the Volvo FH (420-540 hp) and FH16 (540-700 hp).

Picture 2: A Volvo FH model with a semi-trailer and a full trailer connected. Photo: The Volvo Group

Another area is construction work done within or between construction sites and open cuts and usually performed within a limited geographical area. Construction trucks are not built to be agile, but rather to have the strength and movability demanded to freight construction material, like gravel and rubble, on smaller dirt roads and on rougher ground. This type of truck usually shares its work space with other large machinery like wheel loaders. Moreover, they are built to carry heavier weights and to have a higher towing capacity than a standard truck, which for example equals to a stronger engine. The dump truck here represented with a Volvo FMX: see Picture 3, has a flatbed that is possible to tilt and could be connected to a tippable jig or trailer. Volvo FMX is a model designed especially for construction work with a special cab design to function well in uneven terrain. A Volvo FMX has a range of engines to choose from of between 330 and 500 hp, as can be seen in Picture 3, this dump truck has four wheel axles for extra strength.

Picture 3: Dump truck. Photo: M. Ingemansson

One other truck area is timber transport which is a specialized type of goods transport where tree trunks are collected in forest areas and delivered to paper mills. The truck needs to be multifunctional to function both fully loaded on narrow dirt roads suffering from soil frost thawing, as well as the highway, sometimes driving longer distances of 200 km's or more. A timber truck can be seen in Picture 4.

Picture 4: Timber truck with full trailer and crane. Photo: N. Mahdavian

When transporting any type of bulk material a hook lift truck, Picture 5, is a flexible choice; it is equipped with a hook that might load any type of flatbed or container onto the chassi and therefore be able to load many types of material. Trailers could also be connected to this type of truck.

Picture 5: Hook lift truck. Photo: M. Ingemansson

Distribution work is a truck area situted within larger communities and cities and involves shorter travel distances with much start and stopping. Emissions and sound levels are of great importance here. Since this field of work includes shorter travel distances and low-power engines, this is an area where new powertrains are tested today, for example hybrid engines. Distribution trucks, see Picture 6, are usually smaller in size to fit in limited loading and unloading sites and usually have a fixed built-on loading container. The Volvo FL & FE models are designed for city transport and distribution work with a range of "low-power" engines to choose from of around 300 hp.

Picture 6: A distribution truck – the Volvo FL model. Photo: M. Ingemansson

Finally, the truck area of garbage handling is where garbage trucks are used. They have a build-on added to a truck chassi see Picture 7. Within garbage handling, safety is in focus as people are moving and working close to the truck and toxic material might be handled, otherwise garbage trucks are used in the same working area as distribution trucks.

Picture 7: Garbage truck. Photo: The Volvo Group

Generally: truck companies like Volvo are focused on building and developing chassis, engines and gear boxes, while there are companies entirely focused on collaterally developing trailers, build-ons or flatbeds.

A truck is composed of many elements that can be selected based on a buyer's special needs: the cab type, number of axles, type of engine and gear box, etc. Therefore, trucks can have very different abilities and be difficult to compare.

2.3 The truck market

A truck manufacturer might own a range of different truck brands. Within the Volvo group, four truck brands exist; Volvo, Renault, UD trucks and MACK trucks.

The top 3 truck manufacturers on the market are Daimler AG (including for example the Mercedes-Benz brand), the Volvo group and Dongfeng trucks. Other known truck brands that exist on the Swedish market are Iveco; included in the Fiat group and DAF trucks included in the PACCAR group, as well as Scania included in the Volkswagen group and finally MAN SE.

In 2010, 75 229 Volvo trucks were sold worldwide, the corresponding figure was 45 588 for Renault trucks, 29 348 for UD trucks and 13 465 for MACK trucks making a total of 163 630 truck units sold for the Volvo group in 2010. A comparative figure for Daimler AG trucks is 249,000 units sold from January to September in 2010 (Daimler, 2010).

2.4 The Volvo group

The requestor of this thesis is Volvo 3P with head office situated in Lundby, Göteborg. Volvo 3P is itself a company within the Volvo group and develops solutions for the four truck brands that are included in the Volvo group: Volvo trucks, Renault trucks, MACK trucks and UD trucks. Volvo 3P works in close collaboration with, among others, Volvo technology and Volvo Powertrain within the Volvo group, to develop its solutions.

Volvo 3P was formed in 2001 and is a company within the Volvo Group focusing on Product planning, Product range management, Product development including Global Engineering and Global Vehicle Development as well as Purchasing for the other companies within the Volvo Group.

More specifically; Volvo 3P's scope is the truck tractor, minus the drive line and plus any other related services for the truck. One department within Volvo 3P, in close contact with this thesis' creation, is the Cab Interior department, working with for example the development of the instrumentation board in the truck cab.

2.5 Volvo truck Interior

The driver is surrounded by gauges, buttons and levers in a truck cab today, see Picture 8.

Picture 8: Volvo truck interior from a Volvo FH16 model today. Photo: The Volvo Group

To the right of the seat is the I-shift stick. I-shift is Volvo's 12-gear automatic gear box. With I-shift the driver can choose if he or she wants to drive with automatic or manual gear shifting. To the right of the steering wheel, on the instrument panel, a range of buttons can be seen that controls functions like sand distribution or light settings. At the top of the instrument panel is the pop-up display situated which could contain many systems, for example the back camera which when activated displays the signals from a rear-view camera. This display is possible to hide by letting it slide down into the instrument panel body. Just to the right of the steering wheel is the park brake lever. In the center display with the speedometer and tachometer, is a smaller display situated that shows any technical information about the engine, trip meter or brake pad state. Above the windscreen is the trip meter located that is a small computer monitoring the drive- and resting times stated by traffic law. This apparatus will warn by sound if the maximum drive time is imminent.

3 Project overview

The general work stages of the project are presented in Figure 1.

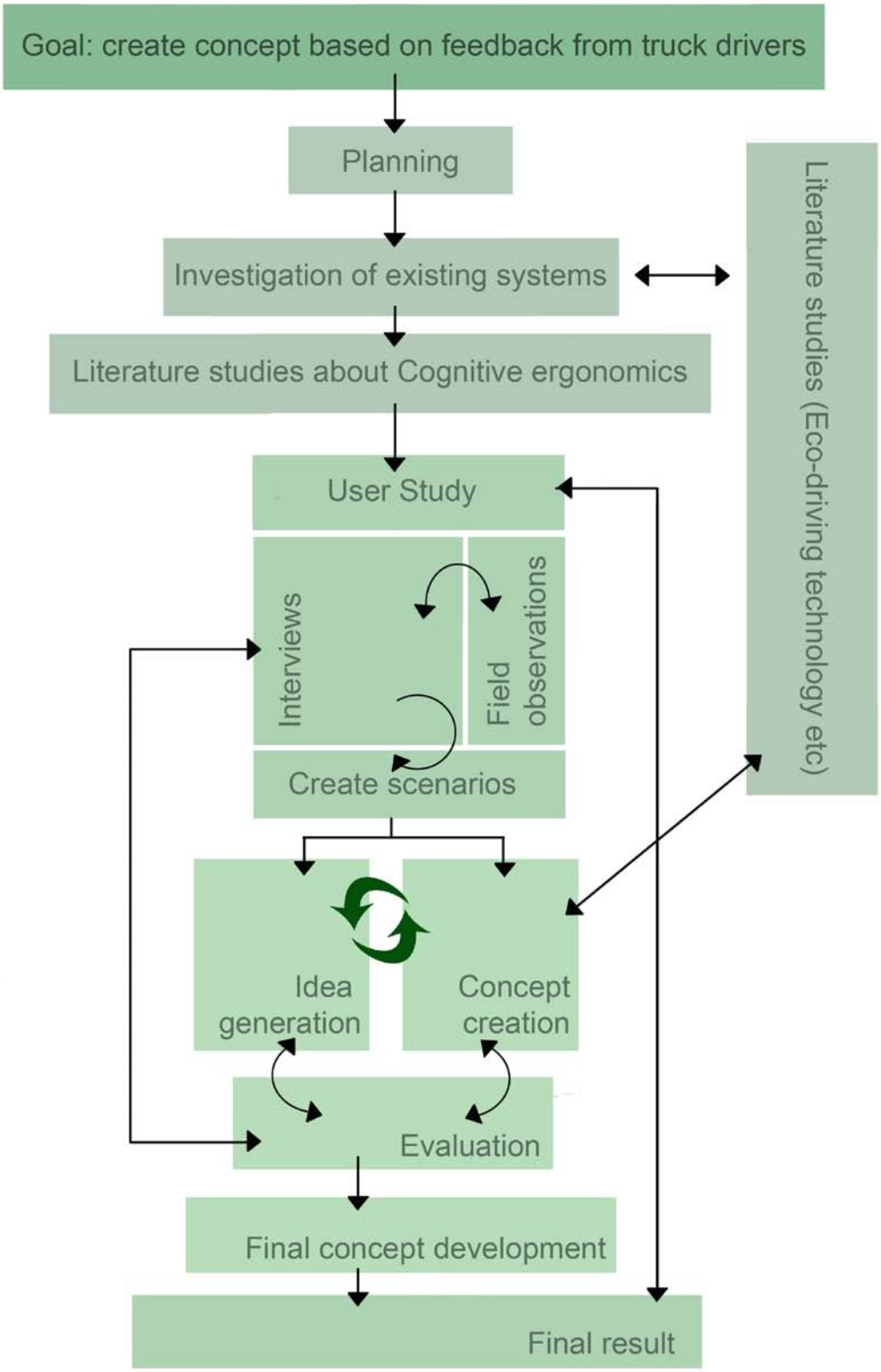


Figure 1: Process scheme, showing the work structure of the project

4 Theory

This chapter will present some relevant theories that will be used in later stages to secure the quality of the work and to evaluate concepts. The concept of eco-driving and what eco-driving techniques that can be performed by the driver are central to this project and are explained in detail. Some traffic factors that affect eco-driving are explained as well.

Basic cognitive ergonomics theory and theories on how to affect the driver to adapt to eco-driving behavior and, as well, continue using it after the initial learning phase are also presented.

4.1 Eco-driving

Eco-driving was adapted to Sweden in 1998 with fuel efficiency in mind and is now growing on the transport market (STR, 2008). The term "eco-driving" is used to mean economical, ecological and safe driving and its main aim is to reduce fuel consumption, greenhouse gas emissions and accidents (Zarkadoula et al., 2007). Road transport is a significant source of safety and environmental issues, based on 2.1% of global mortality and nearly 20% of total greenhouse gas emission (Young et al., 2010). Three incentives for changing these issues are economy, environmental legislations and people's conscience. Environmental issues and economy are intertwined; to lower fuel consumption means to save money. Environmental friendly legislations are getting more important and harder every year that put pressure on car and truck manufacturers. Moreover, drivers do not want to contribute to increasing pollution in society (STR, 2008).

As stated above, eco-driving stands for economical, ecological and safe driving: economical as engine wear and fuel consumption is lowered, ecological as green house gas emissions are lowered and safe, since the driver learns to plan the driving in a better way. In this thesis however, the ecological factor is the primary focus.

Eco-driving education

Eco-driving education could be a part of a drivers driver's license education or a separate course in his/hers working life. When taking a course in eco-driving, the driver is first presented with substantial facts about the reason for eco-driving, eco-driving techniques and technical issues regarding the vehicle and its surroundings that affect eco-driving output. The driver then drives a pre-destined route with his or hers normal driving style with a supervisor and with fuel consumption recorded. This driving could be performed either in a student-vehicle or the driver's own vehicle. After getting feedback about the result and what eco-driving techniques to improve, the driver drives the same route again, the difference in fuel consumption equals to the improvement in eco-friendly driving.

Eco-driving techniques

In detail, the concept of eco-driving means that the driver learns to drive (to use the accelerator, brake and gear box) in a certain manner (STR, 2008):

- Idling should be kept at a minimum and cold starts should be avoided.
- Lowest gears should be used as little as possible. Truck drivers normally don't have to start on the first gear.
- Acceleration should be as efficient/quick as possible and speed should then be kept steady with an as high gear as possible.
- Engine braking and exhaust braking (on trucks) should be used – the accelerator shall be released early before a crossing or hill crest. The exhaust brake saves the normal brake system and slows down the speed in larger vehicles by closing off the exhaust pipe.
- Downward and back slope should be utilized: roll out without gas downwards and keep a steady gas in back slopes preferably with some extra accelerating to gain speed prior to the back slope.
- To plan the route and loading/unloading stops – when approaching a roundabout, crossing, stop signal or traffic queue, any action should be planned by keeping sight far ahead and adapt speed to surrounding traffic. When planning the delivery stops for the day, the shortest route with the best road quality should be choosen.
- A sufficient distance to the vehicle in front of you should be kept to be able to plan the driving.

Even if eco-driving driver techniques are a part of the work needed to improve the sustainability of the transport industry, other actions need to be taken as well. Different transportation companies are trying to produce vehicles or systems installed in vehicles that are beneficial for eco-driving. Fuel reduction after first being taught eco-driving is on average 13%, but the fuel reduction some time after the education and onwards depends on the motivation of the driver (STR, 2008).

From the traffic organizations point of view, improved road networks are important to reduce greenhouse gases associated with transportation because they could reduce vehicle miles travelled and roll-resistance. One other way that traffic organizations can do is to lower speed limits on roads as fuel economy decreases at higher speed (Barkenbus, 2009).

Heavy eco-driving

For trucks, eco-driving is sometimes referred to as Heavy eco-driving since drivers have to deal with larger engines and heavier loads than in the car sector. Heavy eco-driving has to this

date proven to lower fuel consumption more than 10%, compared to traditional driving, as well as general costs, for haulers and truck owners (Pröckl, 2011).

Based on the study conducted by Johansson et al., (2003) and a meeting with Anders Ericsson, some factors that affect heavy eco-driving were identified. First of all, the fuel consumption need to be interpreted for different vehicles since the trucks do not have (among other factors) equal power output or weight. Higher speed increases the wind resistance which results in higher fuel consumption and waste of energy. The fuel efficiency is at its maximum in the range of 60-80 km/h as it optimizes the trade-off between overcoming rolling- and wind resistance (Young et al., 2010). A limit in speed within heavy eco-driving is drawn at between 78 and 82 km/h where the wind resistance increases rapidly. The road and weather conditions also affect eco-driving performance, slippery roads and heavy rain and winds increase fuel consumption.

In the future braking will be the main parameter for the truck driver to affect concerning eco-driving, since gear shifting and accelerating will be more and more automatically controlled. However, in city areas since there are a lot of start and stops, accelerator use might still be under the driver's control and here there should be a limit on the power output of the accelerator pedal in city driving to lower energy waste.

4.1.1 Encouraging drivers towards eco-driving

Since it is the driver that makes the decision and performs the eco-driving actions (i.e. uses the accelerator pedal) the drivers' behaviors play an important role in eco-driving along with vehicle design - especially if drivers can understand how crucial their impact is (Young et al., 2010).

Encouragement by training and education

More education related to eco-driving helps the driver to get a better understanding of the impact of his or hers manner to take the best possible action in various situations. It is an issue that users normally forget what they have learnt as time passes after the course, the 10-13% of fuel saving immediately after a training session drops to a number dependant on the individual's motivation. Therefore, it is essential that education and/or eco-driving advice is provided repeatedly after having first learned the concept.

The best way to change drivers' behavior is to make eco-driving norm rather than exception. Studies show that eco-driving adoption does not depend on the actual education given in a single course, but about changing long-standing and pervasive norms. To make eco-driving more of a part of people's culture, multi-media communication campaigns in Europe emphasizes on cost savings, accident prevention and life style decisions rather than CO_2-savings. The aim here is to try to create an image of eco-driving as a life style and cultural

attractiveness (Barkenbus, 2009). Information is given that eco-driving is not a slower way of driving, but in fact *increases* the average speed by 1 %, this to make the concept of eco-driving more attractive. Many companies employ so called saving coaches that focus on eco-driving and follows up the fuel consumption within the company to keep the fuel saving on a desired level (STR, 2008).

Encouragement by design

Lidman and Renström (2011) have found different examples on how a designed product can have positive effects on users' behavior in the use phase and reduce the environmental impact of a product. Design strategies have been identified for long-term acceptability and effectiveness to induce sustainable behavior in the user. In addition, a model has been created to categorize design strategies in five groups: to enlighten, spur, steer, force or match the user. These design strategies should be applicable for vehicles and encouraging green driving behavior, as well as other products.

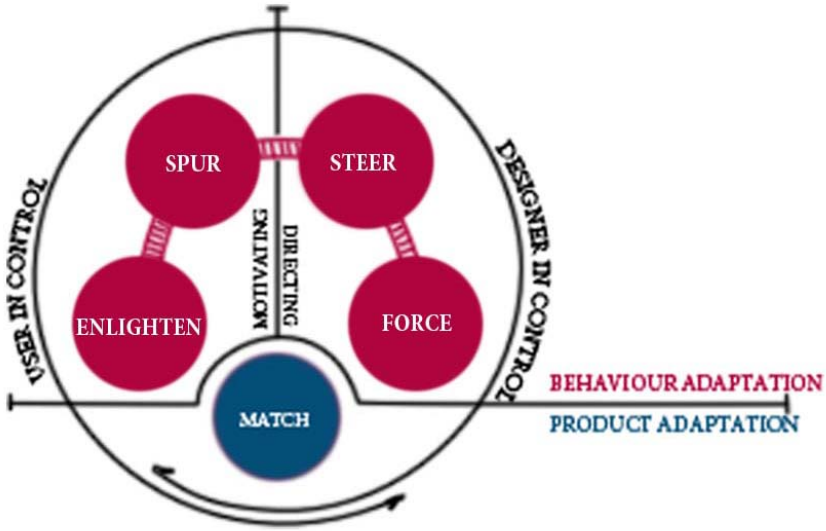


Figure 2: User control versus designer control; a strategy model developed by Lidman and Renström

The first four categories shown in red color in Figure 2 are based on users changing their behavior. Enlighten and spur are motivating while steer and force are directing the user. They are arranged by considering the level of user control versus designer control. The match strategy is different from the others since it does not need or needs very little adaption from the user and is based on a design that is formed after the user's behavior. In this strategy both the user and the designer are in control.

The purpose of the design strategy ENLIGHTEN is to motivate the user to take the sustainable behavior by influencing his or hers knowledge, norms, values and attitudes which can be performed by providing the user with feedback or information. In the SPUR category the user is encouraged to take the desired action by means other than the positive environmental consequences either by other effects of the actions or the actions itself. All the design strategies in the STEER category are guiding the user by making sustainable behavior the obvious choice cognitively or physically. The idea behind the FORCE design strategy is to either compel the user to take the desired actions or prevent them from undesired behavior. In the MATCH category as mentioned before, the strategy is to design a product based on the user's current behavior or desired behavior.

Lidman and Renström's study shows that it is possible to prompt sustainable behavior on a long-term basis by product design. In general, an informational strategy has the potential for long-term behavior change in individuals but incentives and feedback strategies have an even better chance to encourage behavioral change. For newly adopted behaviors incentives and feedback should be firstly provided.

As a means to a successful sustainable design it is recommended to affect users' behavior by first identify barriers for a desired behavior and then combine different strategies to achieve the desired user behavior. A deep knowledge of the user behavior is essential for the designer to be able to combine strategies to adapt the product in the best way

These design strategies can be implemented in eco-driving guiding systems in vehicles. The ENLIGHTEN-category is represented by an eco-driving course, where the driver first learns about a more efficient way of driving. Perhaps one of the best ways to later train eco-driving is to give positive feedback to drivers after taking a desired action. The SPUR-category represents this design strategy. Barkenbus (2009) states that a good eco-driving education program can lower fuel usage with up to 5 % and up to 10 % when in combination with positive feedback. Experience with a feedback device shows that drivers accept it, alter their driving habits and some users develop it into a sport to find the best ways to lower fuel usage (Barkenbus, 2009).

4.2 Theory regarding human-machine interaction and cognitive ergonomics

Different parts of cognitive ergonomics are presented below.

4.2.1 Interaction between user and technical system

A technical system may interact with its user in psychological or physical ways. In the psychological way, the user would mentally control or influence the system utilizing the performance, function, message or expression. In the mental activities, the user's intended feeling and thoughts including information processing and decision making are affecting the output. The driver's mental activities are triggered by the sensory organs. The user perceives different signals from the system, these signals are processed and new signals are returned to the appropriate body area to induce movement for the appropriate actions.

In the physical activities, the user receives messages in form of a signal, sound, tactical feeling, smell or appearance. A problem with this kind of interaction is different interpretation of signals by different users.

Information that requires the user to do something special is sent to the user interface. When the interface functions for example by sending a voice command, the user receives this signal. Interface and technical systems interact with each other to give information to users. When the user operates the interface e.g. by touching an icon, this action sends as a code to the system via the interface and the system sends commands to the interface to show to the driver (Janhager, 2005).

Different types of signals

Between the user and the technical system a variety of signals are transmitted, see Figure 3. Signals from the technical system can be produced by the system or designed into the system or product. Signals from the user can be sent passively or actively (Janhager, 2005).

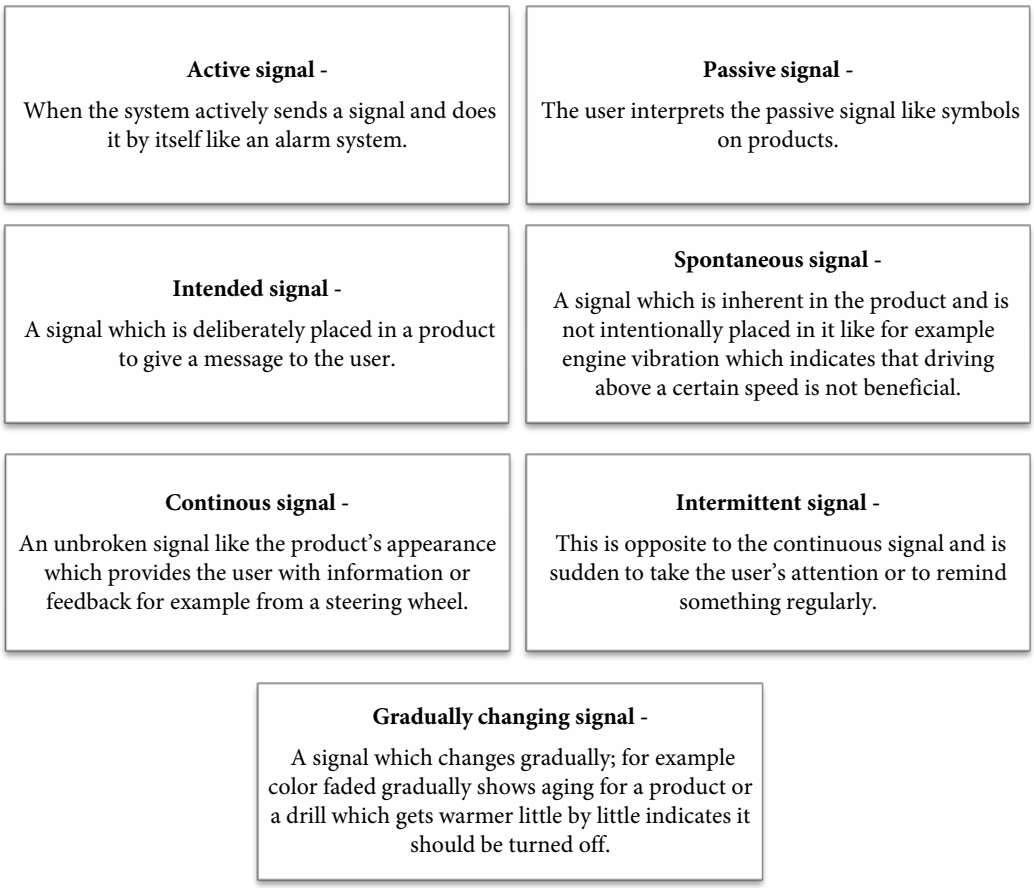


Figure 3: Different types of signals sent between a user and a system interface

4.2.2 Designing for Situation Awareness

It is really important to consider in which way the interface presents information to the user since it influences Situation Awareness (SA). In each situation, the amount of information that can be sent in the limited time available, the accuracy of received information and how well-matched the information with the operator's SA needs is, are important parameters in designing.

Several different principles concerning situation awareness for designing a complex system are briefly explained here. The main aim of the designing based on the SA principles is to create a system that reduces the operator's mental workload and cognitive efforts.

First of all, the system should present and organize information based on the user's main goals and tasks rather than considering the technical issues. This principle will support goal-driven processing. The analysis should guide the design to categorize information in a way that all necessary information is available and to the acceptable extent. Moreover, in presenting this information the limitation of the attention and working memory of the operator should be considered. In this case, it is better to categorize information and put relative data together to

reduce the user's mental workload. For example, it is better to directly portraying the comparison value between two situations than showing lower level data that requires the operator to calculate them.

One of the demanding principles of SA is the projection of the future states of the system. This would help the user, especially novice users, to anticipate in the future occurrences of the system. Another principle is the global SA principle which explains that a subset of information should not take more attention than the necessary information. This frequent problem usually appears when placing various sorts of information in several displays. Providing a global SA in the system that allows the user to have an overview of the whole system and supports the data-driven processing could solve this problem. However, more detailed information related to the current requested information should simultaneously be available. In designing a system this data-driven processing should complement the goal-driven processing in order to prioritize the critical information and not miss out on the less important data. It is important and also difficult to find critical cues for the system since usually the user cannot explicitly mention them. But normally the most important cues are those that show the prototypical situations and should be made salient to the user. In presenting different information, the overloading problem is an important issue in some systems that could be solved by information filtering. In this case, information that is redundant should be removed or integrated to other data levels.

In designing complex systems it is important to consider the ability to share attention between different tasks. The visual sense can get much information at once and even much information can be received by using the auditory sense at the same time. Similarly, the tactile sense can be processed together and simultaneously with two other modalities since these three senses have different cognitive sources. (Endsley et al., 2003)

4.2.3 Designing a complex human technology system

The system designed for a user should be in a way that the user prefers to use it and also be able to use it. Key factors in achieving these purposes are: acceptance and user competence. It should be ensured that the system will be accepted by its users. If not, users should be provided with information to be introduced to the new system so that the system is familiar for them when it is produced. User competence is to give information to the user in order to be able to work with the new system and technology (Osvalder & Ulfvengren, 2009).

Attention

Attention is the activity which puts people's mental resources in the current situation (Osvalder & Ulfvengren, 2009). Less detailed information should be provided whenever the

user has different resources to pay attention to. Also, our mind decides to focus on which of the available resources most, based on different factors such as our interest, characteristics of the stimuli, previous experience and motivation. Selective and divided attentions are two standards of attention.

Selective attention refers to the time that mind focuses on a specific matter and allocates its capacity to it for a short time. This selection for attention happens quickly and mind switch between different available existing resources. Selective attention could be exemplified for driving when the driver switches attention from rear mirror to road, to changing gear and speed and then again to the road. This selection is based on four different factors:

- How salient the signal is.
- What the individual expects to happen.
- The value of the information.
- How much effort it takes to acquire the information.

Divided attention is about getting information from different sources without distracting each other like talking and driving at the same time (Osvalder and Ulfvengren, 2009).

Motivation

Motivation is an important psychological variable as it can influence our choice in a great extent.

Motivation is an internal will to do something that can be influenced by different factors: physiological (like hunger), psychological (like fear, safety), and sociological (like responsibility). Also, motivation affects task performance, decision making and attention.

If it is possible to motivate people based on their primary needs such as willing to improve socially and economically, and combine it with both stimuli in their environment and their good previous experience, then they become motivated to do the desired action (Sutcliffe, 2002).

4.2.4 The design of displays and controls

The technology-centered product development is increasingly replaced by user-centered development that is designing based on user's abilities. In designing interfaces that provide their user with information, data presents in visual, auditory or haptic ways and in shape of monitors, lights, instrument read-outs and so forth.

Color, form, direction and symbols should be used to increase the interaction between the user and interface and also to reduce the human errors and accidents. (Osvalder and Ulfvengren, 2009).

Another factor that should be considered in designing the displays is providing the bottom-up[1] and top-down[2] processes especially for demanding and stressful tasks like driving. This becomes even more important when it comes to the age above 40 that the eyesight gradually deteriorates and people try to detect stimuli more based on top-down process.

The most prominent senses are the auditory and visual resources that most of tasks need them. An overlap in resource requirement would soon use the whole capacity needed for a specific sense, e.g. if in performing a task two different auditory resources are available soon the auditory capacity will be full and performance of both will be affected. Also, two different messages presented by them will mask one another. But if different tasks need two different sources, then they would not affect each other and would work without interfering.

The auditory sense complements the visual sense and can get sounds and information from different sources. Therefore, this sense can be a good help for visual sense when it is overloaded. Sound signals also can help to direct attention to visual information. Auditory signals which are designed to alarm something usually supplement with visual information to show what has happened and how to deal with the situation. (Osvalder and Ulfvengren, 2009)

4.2.5 Design for multimodality information

Through multimodal design, several senses are active and gather information from sources around the user simultaneously. This helps different senses to compensate for individual problems and cover all information presented.

In some situation, different senses have kind of battle in occupying more capacity in the brain. There is a term called "visual dominance" in multimodality that mainly occurs when visual sense and other senses are receiving same information. In this case visual sense tends to counteract other senses and human rely on information receiving by visual sense more. This should be avoided by dividing information between senses.

In designing interfaces it is important to use multimodalities. This helps individual to get the same messages at the same time from different sources. In this way information would

[1] Bottom-up processing is an unconscious and automated process that is based on the available physical stimuli, its characteristics and the status of the sensory receptors (Osvalder and Ulfvengren, 2009).

[2] Top-down processing is based on previous experiences and knowledge that a person has about the situation and perceive events mostly based on them (Osvalder and Ulfvengren, 2009).

received easier and clearer and also the speed of information processing would increased. (Osvalder and Ulfvengren, 2009)

Speech warning

There are different advantages for speech warning; for instance they do not need to be learnt, they can present explicit messages without need to displays. But it also has some disadvantages such as language problem and the speed of receiving information. (Osvalder and Ulfvengren, 2009)

5 Competitive analysis; developed and existing eco-driving advisory systems in cars and trucks

The systems existing today are based on giving different forms of feedback that provides the driver with information about different issues related to eco-driving such as fuel efficiency, sudden speed changes and so on.

Basically two different types of systems exist today; showing eco-driving feedback and drive-information within the truck world:

- On board-systems – that generate feedback between driver and truck in real time.
- Pre-/ Post-trip systems - for example fleet management systems showing post-trip information from truck to the back office.

The main benefits of in-vehicle feedback system are that they provide (Berry, 2010):

- Accurate fuel consumption measurements
- Real-time motivation and reminder to drivers, and
- Targeted driving advice

5.1 Developing an eco-driving advisory system for cars

Andersson and Larsson (2009) developed an interface for eco-driving advice in Volvo cars with manual gear box. The aim was to develop a system that would encourage the driver to drive more environment-friendly.

Andersson and Larsson's result shows that a system for more eco-friendly driving in a car does not produce higher status for the user, the concept for eco-driving advice does therefore not point out the environmental aspects but rather hide them as a positive side effect and integrate the concept in the current instrumentation. The concept is designed not to force drivers to change behavior and make the concept easy to use.

The importance of not distracting the driver when driving is emphasized in this study - time with "hands off steering wheel" and "eyes off the road" must be kept at a minimum. Therefore the reach-distance to controls on the instrument panel and view-distance from the traffic view and instrument view, to viewing the eco-driving system were evaluated. The final concept is built up by different parts, where active interface feedback during driving is one: integrated with variable colors in the speedo- and tachometer it shows, depending on the settings of the user, how well you drive.

Another part of the concept is the statistics screen which shares the display with radio and GPS etc. Here the driver can access statistics for drives during various time intervals, the

driver profile and settings; an internet access is also available. An eco-score called *e*% gives the system a competitive edge, a pre-installed median value of how well different drivers drive on a specific driving route, compares the driver with others through a percent figure of how many that drive better or worse than the driver.

5.2 Existing eco-driving advisory systems in cars

Different car companies have designed this type of feedback device in their cars, a selection of these systems are presented below. This research has been done to find inspiration and provide examples of eco-driving systems today to have in mind when developing a superior, futuristic concept.

5.2.1 Ford's SmartGauge

On its new Ford Fusion and Mercury Milan hybrids Ford has installed what is called a "SmartGauge with Eco-Guide". The SmartGauge display is a high-resolution and full-color liquid crystal display (LCD) that is placed on both sides of the analog speedometer, see Picture 9. This monitoring device is placed in front and center of the driver and allows the driver to select the level of monitoring detail desired. With selection of more detailed levels, the driver can get info regarding average miles per gallon, a color-coded leafy display of eco-driving performance (similar to the Honda system, see 5.2.3) and mileage history (Barkenbus, 2009).

The system is able to show different levels of information, including fuel and battery power levels, average and instant miles-per-gallon. The system coaches its drivers to optimize performance of these cars in order to get a more fuel-efficient driving. It awards the drivers with growing leaves and vines on the right side of the cluster if the driver is driving efficiently.

Furthermore, the driver is able to assess or modify his/her driving habits by receiving real-time feedback from the system and therefore maximize fuel efficiency. When the car engine is turned off, the screen displays the latest trip information such as fuel economy performance and comparative data from previous days (Edmunds Auto Observer, 2009).

Picture 9: Ford SmartGauge. Photo: Ford Motor Company

5.2.2 Nissan systems

The Nissan Intelligent Driver Project (NIDP) contains a satellite-based system that improves the driver's driver habits in order to reduce the fuel consumption and CO_2 emissions by analyzing the driver's actions and suggesting new ways of performing them (Green Car Congress, 2009).

Information about fuel economy is displayed to the driver and data from each trip is sent daily to the Nissan Global Data Center for analysis. This information is then published on the website and each driver has access to it through a private password. Drivers can compare and rank themselves with other drivers.

The Nissan's iPhone eco-driving application rates driving based on factors like acceleration and how well the driver keeps a constant speed while cruising. It is part of Nissan's research into using advanced IT systems to improve the level of driving. Users who tested this system displayed an addictive behavior to reach the highest point. The drivers tried to be more focused while driving after the first time to improve their level of eco-driving and they actually succeeded to make it by taking on new rules (Williams, 2009).

5.2.3 Honda Insight ECON

Honda has designed a system in the Honda Insight car model, called the ECON-system (super economy mode). By pushing the ECON button the system in the car automatically reduces the power and torque output, activates regenerative breaking and a smoother shift pattern. It is a multimodal system and displays information in different forms, see Picture 10. The display has green and blue colors that become greener if the driver utilizes smooth brake and accelerator patterns. There is also an eco-drive bar that should be positioned in the middle and not on the sides – this performed by the user through eco-driving.

On the top of the eco drive bar, an award system is designed that grows leaves and flowers if the driver continues to drive efficiently for long periods of time. The system also allows the driver to compare the last trip with three latest trips showing in bars or the amount of leaves and flowers. Moreover, the system provides a lifetime score that compares the current score with the first time driving score and if the driver drives efficiently to a certain score would receive a cup (Wojdyla, 2008).

Picture 10: Honda Insight interface. Photos: Brian Hoecht

5.2.4 Toyota hybrid car systems

Toyota Prius is a bestselling hybrid-electric car that got much attention for its multi-information display. The display is placed in the center of the dashboard and gives the driver information about fuel economy based on three periods of times: an immediate mile per gallon (mpg) figure; a 5min average mpg; and a trip duration mpg (Barkenbus, 2009).

Toyota hybrid cars, equipped with the Hybrid Synergy Drive system, have what is called an "Eco" mode. An eco lamp lights up on the dashboard whenever the driver drives efficiently enough. The lamp will turn off if the driver pushes the accelerator pedal and speeds up. The lamp turns on again if the driver tries to keep the speeding smooth. This trial and error system will help the driver to save fuel in the range of 5-10%. The lamp also illuminate in manual cars at the optimal shift point. The system additionally displays a fuel consumption average since the last time the vehicle was fueled or the system was reset (d'Estries. 2008).

Toyota equipped all Lexus and Scion models with this system in 2009. The system has four standard drive modes that the driver can select among: EV, ECO and Normal drive mode for typical driving and Sport drive mode for dynamic driving with enhanced steering feel. (Toyota, 2008)

5.3 Existing eco-driving advisory systems in trucks

In this part, two systems existing today on trucks are mentioned. One of them is the Scania driving support system that is the main competitor for the future eco-driving coaching system for Volvo 3P. The other one is the system existing on some Volvo trucks called Dynafleet.

5.3.1 Scania Driver Support

This system was developed in close collaboration with professional drivers to make driving safer, more economical and environmental friendly. This IT-based system helps the truck drivers to save fuel up to 10% by supporting them with direct feedback and tips to improve their driving.

The system takes both mistakes and correct actions into account and the good are rated with stars or in percentage. Hints are shown to the driver continuously while under way, as well as the final assessment for each trip. As seen in Picture 11 below the system is represented by a graphical display in the center of the gauge display.

Picture 11: Scania Driver Support. Photo: Carl-Erik Andersson

Scania driver support analyses information electronically from the truck and assess the drive style. The driver receives positive feedback for four different actions all factors known from eco-driving and present in the Scania Driver Training:

- Hill driving – get stars for good passage of a hill crest
- Break use – panic maneuvers are not rated – correct, as they are needed, should not show in the overall statistics, good use of brakes at an intersection is graded.
- Anticipation - for example to lift of accelerator to slow down to 30 = well done! Well anticipated!
- Choice of gears

At the end the driver get an overall percentage score for each of the four parameters, represented by four icons seen in Picture 12 below, under the fuel icon at the top (Scania, 2009).

Picture 12: Scania Driver Support. Photo: Conny Hetting

5.3.2 Scania Ecocruise

This system is similar to a cruise control but reads the road and terrain and affects the engine so it for example won't accelerate at a hill crest. It also affects the engine so it gains momentum at a downhill, where the truck gains kinetic energy. This system saves 4-5 % in fuel costs compared to an ordinary cruise control (Scania, 2006).

5.3.3 Scania Opticruise

Scania Opticruise is an automatic clutch, where the driver only has to use the clutch when starting and stopping – during the driving the gear box serves itself and is always aimed at reducing emissions and optimizing fuel efficiency. It has different modes like Hill-mode and kick-down to give more power in these special situations (Scania, 1999).

5.3.4 Scania driver training

The driver training Scania offers can be tailored in content and time to driver's needs. The common platform of the driver training takes different factors into account such as environmental issues, safety issues, loading, risk awareness and so forth (Scania webpage).

5.3.5 Dynafleet

Dynafleet is Volvo trucks online transport information system that was first introduced in 1994. The system interchange information such as current location of the vehicles, their fuel consumption, messages etc. in real time between the haulage contractor and the trucks.

This communication occurs in two forms. One of them is a mutual communication form that allows the contractor and truck drivers to communicate through text messages via the office

computer screen and the “info-screen” in the truck, see Picture 13. Information such as messages, regarding planned stops, work hours etc. can be interchanged. The interface in the truck cab is basically made up of a computer screen with an attached computer keyboard.

The other form of communication is a more one-sided form where the haulage contractor receives various information related to each truck; information like trucks current position, vehicle emissions and fuel consumption, fuel consumption for specific routes, service intervals and driver times and stops. The system also offers different functions, for example GPS system that helps the driver to choose the most effective drive route.

Picture 13: Dynafleet system in a truck cab, showing computer keyboard. Approved for publication by: Christer Lindqvist, Brand manager, Volvo Truck Corporation

5.4 Competitive analysis - Conclusion

It would be great if every driver pay attention to his/her driving manner in relation to saving fuel. But, since normally drivers do not, it is better to have a system in the vehicle to remind and advise drivers to take the right action.

To meet this need, different car and truck companies are designing systems regarding the fuel saving issue for their products. These systems differ between different companies in their design: options and functions included, but their main focus is to reduce the fuel consumption as much as possible and in the best way possible.

These systems try to influence the driver to make driving more efficient and sometimes make the driver aware of the situation and the best possible action to be taken. There is a positive effect from these systems; the fuel consumption could be reduced by up to 10 percent if the driver is always attentive to the system.

For this thesis, some parameters that were practical for the new concept were identified in the competitive analysis. The new concept should at least have comparatively similar functions to the existing systems in order to compete with them in the future. However, it has been tried to design a concept that is ahead of the existing systems. Several more systems than what is mentioned here were investigated for the research, but a selection of the most interesting are presented to the reader. There might be more interesting systems on the market, however, most companies were considered to find examples of eco-driving systems.

The selected systems on cars have some functions in common. They more or less have different driving modes that the driver could choose based on the roads the driver is driving on; for example, cruising or Eco-mode. They also basically have a system to communicate and guide the driver via voice or messages. The way this communication forms, might differ but the main purpose, which is to alarm the driver to reduce the consumption, is satisfied in all of them.

Quite all interfaces communicate with the driver in a graphical way. Some of the most frequently used graphical symbols in the found systems are leaves and blossoms.

In some systems, smart phone system or satellite system is used, which seems as the best existing system to communicate with other stations. Except in Dynafleet system, other installed systems are focusing on the driver and the interface communication and no communication between the driver and data stations like back-office exists on them. It might not be important for personal car drivers, but it is necessary for truck drivers to communicate with the whole company drivers, back-office personnel and the company's manager. This communication would enable them to evaluate the fuel consumption better in relation to other driver and might motivate them to make a progress. This function is a missing part that more attention would be paid into it in this project.

6 User Study

The major opportunity during this project was to make contacts with truck companies as well as to take advantage of Volvo's contacts to go out and meet the truck driver. The decision to perform interviews and observations was made knowing that first-hand information about the user and the product environment was needed as the system supposed to have user-centered design based on what was mentioned in the theory chapter. The work connected to the meeting with the user has been a fundamental part of the thesis. The result from the theoretical framework and the user study will finally come together to create the list of demands that will be used in later stages to evaluate concepts and to secure the quality of work.

The result of the user study will also result in the creation of target groups for the concept development.

6.1 User study objectives

The user study was motivated by a number of reasons, one being the need to get a personal insight in the users' everyday work environment as well as general attitudes towards eco-driving and instruments in the driver-cab area. Another reason was to get detailed and practical opinions about the concept design.

6.2 Methods used during the user study

The methods used in the user study were invaluable as means to get a deeper knowledge of the drivers' opinions, as well as to get a wider understanding of the everyday work of the truck driver. Scenarios are used to present the work environment of the truck driver.

6.2.1 Semi-structured, in-depth interviews

Interviewing is an economic way of gathering information and can be performed in three ways: structured, semi-structured and unstructured. In the structured form, the interview strictly follows written questions in a systematic manner and in the unstructured form, the plan is open ended. Interviews can also be performed in a semi-structured manner that mix structured questions with open ended. One problem that may arise when using structured interviews is that the analyst fails to follow the interview guide, the interview guide might also turn out to be wrongly designed when there is some uncertainty involved with the interviewee meeting. Another problem might appear when using a more unstructured type of interview manner; that the user may not tell all his or her information and knowledge - that some questions remain unanswered.

The best place to conduct interviews is at the actual work place. This has two benefits: the user feels comfortable and the user can illustrate and point out things and issues easier and

therefore answer more precisely. In-depth interviewing is a way of interviewing that gives qualitative information rather than quantitative, this method was chosen because of the limited number of interviewees (Jordan, 1998).

The existence of a sufficient number of participants in a user study survey can be greatly discussed. When found the saturation point for information is reached, where the majority of the needs and requirements have been found for a certain problem. According to Barnum, the level of user experience as well as the structure of the tests when conducting (usability) tests affects the quality of the findings. Different information collection methods like interviews and usability tests should be combined to extract information as efficiently as possible. The more participants in an interview survey, the higher probability to have found most of the hidden needs. However a trade-off needs to be made regarding the time and effort put into the study and the result that will come out of it.

Earlier researchers state that effective information extracting usually requires 5-6 participants when it comes to usability problems to find a sufficient share of the needs. 8-12 participants are stated by Jordan (1998) as a traditional number when conducting one focus group, where users are questioned in group.

6.2.2 Field observations

Field observations are made going out to the end-user and observing everyday work performed with the existing product or work tasks performed that concern the potential product. This makes it possible to see practical work be performed and record work being performed to revise later and/or display to other members of a product development team. The informal “feel” for the work area that is acquired when going out to observe the user in his or hers environment is extremely valuable for a product developer (Jordan, 1998).

6.2.3 Scenarios

Scenarios could give a well-defined and specified ground for the product development work in later stages of a project. The aim of using scenarios is to analyze the everyday work of the user, to describe and deeply understand the user of the intended product. With a scenario one defines the problem area, what the situation looks like today and what changes might occur within the time-span that is analyzed (Swart et al, 2004). Weidenhaupt et al (1998) put up four points, which are used below to describe the scenario method.

Firstly, scenarios are being used to help to predict the future. Examining organizational future is a big part of re-engineering. The use of scenarios makes it possible to combine and present what is known of the user and the product environment today and what is thought to exist in the future (Clemons, 1995).

Secondly, scenarios express a number of typical situations in where the user of the future acts.

Thirdly, the form of how the scenarios are written down is essential. They might be written in an informal manner to invite anyone to read it and to make the content easy to grasp by the reader of the report.

Fourthly, the scenarios might change over the concept development period, as new knowledge is acquired.

6.2.4 Persona

A persona is a form of narrative storytelling describing a fictive person that represents the whole target group. The text is founded on extensive facts of the user group and describes key characteristics - the aim is to create closeness with the user (Pruitt & Adlin, 2006).

6.2.5 Methods for defining target groups

User identification and user relations are methods that are aimed to identify and investigate the different user categories of the product that is going to be developed.

User Identification/relations

The method starts with identifying primary users, secondary users, side users and co-users. Users can be classified according to their relation to the product or other users. Different users can have different roles at the same time. Then, requirements of each user are identified. Here, four different types of users are explained.

Primary user: this person uses the product for its primary purpose

Secondary user: this user uses the product for proposes other than primary purpose

Side user: this person without intention to use the product is affected by it, either negatively or positively

Co-user: this person without using the product co-operates with a primary or secondary user somehow

A product might have various users that have different relations to each other. When these kinds of relations exist, they affect the conditions and demands for the design. The result is composed in a table that states investigated and estimated relations between the user and the product and important aspects based on these relations (Janhager, 2005).

6.3 Implementation

The main part of the interviews and observations were set calling the hauling company and asking for a meeting. Firstly cooperative truck companies were searched after, doing searches on the web and getting much help from Volvo's broad network of previous contacts. Personal contacts were also used to try to get contact information. This was done through both e-mail and phone.

The first goal was to get a sufficient foundation for the user study by contacting and interviewing at least 8-10 truck drivers, preferably 10-12, from various truck areas. A secondary goal was to find a smaller number of interviewees that worked in the back office at truck companies, as specialists within the heavy eco-driving area or others that might have opinions. An interview guide specially designed for each user group was created see Appendix 2 - Interview guides. They were made with the goal to extract as much qualitative information and opinions possible. The interview guides were continually modified during the weeks that the user study was held.

The interviews and observations were made during the same visits and in parallel when possible. For a list of the user study visits see Appendix 3 – User Study Visits. Being two researchers for this study, when there were two interviewers available when going out to meet the interviewee; one had the main responsibility for the interview guide while the other had the main responsibility for observing and documenting. When only one person went out to see the interviewee, then the interview was prioritized. Notes were made by hand on paper; no further recordings were made during the user studies. As many members of the user group are not comfortable speaking English the majority of the interviews were held in Swedish.

Scenarios and personas were used as two ways of presenting the target groups, presented through information gathered from the interviews and observations. Personas were written based on information gathered that best described the user groups; activities, work and family life. The scenarios were written down after selecting three typical work actions for a truck driver. In this case; the resulting scenarios describe how a driver communicates with surrounding colleagues, the truck and back-office and therefore the environment in where the product should function.

6.4 Result from User study

The user study has resulted in substantial material. In total eleven truck drivers, three back-office associates and two experts were interviewed as well as one interview held with three pupils at a truck driver education. The complete interview transcripts can be read in Appendix 4 – Interview transcripts. Here the summarized result from the interviews and observations will be presented as well as the resulting scenarios, personas and target groups.

6.4.1 Summarized result from interviews and observations

From the result it became very clear that the developed concept for eco-driving advice should not conflict with the drivers' own experience and driving skills. To have a well developed eco-driving training program parallel to the system in the truck is essential to let the driver act based on his/hers own knowledge. Advice could be given on how a driving maneuver should be performed, but direct orders to a truck driver on driving issues are not effective. The difference between advice and order here is somewhat illusive - what some interviewees meant was that truck drivers have an independent mind and want to choose whether to follow a dictated advice. This is clearer when looking at the older drivers than the younger, but all drivers wanted their independence intact.

The main difference in eco-driving attitude was that the younger interviewees saw eco-driving as self-evident while older drivers, here starting at the age of 30, became more unaware of the concept. All drivers could be said to have an attitude that stated eco-driving as something unnecessary and sometimes silly, they did not want something extra to think about besides the normal driving – they are thinking about the fuel economy anyway. One driver stated that an "eco-driving system" is nothing that the driver would ever buy, while a system for more economical driving sounded very interesting even though they both handle the same issue and come to the same result; lowered fuel consumption. It should be emphasized here that the driver in question was not attracted to an environment friendly system, but rather a money-saving system. The drivers' focus today is economy and fuel consumption, this is what many interviewees stated they already thought about - all throughout their working days.

No clear division could be seen looking at the opinions of truck drivers employed or truck drivers owning their own truck, when it comes to attitudes about the need for an eco-driving advisory system. Owners had a large focus on economy for their business and thus fuel economy was a great issue to them. But also drivers employed in some companies had a good overview of their trucks' fuel consumption and knew that their bosses were aware of fuel consumption in the company. But one difference could be seen looking at drivers employed in larger firms compared to the owners of smaller companies. The closeness to the head-of – business might be a factor here, as it seemed employees in smaller companies and/or with a good contact with their bosses were more concerned of the well-being of the company (and thus the general fuel consumption) than drivers employed in larger companies that seemed to have a more distant relation to their bosses. There is no fundamental difference in eco-driving attitude either between the employed driver and the part owner. The owner is in most cases also a busy driver and the difference you might find here is that a part owner is more concerned about economy and their business survival – prices are under pressure; this might make them both more positive and negative to introducing an eco-driving system.

Nevertheless, all drivers had, or were stated to have the same need to communicate route choice, customer issues or anything concerning the daily work: this mainly done by phone to colleagues, employees and back-office. The interviewees employed at the back-office generally stated that they did not want to interfere in the daily routines of a truck driver. When they communicated they mostly spoke on the phone and discussed customer issues. Back-office personnel stated that time-shortage and stress were issues to them as well as for the truck driver. One thing that possibly would cut down on time used to communicate by phone was a solution that allowed for back-office personnel to write down a message to a specific driver and send it by a simple push of a button. Furthermore, the back-office personnel do not wish to handle any eco-driving information; the fuel consumption issues and technical factors of the trucks are handled by other people at the company and they have no truck license. According to back-office employees; the drivers should be left alone, doing what they are doing best.

The truck driver is independent and works alone most of the day apart from some brief meetings with colleagues that may work on the same haul task or happen to pass his route. But he is at the same time social; keeping contacts with co-workers through his phone all day, which is an important working tool stated as: "the one thing I need". The driver plans the route for the day by himself or while conversing with office personnel, the trip computer might be the only thing regulating his work day.

That the system for eco-driving advice should be a failsafe system and the concern for it to function well in real life was a major issue for all interviewed. The driver might travel on different routes and be exposed to different problems every day. The truck condition and the truck type driven by each driver in a company varies to a great extent, so that the system takes all these variables into account and is not unfair to their colleagues is important to the truck driver. The system should take troublesome workdays into consideration and not only function on the boss's side to provide information continuously of the exact positioning and doings of the driver.

The traffic is a great part of the truck drivers work day – the driver must take the traffic situation into account – and "flow with it". The system should be as simple as possible; the driver only wants the most important info while driving. To plan the route is important, both to save fuel and minding the traffic as well as the different deliveries – but sometimes the traffic makes it hard for the driver to hold delivery times and not feel too stressed. It is common during the work day of a truck driver that cars come driving fast past the truck and then "squeeze in" close in front of the truck; which is annoying to the truck driver and also creates stress. The driver manages a great deal of loading and unloading by himself, which the driver says is good as variety makes the work better.

Many describe today the need for more education in eco-driving, which it is important; both for drivers and other working close to them. Most of the drivers have attended an eco-driving training course within the last years and is positive to eco-driving education. Although the driver might be positive towards eco-driving, thoughts are never focused on this when out working, the automatic gear shift handles itself and the driver focuses on engine indicators that might tell if something is wrong with the truck. The driver expects truck manufacturers to do their bit and construct better trucks and develop better fuels. Eco –driving is ambiguous to the driver; it goes too slow when driving like that, a driver might say, "it does not always work" is the attitude and believing that many drive faster to save time – which also is money.

In the future the drivers believe that more automatic systems will be integrated in the truck and that is ok by him as long as the driver is in focus. It is important to know ones truck and be able to handle it without all the electronics that exist today. The driver should be trusted and not monitored from the back office or being punished for higher fuel consumption.

Statistics from the user study

One clear result of the user study is that the interviewees preferred information to be presented to them in real-time, that is, what is happening right now instead of compiled, summarized information. 11 interviewees preferred this compared to 5 who preferred the opposite.

9 interviewees preferred information available for them to activate themselves - compared to 7 interviewees preferring to have information automatically presented.

The result shows that information and feedback should mainly be presented to the driver when driving - not pre or post-trip. However, many stated that it is good to have information available before and after a drive as well and that there is no contradiction in offering this possibility in the system as well. The scores for information presented pre-trip, during and post-trip was: 6-11-6.

The interviewees stated that visually presented information was the main modality preferred.

Eco-driving parameters that interviewees stated that the system should take into account

Many drivers stated the speed as something that affected the eco-driving abilities, which is true. But at the same time almost every interviewee said time was a great issue in their work.

- *"It takes longer time [with eco-driving] - anyone telling differently […] that is bullshit."*

Speed has a strong connection to accelerator usage, the driver cited above stated that one pushes the accelerator down to keep up with delivery times.

Many drivers were concerned that an eco-driving system that takes brake usage into account encourages unsafe driving or that you would not regard the system as correct if it counted in hard braking (connected to road safety). One driver spoke of a system that gave the wrong output since only the time, not the force used when braking was taken into account. This resulted in drivers doing uneconomical hard braking to score higher scores in this system and get rewards for the wrong type of driving. The system should be failsafe and correct and show a just result between drivers.

Planning ahead was something drivers saw as self-evident, when driving a large vehicle one needs to plan for the road turns and uphill and downhill ahead. One older, more experienced driver stated the driver always planned ahead and that was something the driver did automatically, nothing that the driver needed to be reminded of.

Idling was seen as a major issue for the experts, something that the eco-driving coaching system must take into account. During the user study, the interviewers themselves experienced the occurrence of truck drivers letting the truck stand still idling for extended periods of time. This was mostly done in connection to when drivers are bound to the trip computer time and need to wait for the exact minute when they can start driving.

The condition of the truck is something that drivers are focused on today, oil levels, brake pad wear and the like is something that also affects eco-driving abilities.

The amount of load on the truck is another issue that some drivers stated as something they wanted feedback on. One driver had no way of knowing of how much sand the driver actually loaded onto the flatbed, but went with his instinctive feel and experience; this because there was no load indicator built-into the truck. The issue of overloading is both a safety and eco-driving parameter.

The full list of comments from the user study can be reviewed in Appendix 5: Results from interviews and functions expressed.

6.4.2 Scenarios

The following scenarios describe the surroundings of the user today, the environment and how the user works solving a particular task. The scenarios used are focused on describing the road and road conditions. What the product environment will look like in 10-20 years time is an important question for this thesis, as well as social and technical trends, in this case conditions are seen to be the same for many truck drivers in the future. The three scenarios have been selected describing the top most typical driving situations in where an eco-driving coaching system is most needed to give advice. The scenarios were mainly used to get a deeper understanding for the users and the different user environments.

Questions regarding the future in this project have been:

-What does Volvo's future look like in the truck area? What do they think of the social and technical development?

-What will the working environment for the construction truck, timber truck etc. look like in 15 years time?

Scenario 1 - Low speed, dirt track.

A timber truck driver, owning a company of 6 trucks in total; makes his way through the woods on a narrow dirt track. The driver drives slowly, below 50 km/h. It is the last haul for the day and the driver feels somewhat tired. The truck is a Volvo Fh16 with a trailer, heavily loaded with tree-trunks. There is snow and ice on the road, the road itself is winding through sharp corners and up as well as down hills and the truck driver cannot drive faster than around 40 km/h. The driver has not been on this road before and is focused on finding the right way to the pick-up, again the driver is interrupted by phone calls from employees driving their truck on some other road. There are many crossings to pass before finding the way to the timber pick-up stop. Soon a steep hill appears that makes a sharp turn at the top. The road is so narrow that meeting other vehicles is impossible; the driver shifts down manually and press down the accelerator to max…

Scenario 2 - Higher speed, asphalt road.

The truck driver starts out on the first route for the day with his empty truck. First passing a smaller neighborhood with houses, pedestrian crossings and red lights, the road is quite narrow and has some potential dangers. Soon the houses are replaced by nature and the driver admires the view – the driver is all alone with the truck. The road is well-known to the driver, it permits a speed of 80, but has some tricky places where you have to plan ahead and slow down and coast in the many down hills before taking a turn. The driver has taken these turns before so the driver knows what the driver is doing. Here are some accident-affected road sections with steep down hills on the side of the road, where the driver knows the people involved, the driver thinks back but also admires the scenery- its breath-taking.

Scenario 3 - Idling, trip computer.

The driver is quite satisfied; on-time and sits and waits in the truck, letting it idle, waiting for next truck to weigh-in the load at the un-loading site. After a while it is time to unload the truck, but not in the weigh-site in front of the truck where the driver has been waiting, but the weigh-site diagonally across from where the truck is standing now. The driver is a bit anxious to drive there, starting from a stand-still – it is slightly uphill and quite muddy and slippery in

the wheel-tracks. The driver manages this maneuver by making a sharp s-turn and at the same time accelerates on a low gear. After the weigh-in the trip computer signals for a break within 15 minutes. The driver gets a bit annoyed – the driver wants to hit the road again.

6.4.3 Identified user groups

Through the interviews and visits made to truck drivers, office personnel, experts and truck driver students today, questions were asked concerning eco-driving attitude in general and suggestions on how the concept of an eco-driving interface would be designed more specifically; see Appendix 4: Interview Transcripts. The answers lead to generalized conclusions about the different users that will come in contact with the product in the future and of how to group them into target groups. In Table 1, the different user groups are presented:

User group	Example	Examples of requirements on a truck related to eco-driving
Primary-user	Driver	User friendly icons The system should help the driver to reduce fuel consumption
Secondary-user	Salesman Electronic Engineer IT Engineer	Easy to install on a truck Low consumption lamps- Easy to fix or change lamps Easy to programming
Side-user	Colleagues Other drivers passing the truck	Easy to communicate Simple and not distracting exterior sign to show eco-driving to other drivers
Co-user	Back-office	Easy to communicate, send and receive messages

Table 1: User groups

In Table 2 below different users and their conditions concerning the final concept are investigated.

User Relation	**Explanation**	**Importance**
Control		
User with responsibility and dependant user	The driver has the main responsibility in relation with the product Back-office is dependent on the drivers' actions and information sent. Other drivers could be dependant users as well.	The driver and back office should both trust the product and information it provides for them
Collaboration		
Collaborating users with one user controlling the product	A driver needs to collaborate with back-office personnel who is not primarily using the	This kind of collaboration is often based on rules and regulation

	product but use another product	
Performance and demonstration		
Expert and amateur	Drivers as well as back-office employees have different level of experiences based on years of driving or working	The system should be user-friendly for both groups
Meeting		
Driver and back office meeting via the product/interface Drivers could communicate via the product	Driver and back office may not interact physically but could meet through the product/interface by sending notes	The product/interface should meet both users needs in interaction
Prevention		
User/product inhibit another user with the aid of product/interface	Different icons and messages are designed to warn or notify the driver about the wrong and right actions	Improve the driver's eco-driving manners, reduce the fuel consumption and CO_2 emission
Social relationship		
The driver would use the product/interface to influence the environment, other drivers and the company that works for, by being a good eco-driver	The driver may wants to use the product/interface to give other people the impression of being a particular driver (a real eco-driver) or to show group affiliation	The impression desired of the product/interface to impose on drivers should be considered, whether it should symbolize eco-driving and how the design could support it

Table 2: Result of User relations method

6.4.4 Final target groups

One obvious target group is: "The Truck Driver" as the projects aim is to find a system for eco-driving advice in the truck cab. The other final target group consists of people working in the back-office as they are co-users and work in close collaboration with the truck drivers and is called: "The Collaborators". It is seen as highly likely that these two groups also exist in the future of 10-20 years and are therefore described further below represented by personas.

Persona for the truck driver in Sweden 2011 with a futuristic perspective

Krister Larsson is a 43 year old man with 22 years of experience driving a truck; he works employed in a smaller haulage firm. His work hours may vary to a great extent, there are many things to handle with the truck when not driving, and it most of his spare time. He lives in a house in a smaller community together with his family: wife and two daughters. When not working he enjoys spending as much time he can with his family and working on small renovations on the house.

In his work he does mostly construction work during summers, delivering gravel and stone material to building sites, but during winters with heavy snowfall he performs road maintenance work for the municipality. Krister's house is situated just outside a smaller town

in the south of Sweden and he works within a geographical area of around 250 km in radius to this town. Following the Swedish seasons, the road conditions he drives on vary to a great extent, but he mainly drives during daytime. He will transport basically the same kind of goods in the future as well: gravel will be processed in the same way, and he enjoys his work and way of living. He likes being out on the road, getting exposed to a range of different environments and roads, as well as people, when transporting the goods and he hopes that this will last in the future. It is a pride for him to solve his work tasks – no one who cannot do the same work as him is really fit to decide or give any orders that affect his everyday work. Freedom and to be an entrepreneur is one of the good parts of the work, to feel responsibility for the load and his truck.

Krister always drives the same truck and the cab is his workplace. The truck is around 2 years old and was bought in new by the company owner, he appreciated that his boss left it for him to decide what added features he wanted in his cab. The fuel consumption of this truck is at great focus, he notes it down manually when re-fueling and the increasing diesel price is something he thinks a lot about. He keeps track of what developments are taking place both within "his" truck brand and competitors, as well as colleagues' opinions on these inventions and law changes. Even though he works alone in his truck, he is very social and speaks on the phone many hours a day - the phone is his main working tool apart from the actual truck.

Persona for the collaborators working in Sweden today with a futuristic perspective

Johanna Bergqvist is a woman, 34 years old and with 4 years of experience as a transport leader. She lives with her husband in a house in rural area in the central part of Sweden around 15 km's from her work, to which she drives in her car each working day. She has a dog that takes much of her spare time since she takes it to dog shows and the dog accompanies her to work every day, another interest is to spend time with friends.

Her work task is at the back-office and being the link between the customers and the truck drivers so that they receive their work missions. To be social is essential in her work as she handles most contacts through the phone both focusing on customers and drivers. Her work place is in an office building at a desk working with the computer, sometimes far away from the drivers, but regularly drivers come into the office to receive driving orders directly and chat with her. She is the daughter to the owner of the haulage company. Johanna's attitude and personality is important in the driver-to-office contact; she might discuss what to load, how and when to weigh in the load or which road to take with the driver. She enjoys an open dialogue and wants to decide together with the driver, the best route for the day. It is during this talk that many important decisions are made affecting fuel economy, mainly concerning

route choices. Direct information, orally and face-to-face is the best way to communicate with drivers according to her.

She has no eco-driving education driving trucks, consequently as not having a truck license. Her attitude is that the drivers have to handle every eco-driving issue that relates directly to actual driving themselves. Here there is a big division, she knows she can't drive and therefore is cautious not to interfere with the drivers' area of professional pride. They as drivers might feel she is tedious if she provides information on how to drive, at least if she does it often. What she has control of today is driving times, fuel usage and where the trucks are on a map – but mostly the information is manually written. When talking with the customer she represents the company and this will still be the main communication in 10-20 years.

But changes will come, even though she doesn't know exactly what kind. She has noticed that the younger 20-year-old drivers are more into new ideas within eco-driving matters compared to older drivers. So eco-driving might be more integrated and a more natural part of the drivers' everyday work in the future. She also put a lot of trust to the truck developing companies to create better engines and fuels.

6.5 Primary target group

As eco-driving is performed while driving, and the driver has been stated as the primary user of the concept for giving eco-driving advice – it is natural that the Truck driver target group is the most important one and thus the primary target group. In many ways the truck drivers and collaborators are intertwined and focusing on the truck driver will also render in a concept for eco-driving advice that will speak to the co-users working at the back-office.

7 Result of the information collection

The result from the information collection; theory research, competitive analysis and user study resulted in the list of demands and was the base for the continued work; Concept development.

7.1 List of demands

The list of demands consists of one list of demands and one list of desires. The list of desires is rated on a scale from 1 to 5 where the score 5 is given to the highest ranked desires based on the researchers judgment, see below.

7.1.1 Demands on the system for eco-driving advice:

The system should:
Function with every truck type and Volvo truck model
Present real-time eco-driving information to the driver
Have drive safety in focus
Not interfere with other instruments in the driver environment
Allow for driver attitude and education skills to come first
Be integrated with an eco-driving education program and follow-ups
Feel quick and responsive
Appeal to the economic and truck-caring side of the driver
Function with driver when under time-pressure
Be selective when displaying information to driver
Have functions that are possible to disable
Have a user-friendly design
Not be repetitive in order to not irritate the driver
Take road conditions, weather, load, route choice and the current traffic situation into account
Predict topography and turns of road into account
Have function for accelerator and brake use
Have function for driver to anticipate road ahead
Display fuel consumption per specific unit
Display average speed per specific measurement unit
Enable for truck driver, back-office and customer to exchange information at anytime
Be failsafe
Be cheap and easy to repair
Function well in a dirty environment

7.1.2 Desires for the system for eco-driving advice:

The system is desired to:	**Importance score**
Provide information regarding load to driver	3

Display carried weight per specific unit	2
Contain a positioning system and a map	4
Present best possible routes to the driver	5
Have function for planning routes and loading/unloading sites	5
Provide comparable eco-driving information when driving the same route	5
Provide driver with traffic information like road blocks, accidents and bridge heights	4
Work together with electronic infrastructure systems in roads, buildings etc	3
Be integrated with phone usage	3
Include a social network	5
Enable communication between users regarding eco-driving	4
Allow for drivers to show their skill in various eco-driving branches	5
Indicate with different colors	3
Provide a screen of sufficient size, if a screen exists	4
Be as simple as possible during driving	5
Show how much money you save (through eco-driving)	5
Record fuel and emission data and make this information possible to dispatch (to clients etc.)	4
Provide an automatic fuel consumption report service for truck owners	4
Explain reasons for why a behavior is bad	4
Provide advice a long time ahead of action	4
Give pre-trip advice for idling for example	4
Display driving history within defined periods	4
Appeal to the competitive side of the driver	3
Provide deeper drive statistics and feedback post-trip	4
Provide positive feedback or reward system	5
Show comparative improvement for a specific time period	5
Work together with trip computer to add or deduct drive time depending on eco-driving results	2
Have limited forcing functions; only concerning overload and alcohol lock use	4
Allow for each driver to be anonymous	5
Enable sporadic truck positioning	2
Enable drivers to make comments on road conditions when driving – to share with other drivers and collaborators	4
Enable customer to make quick delivery changes and notify drivers	5
Enable back-office to make quick route changes and/or notify drivers	5
Enable back-office to decide right truck type for each assignment	5
Be composed of 100% recyclable material	5
Present information as compact as possible	3

Have a “static display-mode” for information when driver is overloaded	3
Be designed considering choice of colors, strength of lighting, contrast and angle of vision	4
Provide good vision and auditory support considering the top-down process for older drivers	4
Consider aging and weakness in auditory and visual senses	3
Hand-over functions to other senses to prevent overloading of the visual sense	3

8 Concept development

In this part, the second phase of the thesis will be presented. In the first part, literature studies were done to broaden information about the company, the subject and driver's world. In addition, a user study survey was conducted to find demands and requirements of the user. When having finalized the list of demands the work took a new start by creating new ideas based on the found information.

8.1 Methods

Generating ideas has a lot to do with personal creativity. To not miss out on any ideas, methods were used to steer the concept creation into the right direction. Off course the previous studies were lying behind all ideas and helped to make the right decisions as well.

8.1.1 Idea generation meeting or brainstorming

To gather people not involved in the everyday project work to ask for and discuss new ideas for your research questions could be one productive method. In this case the meeting could be described as a form of brainstorming where people with different background are gathered without preparation and after a short briefing on the core of the problem, start to discuss different solutions. The atmosphere should be positive and people are encouraged to find innovative, strange or even crazy ideas. The ideas are noted by the moderator and /or the participants (Österlin, 2003).

In this project, a group of industrial design students were gathered for the meeting. The subject and aims of the project were defined for them to give an overview to the group. Then, members started to talk about the subject and simultaneously sketching that caused generating remarkable new ideas for the future in truck world. These ideas were gathered to inspire designers for the next step in the project.

8.1.2 Idea Sketching or brain-writing

To use your hands and work with pen and paper is a simple way of getting new ideas noted when in the early stage of a concept development. To let group members work separate as in this method, to sketch down new ideas could be positive as new ideas are not channelized (Österlin, 2003).

8.1.3 Expression board

This is a board of pictures created as a representation of the materials, colors and forms that a product should inherit to fit the user group (Wikström, 2007).

8.1.4 Morphological matrix

The method is focusing on the creation of complete concepts, by combining separate part-solutions that are fulfilling single demands and desires of which the final concept should fulfill all (Johannesson et al. 2004). The matrix could be designed with one column containing essential design parameters and to the right hand of them listing possibilities for meeting these requirements. Different combinations of ideas essentially create new ideas.

8.2 Performing the concept development

The concept development could be divided into two parts: one being the "idea generation part", where scattered ideas took form and the other being the actual concept development phase where complete concepts were created in iterative steps. The concept development and the concept evaluation stage (presented in next chapter) were not performed strictly separated: see Figure 4: *Concept development stage*s where the gray areas represent concept development work stages.

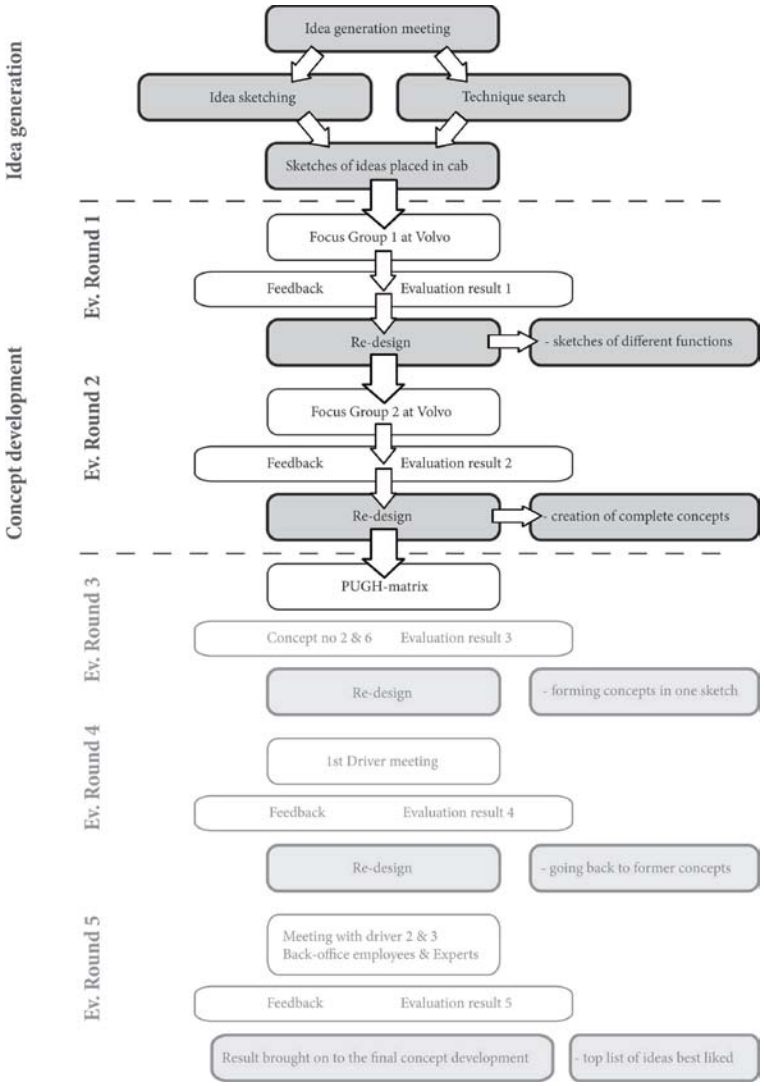


Figure 4: Concept development stages

8.2.1 Initial idea generation

To launch the concept development, an idea generation meeting was held. Six students from the master program in industrial design engineering were summoned to give new input and ideas. First a short summary of the work done so far was presented to the participants; they were then asked the question: "How can an advisory system for eco-driving be designed for truck drivers?" The ideas and comments, as well as sketches drawn during the meeting were collected to have as a background for the continued concept development work.

The formal idea generation then started with group members separated, this to not be affected by another's ideas. The ideas were sketched on paper, initially without and then with a cab interior template as a guide to place the ideas in the cab interior, see Figure 5. One expression board was made for the primary target group and used to give creative input during the sketching sessions and to give guidance for the concept development, see p.49.

Figure 5: Cab template

To find new information and inspirational pictures on inventive techniques and other concept ideas found in earlier work, information was collected from the internet. Some interesting ideas for new materials in the concept were found discussing with Marta Kisand, a Borås University student. Later the group members came together and discussed the ideas found during group meetings to make further developments.

During the first round of concept creation only parts of complete concepts were developed, these parts or functions then went on to the first evaluation round.

8.2.2 Creating complete concepts

The functions and ideas best liked after the two first evaluation rounds were then put together using a form of a morphological matrix to create complete concepts of an eco-driving advisory system. In this project, the matrix was created based on sketches. Each different sketch was combined with other sketches describing different solutions and formed new concepts, see p. 53, *Resulting complete concepts*. These complete concepts were later put through further evaluation rounds and evaluated by the researchers starting with the Pugh matrix (see p. 56, *Evaluation* of concepts). The process of evaluating the concepts further using expert and driver meetings is described in the next chapter.

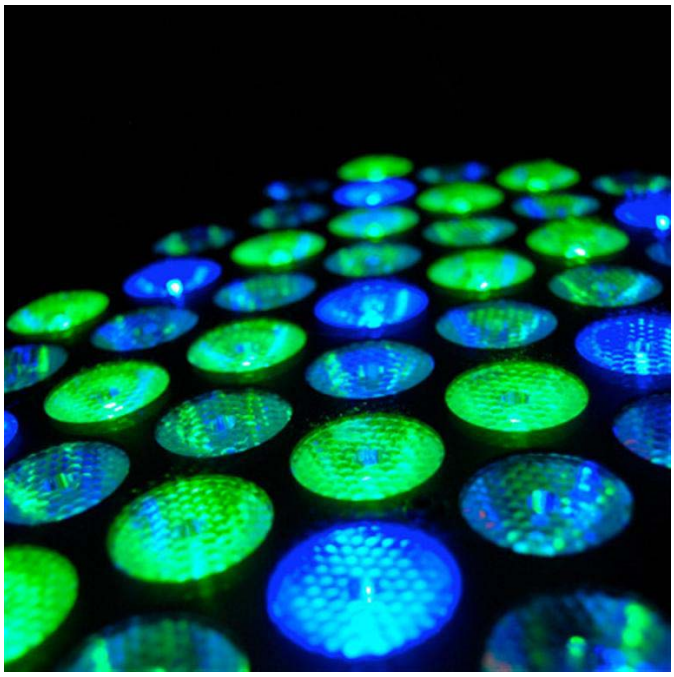
8.3 Results from concept development

Ideas from the idea generation meeting are presented in Appendix 6 - Ideas from idea generation meeting. Many new ideas were found looking at the material presented from earlier work at Volvo; see Appendix 7 - Input and ideas from Umeå workshop.

8.3.1 Technology

The findings of inventive LED-technology and smart textiles were used in the created concepts.

LED-light

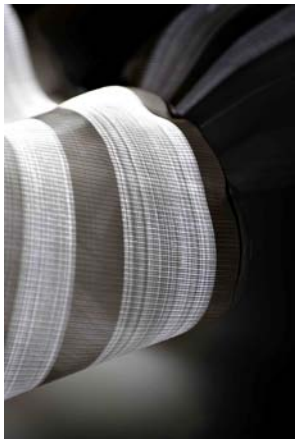


Picture 14: LED-lamps. Copyright, Stu Meech, 2009

LED (light-emitting diode) lights are used in the next generation of lamps. This technology has some advantages in comparison to technology in traditional lamps such as lower power consumption, reliability, high brightness and long life. These lamps also have higher tolerance to humidity and minimal heat generation lighting. Moreover, they are smaller in size compared to usual lamps and have lower voltage. LED lamps provide great flexibility in terms of shapes to create patterns and colors. These lamps are also used for different means of illuminations like in traffic signals and full color displays. (Komine, 2004)

Smart textiles

Smart textiles are referring to textiles with added technical abilities which make textile material usable for industries like the car industry or medical care (Smart textiles - The Swedish School of Textiles, 2011). Textile has always had favorable properties like pliability and softness, but with different coatings and dyes, textile is given new properties like improved dirt and water repellency, and electrical, light or heat conductivity.



Picture 15: An example of smart textile: textile with optic fibers. Photo: Jan Berg.

One interesting function textiles could have is semi-transparency so that it allows light to shine through (Kisand, 2011). It might also contain thermo-chromatic dye which makes it able to conduct body heat and change color accordingly, or may be combined with LED-light (Cobb, 2011) or optical wires woven into the fabric that conduct lights (Smart textiles) see Picture 15.

Examples of smart textiles and its future applications and possibilities in the truck interior can be shown looking at the work performed at Borås University and Kisand's thesis *Smart Textiles as Innovative Interface for Commercial Vehicles.*

8.3.2 Expression board

The expression board was developed on the background of the experience from the user study. It displays the materials, forms and colors that represent the eco-driving advisory system see Figure 6.

Figure 6: Expression board

8.3.3 Initial idea sketching

Below in Figure 7, some of the initial ideas sketched separately by group members are presented. They show some scattered ideas for different parts of the advisory system.

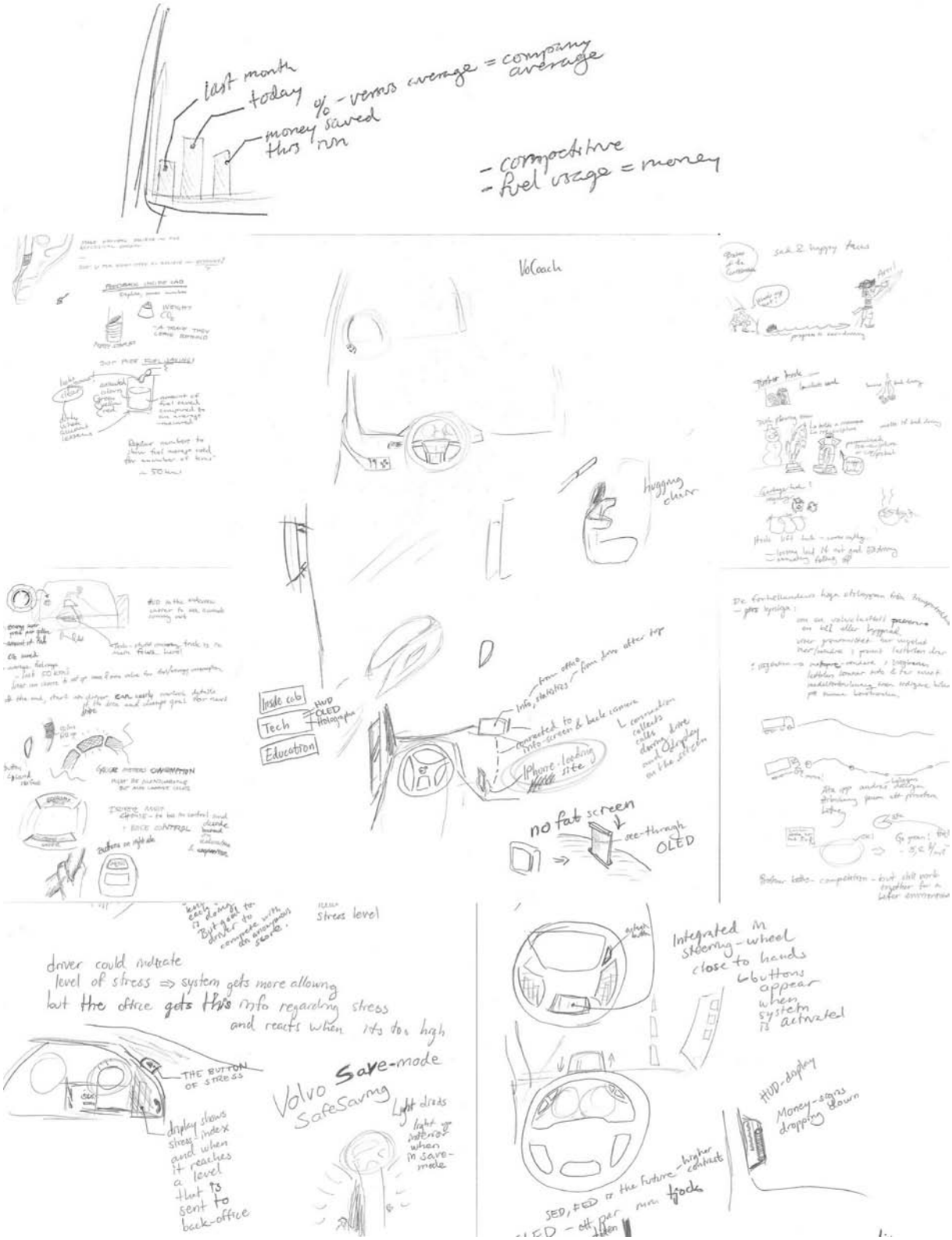


Figure 7: Selection of early idea skecthes

8.3.4 Template sketching – placing ideas in the cab

When adding the ideas to the truck cab interior using a sketch template, new ideas evolved. A selection of the ideas placed in the cab and their description is presented in Figure 8. While they are placed in the cab, or onto other places of the truck body, they are still separate part solutions and no complete concepts for the advisory system.

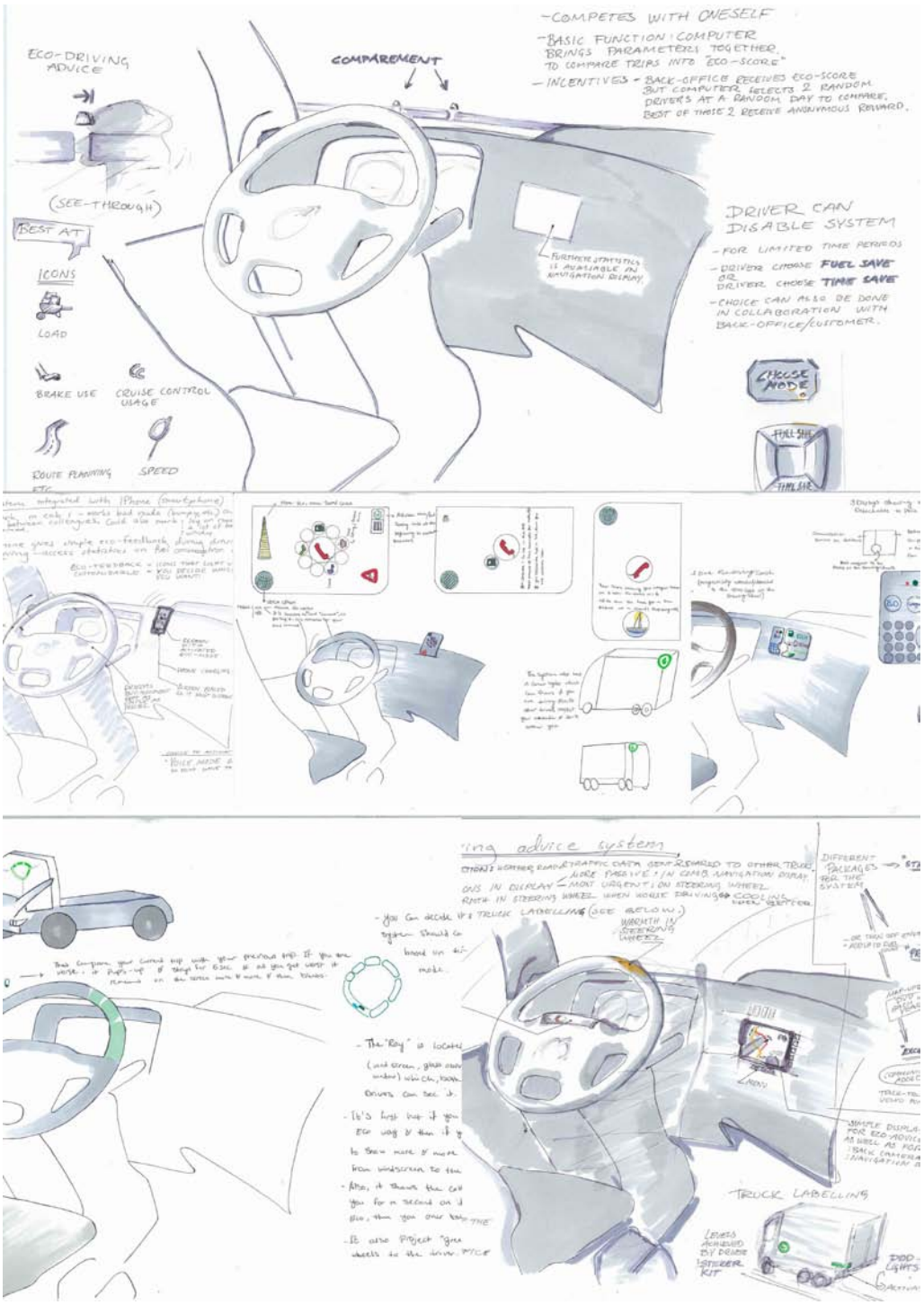


Figure 8: Selection of ideas placed in cab

One idea which can be seen at the top of Figure 8 is the *Basic function* idea: which is a function thought to exist in the advisory system that calculates a comparative score for all trucks and makes it possible to compete in eco-driving no matter what prerequisites one truck driver has compared to the other. The computer in the system would calculate an eco-score based on a number of eco-driving parameters including for example: weather, load and city driving. Another idea shown in Figure 8 is the *time save/fuel save-function* which basically lets the driver actively decide if he/she wants to focus on driving eco-friendly i.e. fuel save driving or does not have time for this at present i.e. time save driving. The comparison-graphics seen in the windscreen is one idea to display the *Virtual competitor*-function. One icon representing two different drivers are animated along a line – the icon positioned furthest to the right is the leading driver looking at fuel usage. This is an idea that lets the driver compare fuel usage to other drivers and is therefore acting as a form of reward system if you are better than the other driver. At the lower left side of the top picture a selection of different *icons* that can be used in an eco-driving advisory display are presented.

The row of pictures in the middle of Figure 8 describes the idea of incorporating the driver's *phone* in the system. Future traffic regulations might prohibit truck drivers to talk in the phone while driving without a head-set or similar. But with this idea, the truck driver will have eco-driving information available in his/hers phone at any time, the system will also contain functions for communication easily with colleagues, back-office and customers. One part of the phone idea was to add eco-driving advice on the steering wheel using smart fabric. The idea of integrating the phone leads to another idea of allowing the system to send information affecting eco-driving to other trucks in the area: a form of *driver community* in the eco-driving advisory system. With this function, the system would send information for example regarding road and traffic condition to other trucks in the network.

The bottom row of pictures in Figure 8 displays the *green ray-idea* to the left and the *eco label-idea* to the right. The green ray-idea indicates with warmth and colors on the steering wheel when the driver performs different eco-driving actions. Different colors and warmth would indicate a different eco-score. The eco label-idea is thought as an exterior placement for example with LED-lights to indicate to other actors in the traffic that you are driving eco-friendly or not. This is also something for the truck company to show that you are doing your best to lower fuel, or at least that you have an eco-driving advisory system installed.

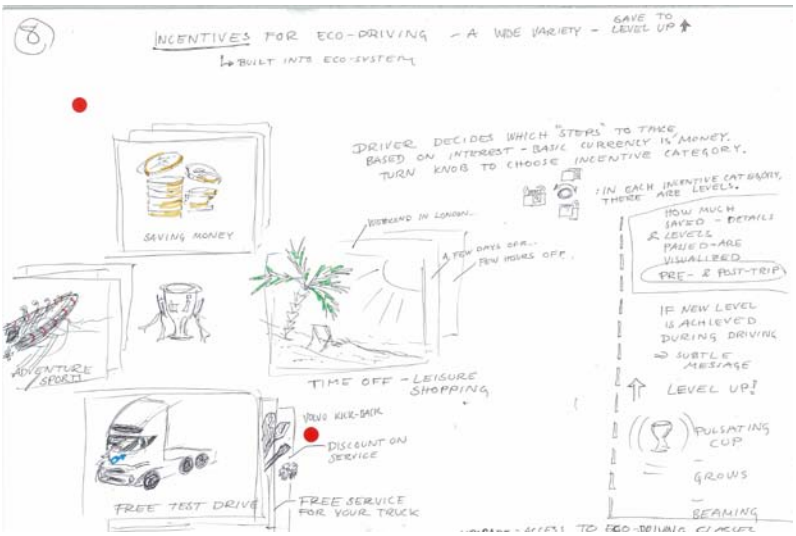


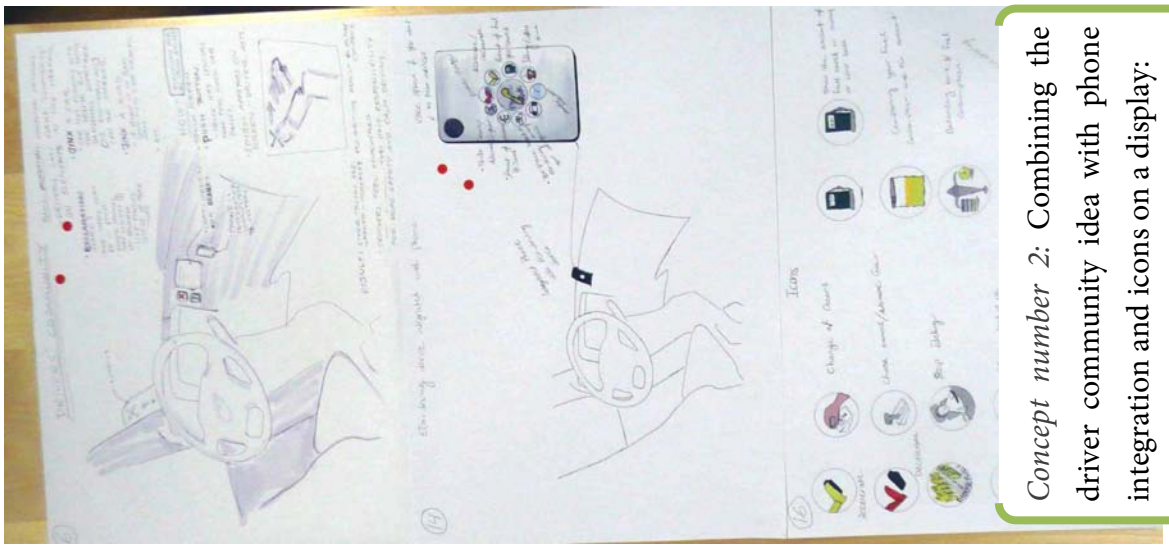
Figure 9: Sketch describing the incentive/rewarding idea

One idea that evolved was the idea of an elaborate incentive function in the system, see Figure 9:

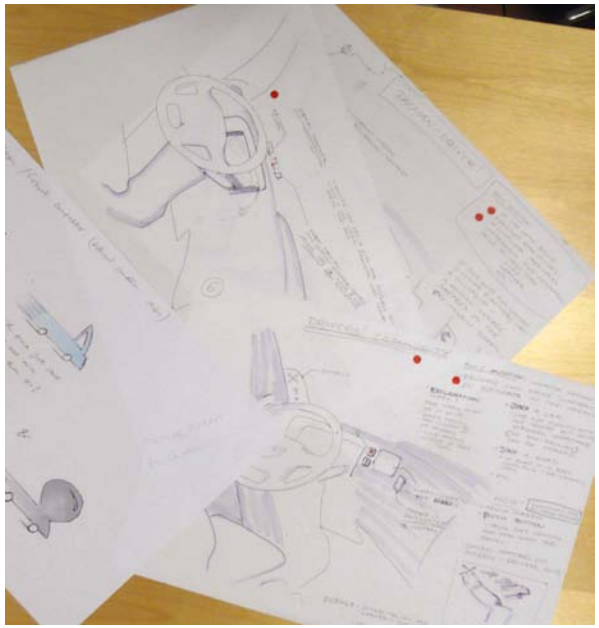
To give a driver rewards, different sorts of *incentives* on different levels could be a part of the eco-driving advisory system. For example: pay back on truck service at Volvo or money paid to the driver for saving fuel. This idea bases on the motivation section in the theory chapter where it is explained why a driver would be more willing to repeatedly take the desired action if motivated economically.

8.3.5 Resulting complete concepts

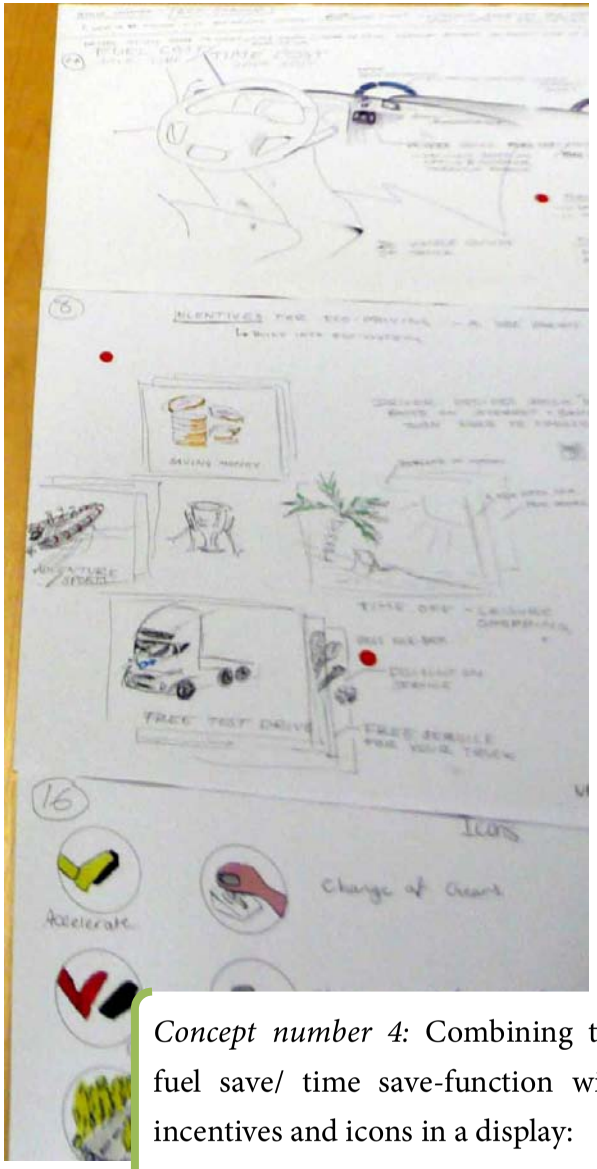
Complete concepts were created after the second round of evaluation at Volvo (see Evaluation chapter) using a form of morphological matrix. Different ideas that could be added to each other to create a complete eco-driving advisory system were combined based on the researchers' judgments. All concepts presented below will be compared to the Scania Driver Support system in the next chapter. Scania Driver Support is numbered as the comparative number one and to avoid later confusion the resulting complete concepts created are numbered as in the evaluation: starting with consecutive number two.



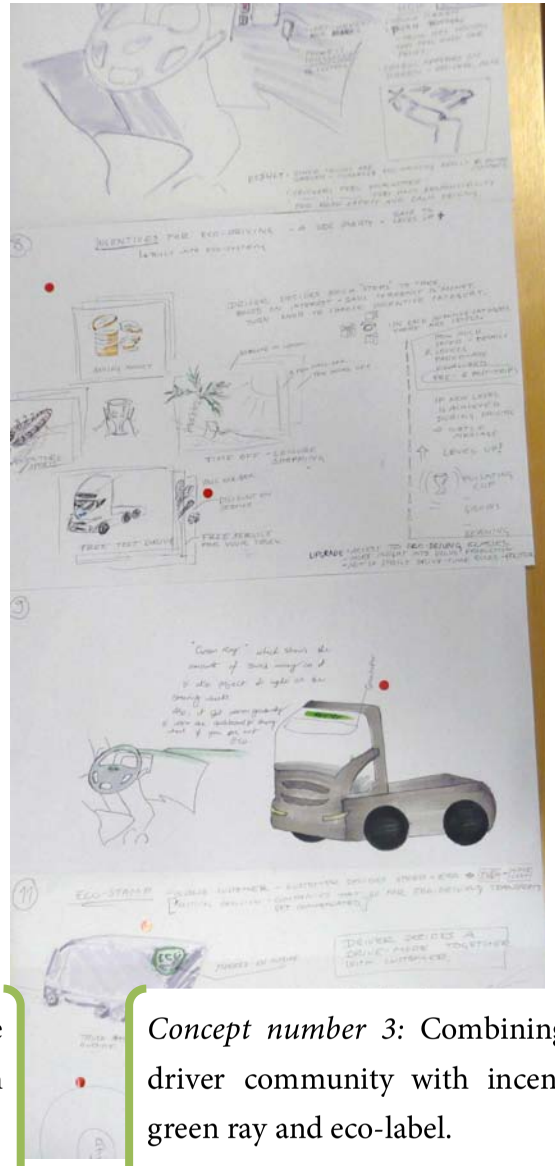
Concept number 2: Combining the driver community idea with phone integration and icons on a display:



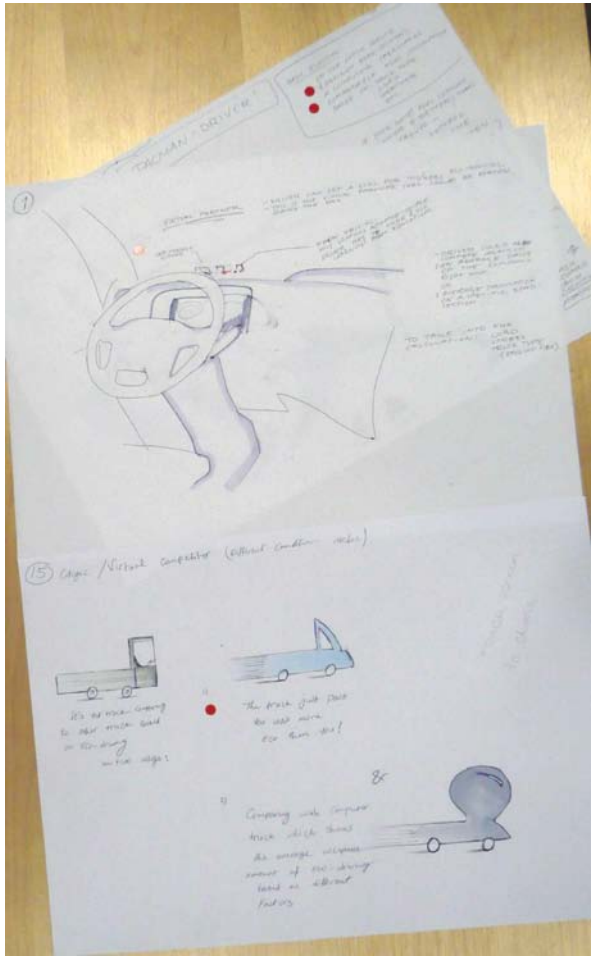
Concept number 5: Combining the basic function on the same route with virtual competitor and driver community:



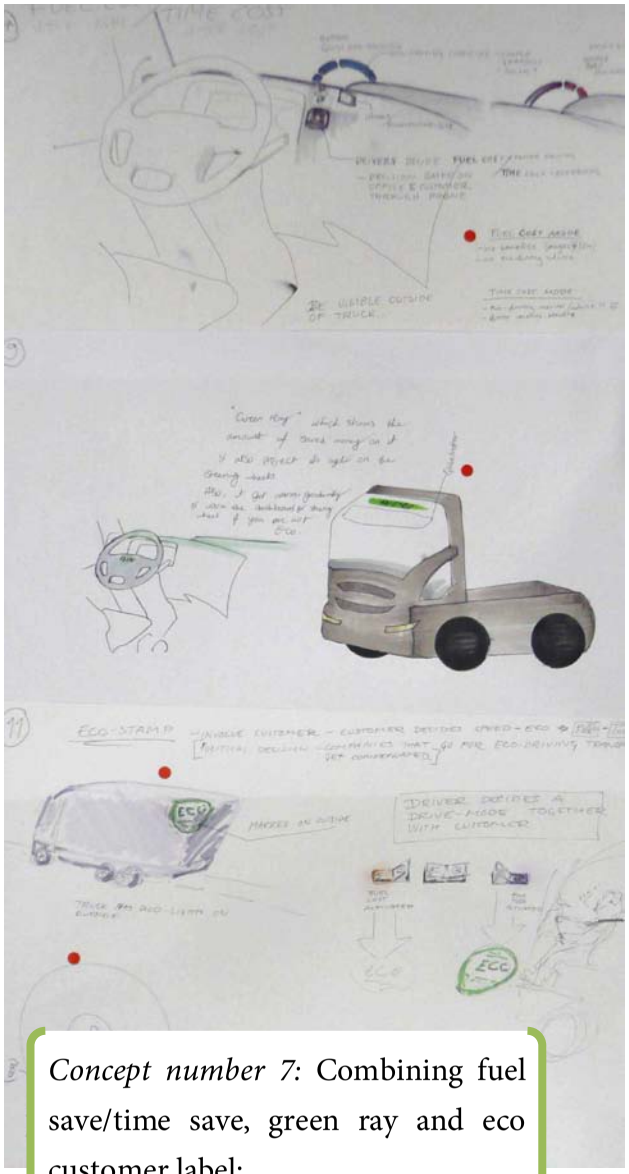
Concept number 4: Combining the fuel save/ time save-function with incentives and icons in a display:



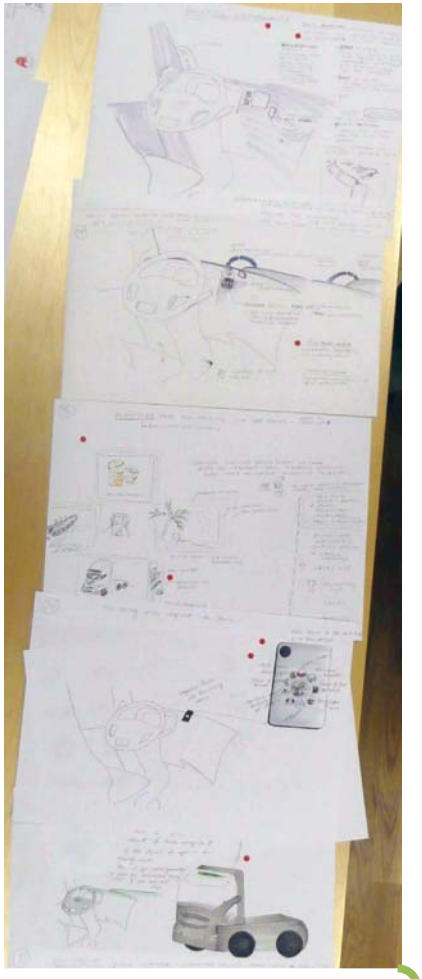
Concept number 3: Combining the driver community with incentives, green ray and eco-label.



Concept number 8: Combining basic function on the same route with virtual competitor:



Concept number 7: Combining fuel save/time save, green ray and eco customer label:



Concept number 6: Combining driver community, fuel save/time save, incentives, phone, green ray and eco customer label:

9 Evaluation of concepts

The evaluation of concepts has been performed interlaced with the concept development, creating an iterative process for creating the best solution for an eco-driving advisory system.

9.1 Methods used for evaluation

Two methods were used in the concepts evaluation phase, besides regular meetings and discussions with users, and are listed below:

9.1.1 Focus groups

In this method, requirements are elicited from a group of users during a conversation session. The analyst explains the topic and asks participant to give their opinions about it. Conversation hopefully improves during the session as participants might extend and improve each others' opinions. The focus group participants should not consist of a biased selection that might lead the conversation to irrelevant result and the analyst should keep the conversation at a moderate level to find all opinions (Sutcliffe, 2002).

9.1.2 Pugh-evaluation matrix

The Pugh matrix was invented by Stuart Pugh at the University of Strathclyde, for evaluating multiple options against each other, in compare to a standard or accepted option.

One product, a so called baseline concept, is chosen to evaluate the developed concepts against. The demands for the developed product are placed in a column and the concepts to evaluate are placed in a line at the top. The concepts are then evaluated against the baseline concept and receive a plus, minus or a zero depending on if they are judged to fulfill the specific demand more, less or the same as the baseline concept (Johannesson et al, 2004).

9.2 Performing the evaluation

The first idea generation phase was based on the user study and the drivers' opinions, the project's aim and other background studies. During the evaluation rounds: represented as grey areas in Figure 10, re-connections were made with users and information found earlier to secure the quality of the developed ideas. In total five meeting rounds - with people from Volvo, drivers and one expert were held during the evaluation. One evaluation round was also performed by the researchers alone: using the PUGH-method.

In each evaluation round with Volvo employees, drivers and experts, the participants were asked to state their top three ideas. Naturally some ideas were found to be more positive than others, while some were declined completely. Based on the result from each round, ideas were adapted, removed, or new ideas generated. This resulted in that the ideas shown to the first group was not the same as the ones shown for the last group.

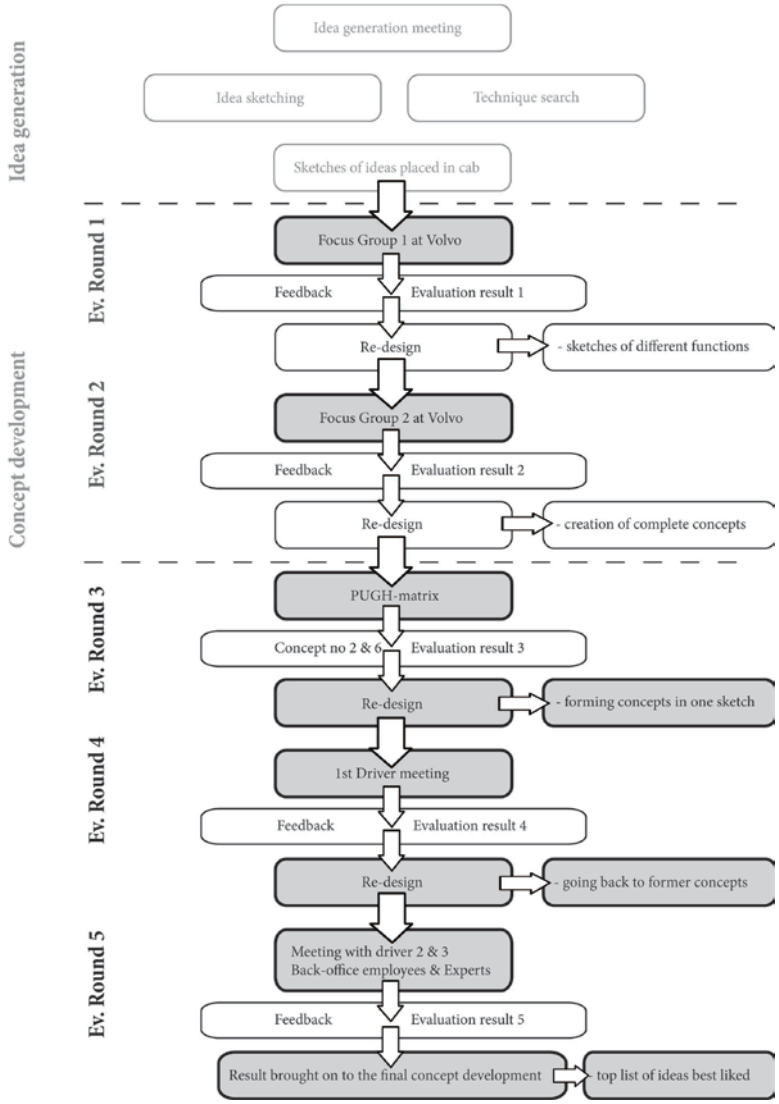


Figure 10: Evaluation phase

9.2.1 Evaluation round 1 – Focus group 1

The first evaluation round took place after having performed initial template sketching (see page 51) and having placed different ideas in the truck cab. This round consisted of the first of two focus group meetings held with three truck development experts at the Volvo 3P site in Göteborg.

During the focus group, sketches were spread across the table and explained to the participants while they were looking at them. Participants were urged to make notes or draw new ideas on paper while the sketches were displayed to them. After explaining the ideas, participants were urged to discuss about positive and negative parts in each sketch. The top three functions and ideas that were liked the most by each participant were marked with a red sticker on the sketches.

After this meeting a list of the participants' comments were completed and a number of ideas that did not get any positive response from the meeting were disposed. New sketches were made of new ideas that came up at the meeting and sketches were re-made for some of the ideas that stayed on for another round. The re-making of sketches was done partly because of the lack of visual equivalency among the sketches – this made the participants to state different opinions on ideas based on the sole look of the sketches which was not wanted. Finally, the sketches were revised to see to that there were sketches for every new idea and functions that got mostly positive response – these went on to the second evaluation round.

9.2.2 Evaluation round 2 – Focus group 2

It was desired to make a second focus group at Volvo to find as many of the opinions by truck developers as possible, since Volvo's opinions were important during the project. Three more

truck developers were asked to participate in the evaluation. The sketches that went through the first evaluation round and which had been partially re-made were spread on a table for all participants to get an overview.

Once again comments were gathered and the three ideas best liked from each participant got a red sticker. Finally all the ideas that got the highest score from both of the focus groups were summed up in a table. The top ideas were modified if needed and combined to create complete concepts, see Resulting complete concepts, p. 53.

9.2.3 Evaluation round 3 – PUGH-matrix

The complete concepts created (concept number 2-8, see Resulting complete concepts, p. 53) were placed in a PUGH-matrix, see result in Figure 14, and compared to the main competitor: Scania Driver Support, comparing concept number 1. A selection of the demands and desires in the complete list of demands were selected to be used in this evaluation. Each concept was judged if it fulfilled each selected demand better, to the same extent or less than concept 1. The assessment was made marking in a table with a (+) meaning better, (0), the same or (-), worse, by and based on the knowledge of the researchers. Then, for each column the total number of each sign was summarized and each concept got a score. The top two concepts were selected to go further with into the evaluation.

Some more sketching and re-design was made to sum up and place each of these two concepts in one sketch each, before going into the next evaluation round.

9.2.4 Evaluation round 4 – Driver meeting 1

The effort was made to go back to a few of the drivers that had been visited during the user study. The first driver was a timber truck driver met in his own truck cab, where he was presented with the two winning concept sketches from evaluation round 3.

The driver could then make his comments, they were noted down and photos were taken during the meeting while the driver pointed at different aspects of the concepts on the sketches or areas in the truck cab.

The comments from the driver were taken into account and further re-design in the form of sketching was made. Some ideas that had been discarded because of the PUGH-matrix were also revised again resulting of the driver's comments.

9.2.5 Evaluation round 5 – Driver meeting 2 & 3 and Expert meeting

With a selection of six sketches showing the concepts revised after round 4, two drivers, two back-office employees and one expert within eco-driving were re-visited for a final evaluation round. This was performed on two occasions, one on-site at the office building of a

construction truck firm in the south of Sweden and one at a neutral meeting place in central Göteborg. At the construction firm, two drivers interviewed before as well as two back-office employees and one share-owner of the company participated in the evaluation. The expert within eco-driving was met in Göteborg, discussing the ideas with him separately. All made their contribution by stating their general opinions on the sketches.

Each idea within a sketch/concept was explained in detail to bring forward all aspects the designer had in mind. Thereafter, the drivers as well as back-office employees and the expert had time to give their opinions about different parts or the whole idea. The evaluation participants were urged to start an unstructured discussion about the different aspects of the concepts they liked best. During the meetings notes were made by the researchers and ideas that were explicitly pointed out were marked with a sticker.

In the end of evaluation round 5, it became clear that what had been pointed out from the two last evaluation rounds were all different factors and ideas that were more or less liked. These factors were summed up and ranked based on the different comments received. Those factors/ideas that got the highest score were listed as the final concept's parameters that the design of the eco-driving advisory system should encompass.

9.3 Result

Now the results from each evaluation round will be presented. In some cases new sketches were made while in other, only lists of comments were the result. In Figure 11 a collage of sketches shown to the first focus group can be seen.

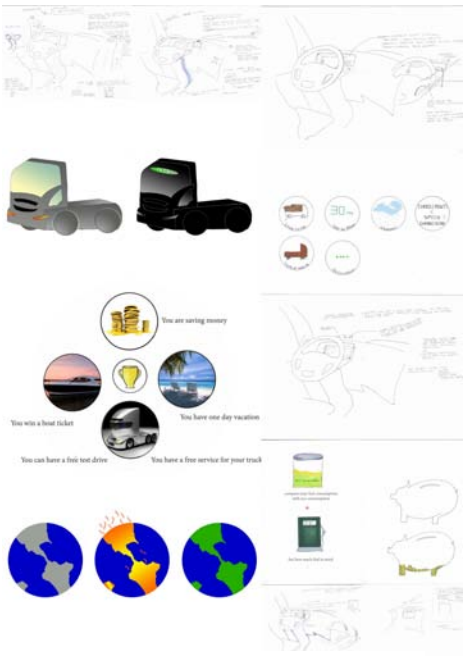


Figure 11: Sketches shown to first Focus group

9.3.1 Result from evaluation round 1 – Focus group 1

In the first focus group, three Volvo employees commented and marked the ideas and functions they liked best. This resulted in some re-designing and new ideas for functions in the system. The resulting sketches after the first evaluation round can be seen in Figure 12, these were the sketches then shown to the second focus group.

One major issue from the first evaluation round was that the sketches needed to look similar in order to get fair responses by participants in the next focus group.

Some ideas that were seen as positive were:

- The virtual competitor and driver community (see closer description on page 51). To work in a collaborative way is positive and to compete on the same route. The virtual competitor idea was something that could be visualized by a computer game shadow that the driver can compare oneself against. It is a good idea if the user can customize this function and choose how to compete; with one self, other drivers or no competition at all and just get advice.
- The time cost/fuel cost mode was also stated as a good idea by the Volvo employees however, the technical solution of time-saving is hard to find an algorithm for. For example if a driver has to catch a ferry or a delivery time, then the system needs to know the ferry times.

Ideas that were discarded were for example stress-level (that the driver could indicate stress-level when driving and therefore have an excuse for less eco-driving) and having markings on steering wheel's outer rim.

–"It is tricky with displaying information where you have your hands; maybe the information could be displayed in the center of the steering wheel instead?"

One opinion from the Volvo employees was that it is not good if the driver can change all parameters related to eco-driving himself, then the driver might cheat in setting the parameters; e.g. always state that the weather was rainy so it was not possible to make the delivery on time.

One important parameter for Volvo is safety. This is an issue when looking at the placement of the eco-driving advisory system, because you add extra info in one already cluttered driver environment. The amount of info that is displayed to the driver could be changing: having only one aggregated value or gauge that is displayed during driving and then

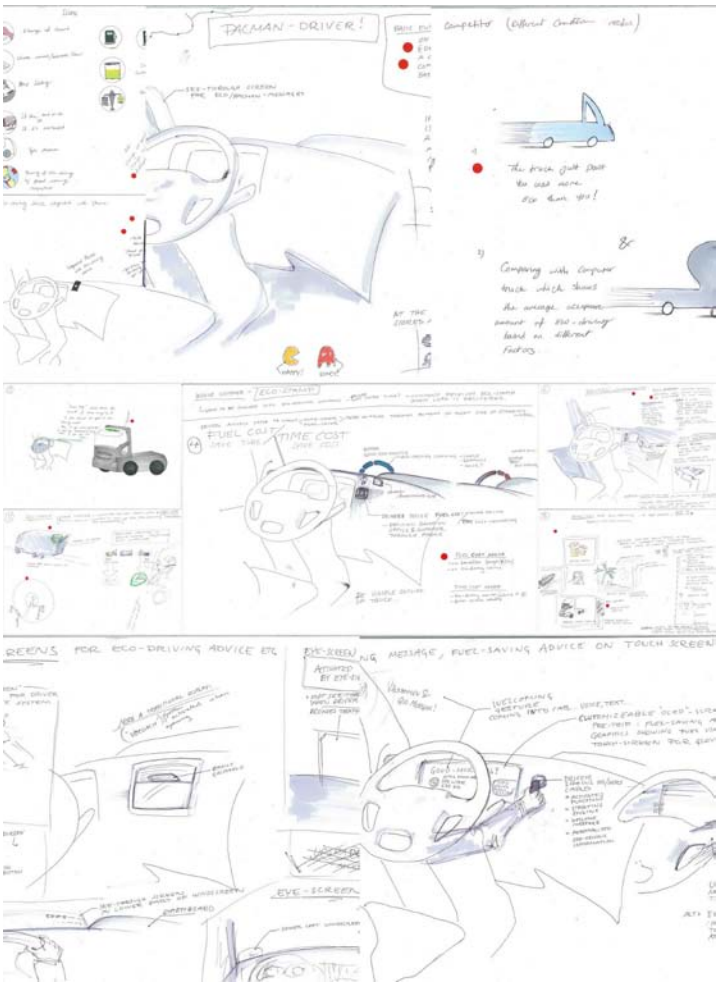


Figure 12: Resulting sketches from first evaluation round

showing info more in detail, what was done wrong after driving. Maybe just one factor is displayed, the one that is the most affective for eco-driving at the moment as many values could result in too much input.

9.3.2 Result from evaluation round 2 – Focus group 2

In Figure 12, some of the sketches are seen that were shown to the participants of the second evaluation round. The following comments and opinions resulted from the second round:

Eco-cruise control

First of all, it was discussed that in the future a totally automatic driving system with optimized eco-driving minding the topography of the road ahead will be developed by truck manufacturers: a so called Eco-cruise control. Then you have an automatic eco-driver built into the truck, the driver just has to decide when to activate and disable it. This is something that the developed eco-driving advisory system has to take into account.

It is better that the system is automatic than the driver having to decide. But other opinions came forward that it still is good if the driver could activate functions him/herself. For example choose to sometimes have an active drive and sometimes a more passive eco-drive coaching.

One of the issues for the concept is the placement of it especially when it comes to showing outside what the driver is doing. One idea in mind was an eco-label on the outside of the truck that is interesting. This marking explains to the surroundings, maybe a sticker-kit could be provided if not lamps? The Globetrotter sign in the top-front of the cab could be one other place to place info about your company and your eco-driving result to show off to the surroundings. However, this labeling is ambiguous:

-*"We should never work with green washing at Volvo."* Volvo wants to be clear with how it really is, not label something eco-friendly if it really isn't.

One more idea relating to the placement of the display was a so called Head-Up-Displays in the wind screen that did not sound good and agreed that it is for more important information than eco-driving advice. Eco-driving is more "slow" and evolving over time and that kind of information should be shown at the side. But a see-through display is interesting.

In this meeting, the idea about having different driving modes depending on the driving area was under the discussion. To choose a certain driving mode when going into town and different environmental zones could be one way of improving eco-driving, this could be combined with clean techniques like hybrid engines.

Part if the eco-driving is about saving money and consumption. It was discussed that displaying money saving for example like coins building up or declining is interesting, it could show after trip statistically how much money the driver saved. But it is easier technically to produce information that shows your percental waste of fuel.

Finally, it was mentioned that it is a good idea that the driver could bring eco-driving information along in a Smartphone. It takes a long time to change the cluster in the cab: a phone already has a user interface in it. An integrated solution for eco-driving advice is better, but the phone solution/external solution is cheaper! The phone solution was one of the major positive ideas brought along from this second round of evaluation.

After the second evaluation round the functions discussed was summarized in a table, see Figure 13:

Graphics	Incentives
Virtual Competitor	Drivers rewarding each other
Clear Numbers	Different levels (incentive graphics)
Describing Balance	Level up
Choose Fuel cost/Time cost	Pimping outside
Advices-icons	
Global view	
Pacman	

Placements	Info-presenting
Whole windscreen	Foldable display
Outside body	See-through display
Inside-on right side	Touch screen
Inside-lower windscreen	Haptic pedal
Inside-side of windscreen	Hot steering-wheel
Inside-center of attention	Different buttons
On the whole dashboard	Sound&Voice
On center of steering wheel	Eye-screen

Technical functions
Computer sums parameters into a comparable score
Comparing fuel usage to average score
Integrating (with phone etc)
Fuel cost/Time cost
Competetive level (driver decides)
Drivers can comment-social community
Show numbers (money saved, fuel usage)
Stress-level
Eco-driving packages on road
Forcing level - high in beginning, returning in intervals
Involve customer

Figure 13: Summarized functions from evaluation round 1 & 2. Positive ideas are green, negative red and the ideas that need re-design are yellow.

9.3.3 Result from evaluation round 3

After the second round, a number of functions that all had at least one positive comment from the focus groups were merged into complete concepts (described in the concept development chapter, page 53).

These concepts were evaluated by the researchers in evaluation round 3, using the PUGH-matrix. The result of the Pugh-matrix can be seen in Figure 14: PUGH-matrix evaluating composed concepts from the concept development.

Pugh matrix

1 (Ref) - Scania Driver Support
2 - Driver community - Phone - Icons
3 - Driver community - Incentives - Green ray - Eco label
4 - Fuel save/ Time save - Incentives - Icons
5 - Basic function on the same route - Virtual competitor - competition - Driver community
6 - Driver community - Fuel save/Time save - Incentives - Phone - Green ray - Eco customer label
7 - Fuel save /time save - Green ray - Eco customer label
8 - Virtual competitor - Competition colleague - Basic function on the same route

Criteria The system should...	Solutions 1 (Ref)	2	3	4	5	6	7	8
...present real-time eco-driving information to the driver.		0	0	0	+	0	-	+
...be education-based.		0	0	0	0	0	0	0
...feel quick and responsive.		-	0	0	0	0	0	+
...appeal to the economic and truck-caring side of the driver.		+	+	+	0	+	+	0
...be able to disable.		+	0	+	0	+	+	0
...user-friendly design.		+	0	0	0	+	0	+
...take different external (traffic&load) criteria into account.		+	+	+	+	+	0	+
...function for different driving criteria (brake use etc.)		0	-	+	-	0	-	-
...communicate with back-office and customers.		0	+	0	0	+	+	0
...have function for route selection.		+	0	+	0	0	0	0
...provide eco-driving information when driving the same route.		0	0	0	+	0	0	+
...work with electronic infrastructure system in roads, buildings.		0	+	0	+	+	+	+
...be integrated with phone usage.		+	0	0	0	+	0	0
...include a social network.		+	+	0	+	+	0	0
...indicate with different colors &/or multimodalities.		0	+	0	0	0	0	0
...be as simple as possible during driving.		+	+	0	+	0	+	+
...show fuel consumption &/ or money save.		+	+	+	0	+	+	0
...give pre-trip advice.		0	+	+	0	+	0	0
...provide deeper drive statistics and feedback post-trip.		0	0	0	-	0	-	-
...provide positive feedback or reward system.		0	0	+	-	+	-	0
...allow for each driver to be annonymous.		+	0	0	0	0	0	0
...system should mind ergonomics factors.		0	0	0	0	0	0	0
Number of +'s:		10	9	8	6	11	6	7
Number of 0's:		11	12	14	13	11	12	13
Number of -'s:		1	1	0	3	0	4	2
Netto value:		+9	+8	+8	+3	+11	+2	+5
Final ranking:		2	3	3	5	1	6	4

Figure 14: PUGH-matrix evaluating composed concepts from the concept development.

The winning concept was number 6, but since it contained a very large number of functions and it could be said that this fact affected the outcome, it was decided that also concept number 2 that was ranked as number 2 from the PUGH-matrix should be developed further.

These two concepts were re-sketched on one single paper each; see Figure 15 and Figure 16, and brought on to the fourth round of evaluation, the first driver evaluation.

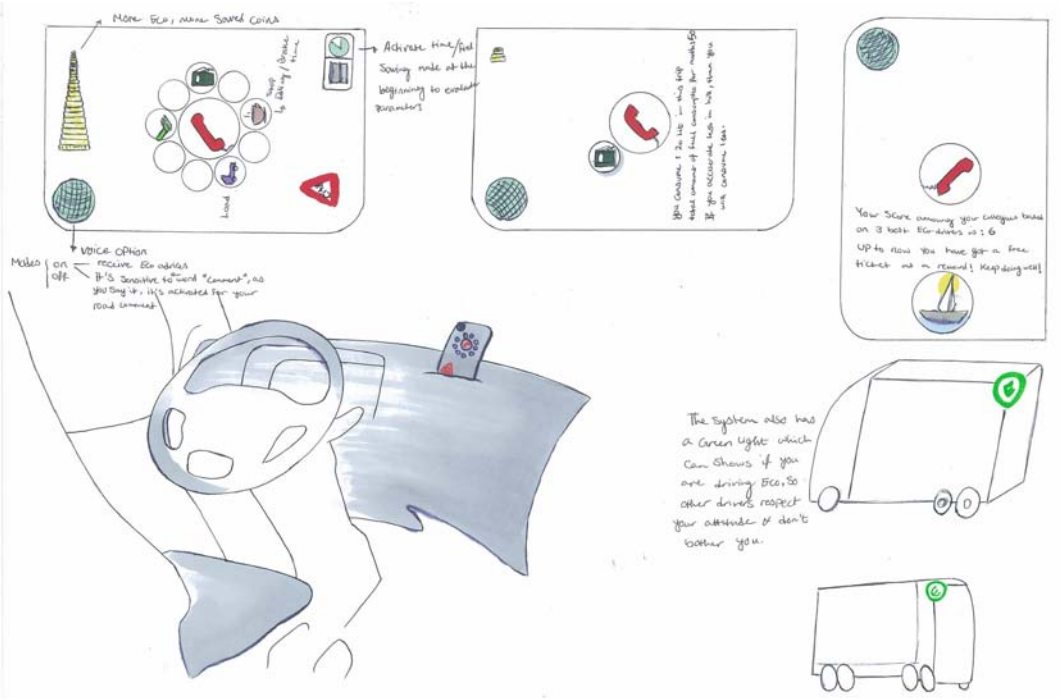


Figure 15: Resulting sketch from complete concept number 6: Driver community, fuel save/time save, incentives, Phone, Green ray and Eco customer label ideas merged into one sketch.

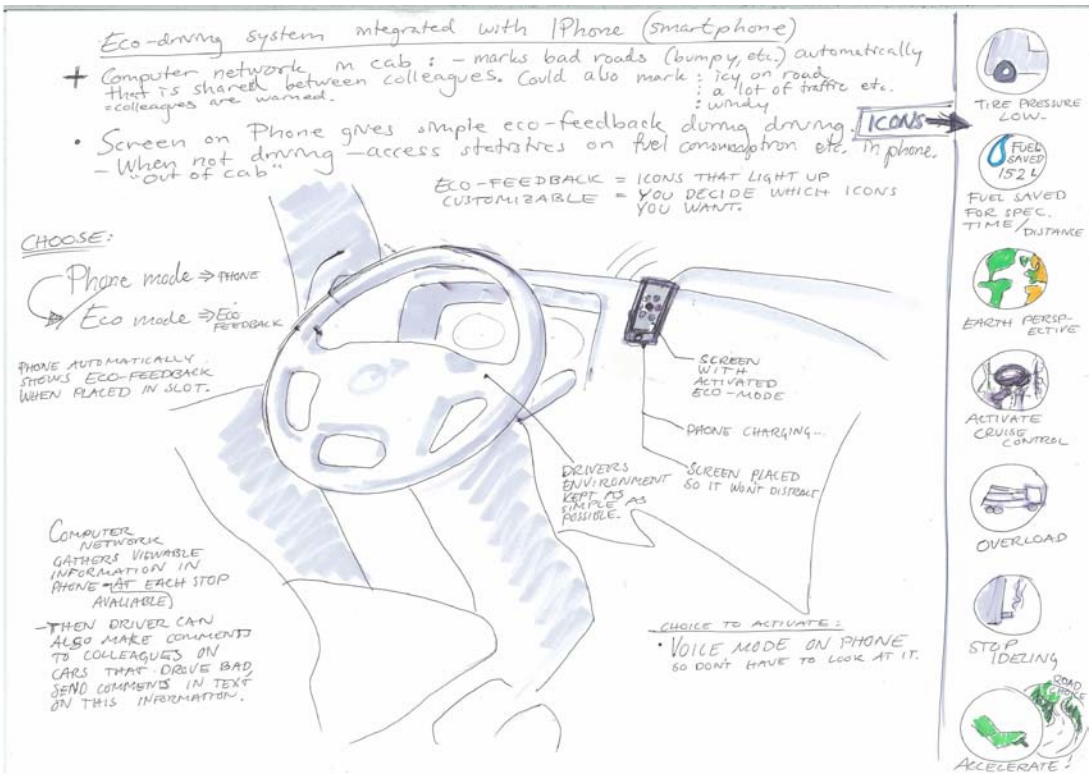


Figure 16: Resulting sketch from complete concept number 2: Driver community, Phone and Icons

9.3.4 Result from evaluation round 4

The driver in this evaluation round stated that pushing a button as in the icons in Figure 15 was good to easy get fuel consumption info. The driver also said that:

- To compete could be dangerous and put the driver under stress and effect the driving - but the Virtual Competitor is a good idea and other examples of it exists today
- Touch screen is good
- Graphical symbols are good overall
- It should not be too complicated; simple in the cab and only statistics for back-office. Statistics should be sent automatically to back-office

As the two sketches were very focused on the phone integration, the driver had many comments about this:

- Phone is always with you but then you never get off work!
- You do not have mobile coverage in many areas up here in the woods in *Bohuslän* and *Dalsland*
- Phone will be lost and it is an expensive solution
- Volvo should not go into the phone market
- We sometimes talk on the phone and simultaneously check different driving data – then it's no good with driving data in the phone

As a final comment the driver said that:

- The system should not be too complicated; simple in the cab and only statistics for back-office. Statistics should be sent automatically to back-office
- System should be clear - so you can read it at night, with animals in the woods, and at high speed easily and without danger
- No incentives – drivers should drive well anyway – I pay them to drive economically!

Based on these comments the sketches were re-designed. Earlier ideas were revised again and ideas less focused on the phone integration were considered. The resulting sketches from the fourth evaluation round can be seen in Figure 17 to Figure 19. In Figure 17 a larger screen is added to complement the smaller phone screen. In Figure 18 a concept with no traditional display is presented with a projected graphics on the steering wheel, developed from the "green ray" idea.
Figure 19 shows a continuation of the winning concept number 6 from the PUGH-matrix, with a larger display on the instrument panel and outer eco-label.

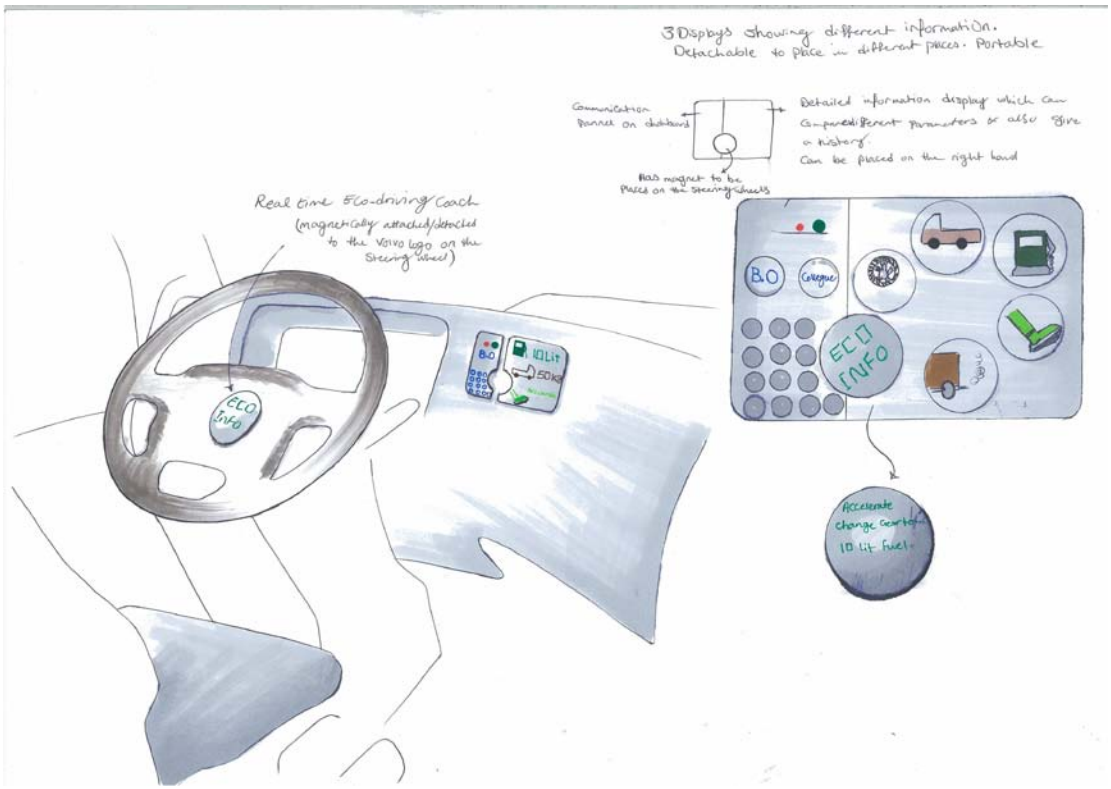


Figure 17: New idea based on the opinions from fourth evaluation round having a larger screen together with a Smartphone and one placement of advice on the steering wheel.

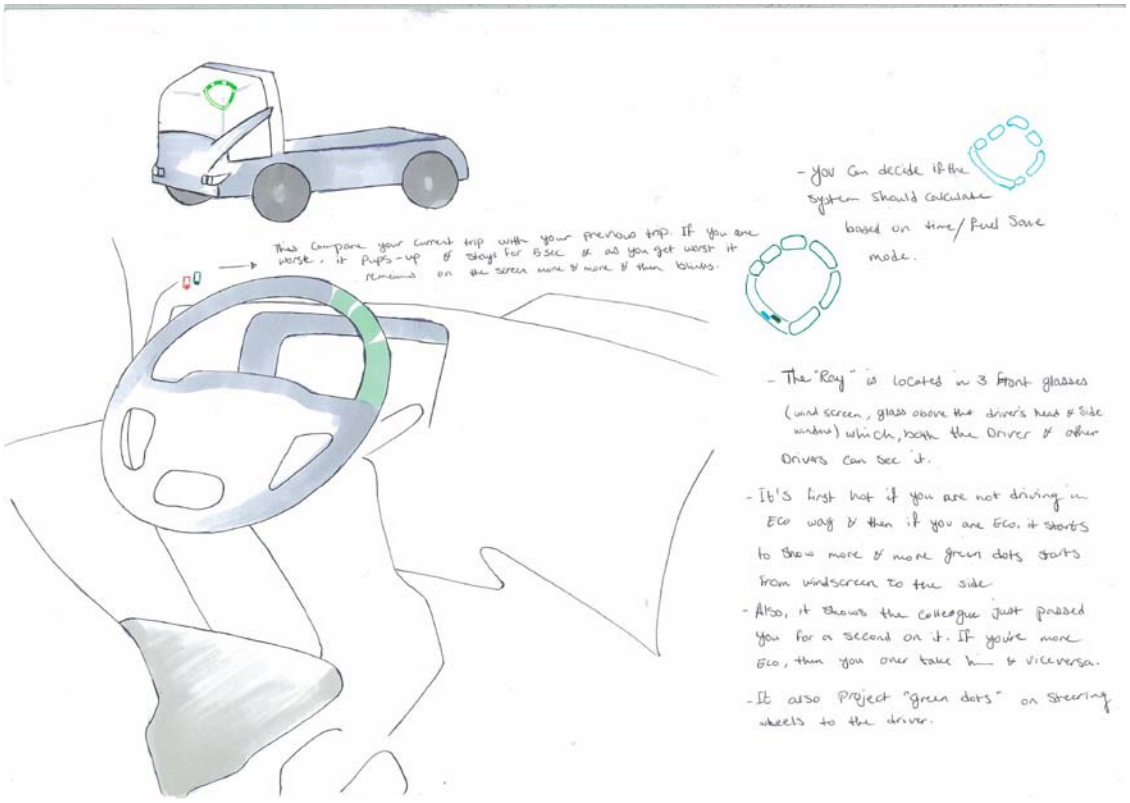


Figure 18: Developed idea from earlier ideas – the green ray - now showing eco-driving advice on steering wheel with both colors and warmth to indicate progress.

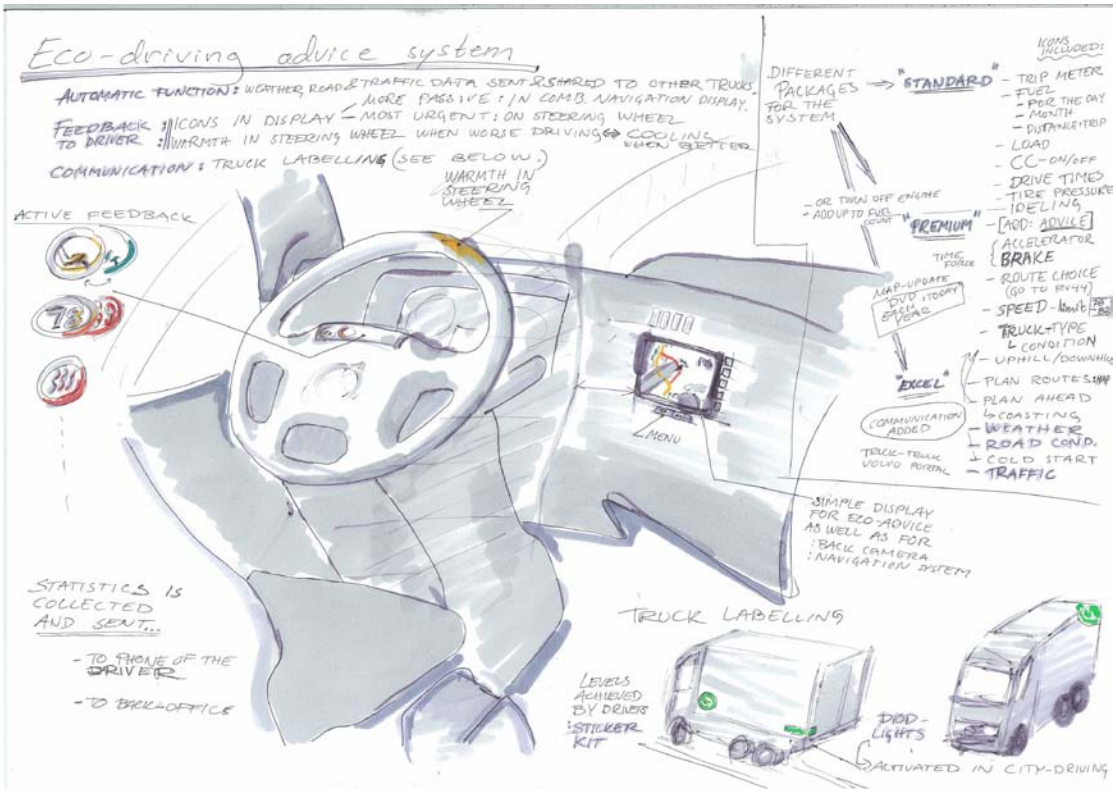


Figure 19: Developed concept number 6 from the PUGH-matrix.

9.3.5 Result from evaluation round 5

Some comments from revisited drivers 2 & 3:

- Showing money on the windscreen is good for the back office, company owners and owners of their own truck not us employed drivers.
- It is good to compete with yourself but for example in the end of the year you can see who was the best eco-driver
- It is both good and bad to compete. Good to compete with yourself – this is best. But also good to compete with others. But it's hard to handle if you are never good enough.
- Not too complicated.
- It is good to have the virtual competitor on the gauge screen/ We should have it in the centre on the wind screen not down on the gauge display
- It is good to have a small GPS on the screen, we don't know some roads
- Combine information with the phone is good.
- Good to have information on the steering wheels like icons but depends on how much information it present
- The voice idea is good but be able to turn off; conflicts when you are listening to music

- Outside display can be good - depends on how sensitive it is; it should not display not being eco when you cannot do anything about it. For example: the green light should not turn off in the middle of an uphill so the cars around you see this.

Some comments from revisited back-office employees:

- It is good to send messages since we have a lot to do and cannot call them directly as we get an order. We have customers to focus on and do not have time to call drivers and talk to them.
- Write on a display and just send electronically to drivers like giving them notes.
- Marking on the outside of the truck is commercial – good to show that you have an eco-driving system installed in the truck.

Some comments from re-visited expert:

- It might be forbidden in the future to have displays with a lot of information in the cab, even GPS might be forbidden.
- Good with the idea to have the phone integrated with the system and information showing on the steering wheel.

After meeting two other drivers and back-office employees as well as one expert, the best liked ideas were summed up to get an overview after the evaluation rounds.

A list was made to show the top ideas to integrate in the final concept, see Appendix 8 – Top concept parameters. The communication function between the back office and the driver got the top score. After it, integrated system with the phone, customizable icons or apps, virtual competitor, compete with your colleagues, load, truck labeling on the outside, one display for many systems, system on the steering wheels, were the parameters which got the highest score.

9.4 Evaluation of concepts - Summary

From the first meeting at Volvo about the project and its aims, it was mentioned that the gap between the driver and back-office is an important issue that should be solved in some way. The communication between the back-office and the drivers, and in addition sending information to the back-office was the function that the back-office personnel were really interested in and needed to have. But, this function was not pleasant to all drivers especially if

the system supposed to send any information automatically, on the other hand at least one driver stated this was a good idea.

For the final concept certainly a way for communication should be exist that does not irritate the drivers but keep the contact with the back-office and send information.

To find a solution for problems that fit different groups of people involved in the project is a challenge, Volvo employees, drivers and back-office personnel had all their own background and benefit of the ideas. These differences sometimes led to a new idea, but sometimes made the elimination of the concept difficult.

One idea that was discussed by Volvo personnel but was not in the drivers' interest was to give the drivers various incentives when they are doing well. The drivers thought it was not a professional solution. Related to the subject of being professional, icons and functions that did not have this aspect were rejected, mostly by the drivers.

There was also range of different opinions around the idea of showing the driver's behavior to the outside world and other drivers. The main problem with this idea was that the drivers believed that in some situations it is really hard to drive eco-friendly and they did not want to be judged by the outside environment. On the other hand, people at Volvo, some office people, and some other drivers were fond of this idea. Therefore, it was finally decided to have the function with respect to the driver's freedom.

Probably one of the positive points about the job is its freedom but on the other hand it should be limited. The limitation should be as much as the safety issues are not in danger. Therefore, for some aspects of the design that did not threatened the safety, the deactivation function was considered.

The final concept supposed to be integrated with other related devices. One of these devices was the phone that is the main way of the drivers' communication. Although there was a discussion about the safety and economical issues behind, it was decided to integrate the phone in some way in the final concept. First of all, it would not be an expensive solution compared to if it is integrated in a larger and more expensive system. Then, it is not so much distracting and the function on the concept would take only important communications into account.

10 Final concept

Here, the final solution for the eco-driving advisory system will be presented.

10.1 Final concept creation

As the sketches were evaluated and developed following the evaluation rounds the result of the evaluation ultimately was a list of top desired factors. The next step was to design and sketch the final eco-driving advisory concept based on these factors. Different modes of each part of the interface were created in detail to give a clear image of the final concept.

The systems' various technical, electrical and distanced communicational processes will not be taken into account in this thesis. The purpose of this study is to focus on the system's placement(s) in the cab, sensory modalities and eco-driving parameters it will utilize.

Three different placements were chosen for the concept that communicates with the driver instantly, in detail and with other drivers. The evaluation result shows that top ideas on different placements are: placement on steering wheel, one display for many systems as well as the phone integration/bring system out of cab. All of these ideas, some more clearly than others, have come to use in the final concept.

To use different icons, a touch screen and having a voice option in the system were three other ideas out of the best liked functions coming from the evaluation. These ideas were put into the final concept as well, sketching how it would look in the cab and this based on the researchers experience from earlier parts of this study.

Automatically communication with back-office and phone integration, load and fuel usage were three ideas for functions in the system that got high scores as well. These ideas were also considered to have a place in the final concept and were sketched into place in the truck cab during the final concept creation.

In the last phase of the final concept development the heuristic assessment was made to see if any usability and/or cognitive ergonomic factors needed to be revised. An assessment was also done comparing the final concept to the list of demands. During both assessments, the stated demands and questions were considered while having the final concept in mind, a marking and/or comment was added to the specific statement.

10.2 Final concept result

The driving task is an activity that needs a high level of attention and focus in order to prevent accidents and provide safe driving. The driving task takes a quite large share of the capacity of the brain which makes it not as easy to do other tasks simultaneously.

The concept that this thesis was aimed to develop is an eco-driving advisory system that should both inform as well as coach the driver in some form. Since giving information is a requisite for advising, the contradiction between informing and advising has been solved during this development. The solution has been to divide information based on importance, level of advising, and safety issues into different parts and places in the cab interior.

The user study showed that the driver needs instant feedback while driving to improve his or hers eco-manner at a particular time. In addition, the driver needs to get more information about the reason for feedbacks received for each time. Finally, the driving task has an interaction part with others that results in the final concept having a part which shows the driving state to the outside.

Based on designing a complex human-technology system, the designers have made the different parts of the interface as acceptable and familiar to the user as possible. To ensure the acceptance of the concept, interviews, observations and revisits showing the ideas to real users have been made.

Below, the final concept properties will be presented in detail based on different areas: technical features, eco-driving factors and finally the three different placements and functions of the advisory system at these placements.

10.2.1 General technical features – parameters that will not show to the driver

There are some technical functions that the system generally should perform; these functions are briefly mentioned below.

The most important function of the concept is to calculate the fuel consumption based on different parameters and make it comparable to the driver. Therefore, the system needs to collect and calculate different related eco-parameters to present a comparative score to the driver. The factors that should be considered are listed later in the "Final concept factors" chapter. Parameters could be gathered by the system for example through the internet and then based on any change in the situation the data would be considered in score calculation: For instance if it is raining heavily in the area of the truck, the calculation of the "eco-score" deducts a share of the extra fuel consumption down to a certain level - as the conditions are affecting the drivers performance. Another example of this basic function for the system is when the system collects parameters from load sensors on axles etc. To make it possible for a fully loaded truck to compete on an eco-driving basis with an empty one, the fully loaded will get a deduction in fuel consumption based on the amount of load the comparing truck is

carrying. The system should be able to compare the collected data with the average fuel consumption data for the company, the driver or different colleagues.

Communication with back-office is one of the important parameters of the system, which requires a communication system and a positioning system to send and receive messages. The positioning system will also be used to remember specific road sections the truck has travelled to compile scores for these roads.

Moreover, the system needs to have a memory to remember previous events. For instance, the system should keep a history of all roads the driver passed or other drivers passed and saved in it, so it could predict which road is the best for every trip. The system should also remember and record all actions performed by the driver to save in the statistics screen.

Furthermore, the final concept requires a system that can transfer/translate texts and notifications into a voice reader. This functionality would be activated in order to help the visual sense of the driver, based on what has been mentioned about designing for these senses in the theory chapter. The reason for why added sensory modalities could be a good idea is that the driving task is mostly based on the visual sense which can soon be overloaded. When adding a voice reader the driver would be able to listen to information which is faster and less distracting than added visual information.

10.2.2 Final Concept Factors

During the literature studies, interviews and meetings ranges of factors were investigated that affect eco-driving, they will be presented here. The different concept placements have a variety of these functions in each part of it, which are explained later as well.

The system should consider different factors related to eco-driving in order to calculate the score, average, and level of competency. The following factor is processed automatically and not explicitly shown to driver; the following factors after that one are shown to the driver in ways explained in the final concept placement chapter.

- A *Total resistance score* for each vehicle is calculated based on: wheel pressure, wheel axle settings and wind resistance (air deflector settings, distance between trailer and cab etc.) As you know the weight of the truck, you have a nominal value for the resistance – everything that is not normal deducts from the eco-score. This is done automatically and not shown to driver.

- Especially here in Sweden weather changes a lot. Since different weather conditions affect driving, this function is considered. A weather system installed in each truck would be more accurate; however the final concept will only receive internet based weather information based on the geographical area that the truck is positioned within.
- The fuel used for different time and distance periods will be measured.
- A time limit of one minute for idling.
- The weight of the truck, this implies that the load will need to be registered through sensors on the different axles of the truck and sent to the system.
- Tire pressure affects fuel consumption, a sensor in each tire records the pressure and sends to the system and warns if the pressure is too low when the driver enters the truck.
- Speed affects eco-driving to a great extent. Above 81 km/h the system will acknowledge this and send a signal to the real-time advisory system to alert the driver.
- Accelerator and brake use is recorded and sent to the system.
- Topography ahead will be known in the system memory, so that the system knows when to advice the driver to decelerate and accelerate or roll out respectively.
- Route choice is decided by the driver, different alternatives are presented by this system on a map displaying the most eco-friendly route based on length, topography, weather and road condition.
- The traffic situations which vary in different trip parts e.g. inside a city or in highways, thus changes the parameters for being eco-driver. Within city borders the driver will only be encouraged to accelerate at a 70% rate of when out on the highway. The truck will be in contact with a local network that makes times for red-light etc. visible in the system.
- One truck communicates with others working in the same area. Bad road conditions on the highway or traffic queues will be recorded by the system and sent to other connected trucks.
- The system is connected to the eco-cruise control which will be developed in the future and handle gear shifting and accelerator use in the most optimum way based on the topography. The time used with this cruise control activated is positive for the eco-driving advisory system.

These information shows on the interface lead user to take specific actions. This was indicated in the interaction between user and system in the theory chapter that to receive this necessary information the user functions the interface and the interface in interaction with the technical part of the system send requested information. As will later explain, the driver will receive

some of these data by actual using like touching an icon and some of them automatically by technical processes of the system.

10.2.3 Different types of signals in the final concept

The final concept like other interfaces communicates with the driver by means of sending and receiving variety of signals.

The main interaction between the truck driver and the interfaces is through various icons in two interior displays. Although the designers tried to design as clear and familiar icons as possible, it might still be assumed as a passive signal to some users for the first time using or for a while. Based on the aim of the interface, which is to guide and advice the user in eco-driving, most of the icons could be presume intended signals. The voice message is an active signal that reads messages automatically to the driver, if is activated. The exterior display is a continuous signal based on its form, "E" letter that stands for eco-driving and is always placed on the outside of the truck. This sign and virtual partner also gradually change based on the driver's way of driving.

The drivers were not interested in signals that keep reminding them the right action. Therefore, intermittent signals were not used in the design.

10.3 Final concept placements

The final concept is divided in three parts that are listed based on their placements below:

Real-time on steering wheel

Detailed information on dashboard

Display eco mode on the outside of truck

Below, the three different parts are explained in detail with their images to give a better overview of their functionality, form, and placement.

10.3.1 Steering wheel placement

The most important question for the real-time feedback part of the final concept was the placement in the driver area. In the final solution the real-time feedback is placed on the central area of the steering wheel. This is a new and inventive placement, an area in the truck cab that is not utilized to its full potential. However, the area has important technical systems placed within it; for example the airbag system. This raises safety issues and difficulties to

place any displays in its traditional form in this area. In the final real-time feedback concept the traditional plastic display is therefore replaced by a fabric-material to present visual information to the driver. The fabric is soft but still wear and dirt-resistant. It contains electric conductive pathways that make it possible to display customized figures and graphics on an even surface, for further information see p. 48. The fabric has a dark grey color to blend into the interior of the truck cab and have a simple expression, see Picture 16. When graphics are lit, they will be white in color for a simple, clean look.

Picture 16: Fabric surface on steering wheel center

The real-time feedback is placed on the steering wheel where the driver can see it easily while driving. The placement will not distract the drivers' attention from the road to a great extent since based on the attention in theory chapter the information is not in detail and the driver could quickly switch his or hers attention from the feedback to the road and traffic. Placements that were rejected during the concept development were in the windscreen and in the gauge meter area. These placements are closer for the eye to move to from the road situation, however, the placement in the wind screen was stated as reserved for more important information than eco-driving advice, while the gauge meter area is too cluttered as it is today and should be reserved for traditional gauges like speedometer.

The icons on the real-time feedback are designed so that the driver might take a different action at each moment when looking at them. This driving behavior change would improve the driver's eco-driving. The more detailed feedback is a sort of self-training for the driver that would help him or her to take the right action in similar situations in the future. Moreover, this feedback might reduce the need for real-time advice next time; advice that could be irritating for some drivers. For the safety issues and based on SA theory, it was not a good decision to have the detailed information display in the same location as the real-time

feedback. Reading advice which is shown in the form of text messages sometimes takes more time than the safe time to look somewhere else than the road. Also, the user might need to focus on two tasks at the same time which takes more capacity of the brain. Moreover, the level of information that the driver could perceive in a glance is limited and if exceeded, the perception would not be accurate enough.

The feedback is given to the driver mainly in visual form but with an added function for auditive messages from the detailed information panel, described further below. Different advice and its consecutive icons are active when driving compared to when the truck stands still.

Icons on the steering wheel are designed in the simplest possible way both in form and color since they are in the center of the driver's attention and should not distract him or hers. Also, it was mentioned in the design of displays and controls theory part that color, form and symbols are key factors for providing a good communication between the user and interface. The acceleration/deceleration icons formed in two arrows showing up and down. It could be easily perceived that in relation to driving task what they are indicating. For the virtual partners, icons might be assumed as passive signals for the first time of use as the driver might not be able to realize which symbol stands for which competitor. On the other hand, after getting familiar with them, it would be easy to see them and understand the current status of the eco-driving. They are also formed with simple graphical symbols; the form of a truck is used for the driver and also the colleague average consumption. This form is a straightforward form since it is similar to the actual shape of a truck. The back-office or company is reminiscent a building that is used for the company's average icon here. A simple shape of human body is used for showing your (the driver) current situation.

It is always a bit tricky to show abstract messages that are understandable for everyone. The same problem existed in finding icons for the idling and overloading factors that could clearly stands for their meanings. It was thought that the main effect of the idling is CO_2 emission that shapes smoke. Thus, a cloud form was decided to pups up to advice the driver to stop idling. Different ideas for the overloading also were sketched to find out in which way it could convey the message better and faster. Finally, a weight lifting form was chosen that has the load and weight in its function and also is a strong and masculine object that matches the truck properties.

Finally, a "cc" icon will be shown to the driver that clearly stands for the cruise control word.

The central functions displayed visually when driving are the *Virtual Partner* and the *Current fuel usage* figure. These are dynamic functions of the real-time display that update continuously.

The *Virtual Partner* is a way of encouraging the driver to improve eco-driving abilities. This is done by graphically displaying the driver's current fuel consumption compared to a choice of three different settings: your own average fuel consumption for a decided time period/distance, your company's current average fuel consumption or a specific colleague's current fuel consumption. Your own current fuel consumption is represented by a truck with a diamond beneath it. If comparing to your own average fuel consumption, the truck with the diamond is moving along the displayed line comparing with a person figure, see Picture 17. If comparing to your company's current average fuel consumption you are compared with a house, see Picture 18 and if comparing to a specific colleague's current fuel consumption you are compared with a simple truck symbol, see Picture 19. If you are better i.e. having lower fuel consumption than the comparison, the truck with the diamond will be positioned ahead/to the right of the comparative symbol and vice versa. The continuous update of the factors in the Virtual Partner should update sufficiently often to show a smooth animation on the display.

This simple comparison of the driver with others does not ask the driver extra attention and calculation. Therefore, the process does not occupy much place of the working memory, which is based on one of the SA principles for designing.

Picture 17: Virtual partner comparing with you

Picture 18: Virtual partner comparing with company average

Picture 19: Virtual partner comparing with colleague

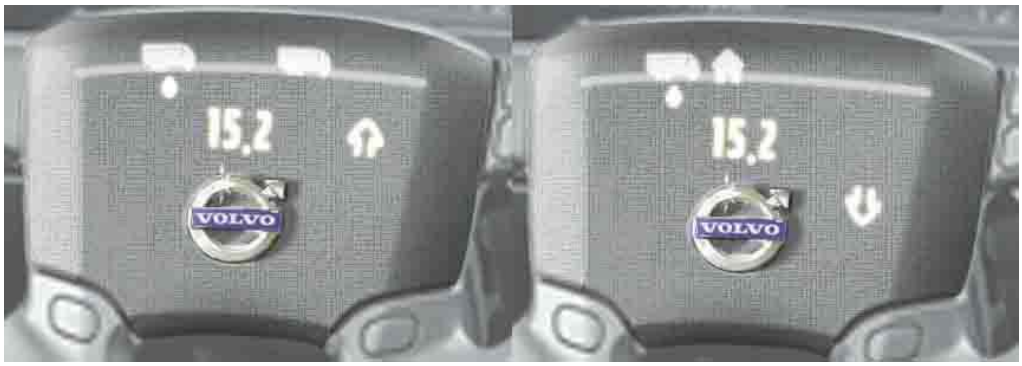
The Current fuel usage figures update continuously in a similar way as the Virtual Partner, but here the figures visibly change form. The fuel usage figures is a simple, straight-forward way of displaying to a driver his/hers current eco-driving "score", see Picture 20: Current fuel usage.

Picture 20: Current fuel usage

The other symbols in the real-time display are the icons for Cruise control activation (Picture 21), Voice message from the detailed instrumental panel (Picture 22), Deceleration and Acceleration (Picture 23). These are icons designed to notify the driver when driving that the Eco Cruise Control is activated or not, there is a communication message pending from back-office or not, or if the driver should decelerate or accelerate respectively.

Picture 21: Eco Cruise Control is activated together with Virtual partner comparing with colleague and current fuel usage display.

Picture 22: Voice message pending



Picture 23: Accelerating and decelerating icons are lit to advice driver to take the necessary actions

When the icon for voice message from back-office is lit, the driver can expect a voice message to be read within a limited time period. This message is expected to contain highly important route information from back-office; for example that a certain customer will not receive any more deliveries today. The time issue here is of great importance, as eco-driving is highly dependent on route choice and the avoidance of unnecessary detours. However, the driver is able to accept or decline after this message is read. This is done with a touch-screen button at the main display.

When the truck stands still, the icons activated when driving are disappearing and two other icons are appearing on the steering wheel surface. These are the idling and overload icons and are meant to notice the driver to turn off engine and mind the amount of load, see Picture 24. When the truck has been standing still with its engine on for more than one minute, the idling icon will appear and thus advice the driver to turn the engine off or start driving. The overload icon will appear if the system calculates the average main gross weight of the truck to be too large. Thus, the driver is urged to make the necessary undertakings to solve this issue. More information on the overload as for example loads per axle and the like is to be found in the larger display under the technical menu.

Picture 24: Real-time advice displaying from left to right: idling icon and overload icon

10.3.2 Dashboard placement

Beside the feedback that the driver get from the real-time display on the steering wheel, the driver would need to know why the action was awarded or alarmed. In order to give the driver more detailed information a larger display on the right hand of the steering wheel is designed. This display supposed to be able to be integrated with other systems such as GPS. This system uses the wireless and radar system to communicate with other related organizations to receive and display information. It is a touch screen display to cope with similar technology exists today on systems.

The larger screen has the portable function that can be detached from its place on the cab and carried after work or during a break. Designing this detailed information display that mainly is used after trip was a bit tricky based on drivers' opinions that some did not want it. On the other hand, it was thought that for improving the eco-driving manner just presenting advices without knowledge behind them would not be helpful and understandable. This function lets the driver view his history in different driving tasks, view back-office's notes, choose the rout before moving, or any other activity that the driver would like to do while the driver is not driving.

The system could be placed on the right hand by slots on either sides of it that fits the place on the cab. This makes it possible to be removed from the cab and placed anywhere else, where is slightly bent. In this case, all icons would change in direction like other similar products if the direction of the display changes.

The display has a shiny black surface, which enables the driver to read the information easily inside the cab with the daytime light. Like other new technology devices it has a touch screen display that lets the driver to surf information on it easier and faster. The material does not get dirty easily and if it happens, it could be cleaned simply. The outer part of the device could be made of a grey soft plastic such as polymers group that is in harmony with the cab interior color and material.

Considering the global SA, this display categorizes information in three different pages; "eco-information", "communication information", and "technical information". These modes' icons together with the voice activator are available on the left hand of the screen. In this way, information presented is clearer and more organized based on different categories that they are belong to. Reading messages by the voice function, which could be assumed as speech warning, together with icons shown visually takes lesser capacity of the driver's memory and makes the decision making process faster. By touching each of these modes, icons related to it will appear and the other mode's icons disappear. In each mode, by clicking on each icon detailed information related to it will be presented and other icons faded behind the active icon that could exchanged whenever is needed by touching the mode's icon to back to the main page.

The GPS function and also communication with the back-office are two icons that are active while driving. There was a discussion in one of the meetings that truck drivers might not be allowed to talk on the phone. Therefore, if it is restricted in the future this function also could be deactivated during driving by the company producing the system.

The eco-mode contains six icons that each of them presents more information to the driver by clicking and enlarging it while the truck is standing still. Fuel information, traffic information, weather information, best choice of the road, brake use information, and a map functioning like a GPS system are the icons on this mode. Icons designed in a simple way that is user friendly and easy to communicate.

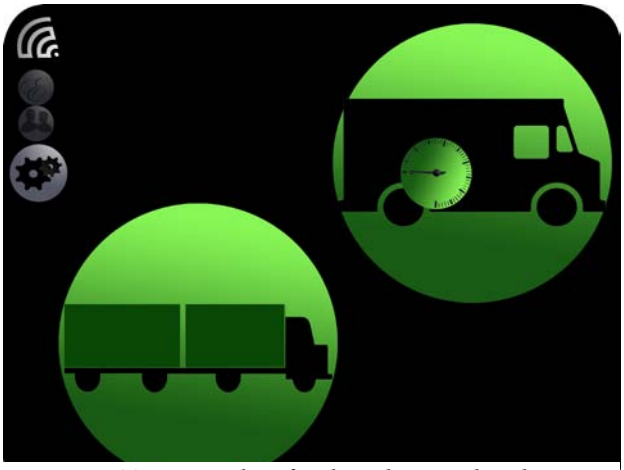
Picture 25: Six eco-mode icons, viewed from top left: fuel information, brake use, road choice, forecast, traffic information and GPS.

On the communication mode, three icons could be found. In this page, the driver could communicate with the back-office by text messages or phone. Also, this function enables the driver to communicate with other colleagues. By touching back-office notes icon, messages sent by back-office will appear to the driver. Whenever the driver is not driving, the text message is active and the driver could also write messages in answer to the back-office. The other icon that is for communication with colleagues functions like a normal walky-talky while driving and works as a simple phone when the truck is stopped. The walky-talky function lets the driver a quick connection especially to the back-office by just touching the icon. This is more in concerning to the safety issues that the driver should not be distracted. On the other hand, communication is an important need in truck driver's work that had been

Picture 26 : Three icons in communication mode- back-office notes, call back-office, call colleague

Each vehicle is designed with different technical and physical aspects that directly affect eco-driving. For instance, obviously the longer the vehicle is the heavier it is and therefore the more fuel it consumes. For the trucks, in addition to their own weight, the loading is important as an additional weight that is not good for the eco-driving if exceeded. Also, the power of the engine affects driving parameters. As the engine gets more powerful usually it is more resistant to the wind and the vehicle moves faster and easier. Thus, all these things together have impacts on the eco-driving that should be considered as precisely as possible.

Therefore, the technical information mode is designed to be presented to the driver when the truck is stopped or before the driver starts the work. Load information, truck condition and brake pad are three examples of options that are intended. When the driver loaded on the truck, if it is overloaded an icon will pups up on the steering wheel feedback. Then, the driver could go to the technical information and find more detailed information about this overloading, for example on which axel the overloading is, on this menu.



Picture 27: Two examples of technical issues that the system takes into the account- tire pressure, loading

On the top corner of the screen there is a button which can activate/deactivate the voice. This voice should be able to be turned off since sometimes tasks need more focus. The voice only read messages once and does not keep repeating. It mentioned in the theory chapter that the sound is transient and should be repeated if it is necessary. But since the eco-driving messages are not urgent messages and the action would be taken immediately after receiving them, there was no need to define the repeating function for the system.

Picture 28: The display's placement on the instrument panel

Eco-mode

- Fuel: which indicates how much fuel the driver consumed during the last trip, how much the driver has saved based on his eco-driving. Also, these parameters could be compared with other colleagues, his or heraverage performance (time/distance based) or company's current average fuel consumption.

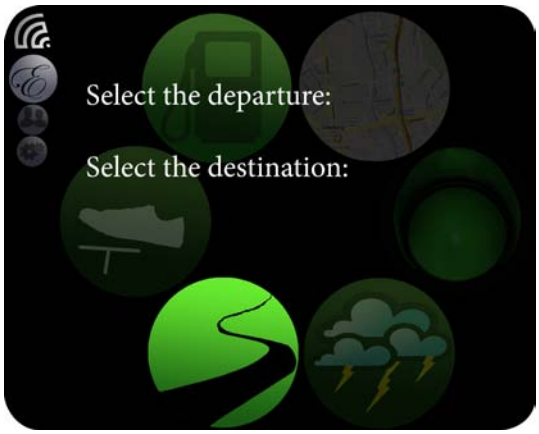
Picture 29: By clicking on the fuel icon, the driver could see different information related to fuel consumption

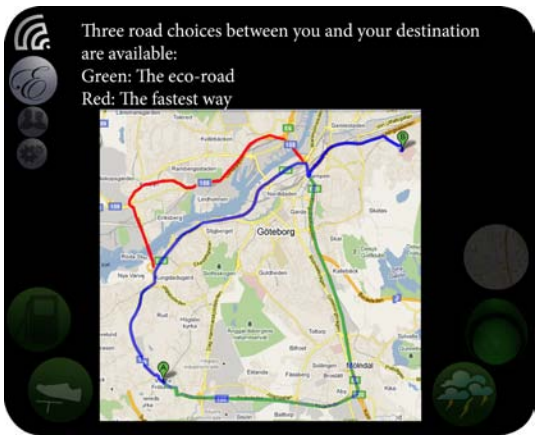
- Forecast: Changing in weather could have a great impact on eco-driving. The simplest weather change might be wind blowing that causes more wind resistant for the vehicle and therefore affects the eco-driving. In this case, the power needs more energy to overcome this extra resistance that will result in more fuel consumption and gas emission. Other changes in weather could similarly affect the eco-driving as well. Rainy or snowy roads are slippery and hard to drive that obviously gets more power from engine and fuel from the fuel tank.
  This icon could tell the driver about the weather before the driver starts his work and also if the driver got a new delivery during the way where is in other areas

Picture 30: Different data related to today's weather is presented to the driver

- Road-choice: the system would consider the weather and different possible roads when the destination is set by the driver, and then recommend the best road to drive based on eco-driving factors
  Together with all other factors, the trip also should always be planned ahead. This icon would help the driver to get an overview of his whole trip. Therefore, the driver could

avoid sudden brake use that waste energy and is not ecological and economical much better.





Picture 31 and Picture 32: Various choices of roads with their advantage or disadvantage are presented

- Map: the map would show the way that the driver could take which could be the fastest way or the most eco-road for instance

Picture 33

- Brake use: after each trip, the driver could review how good or bad the driver was in using brake or accelerating/decelerating and get some feedbacks to improve his or her eco-driving

  Right change of gears, brake use and acceleration all together could lead to the eco-driving. If the driver for example knows that s/he should accelerate from the hill crest to the peak and idle to the downhill, then more fuel could be saved. It will be shown to the driver right away on the steering wheel and reviewing information history here helps the driver to learn more about these factors and their situations for the future.

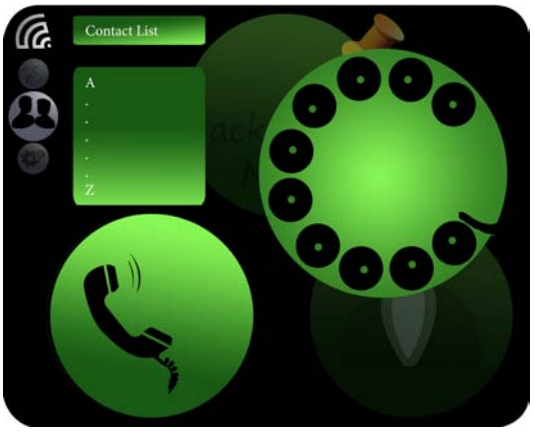
- Traffic information: this icon can indicate the traffic information ahead like accident, queue ahead and traffic light situation when the driver got there which enables him to decide and plan the trip in advance
- Communication mode
- Back-office notes: notes could be sent by back-office to the driver and the driver also could send notes back by pen and hand writing on the screen. For the safety issues, the driver could write notes only whenever the truck is stopped.

Picture 34: Real-time advice displaying from left to right: idling icon and overload icon

- Phone back-office: the driver also can directly call the back-office simply by touching the back-office icon.

Picture 35: Touch the icon to call back-office.

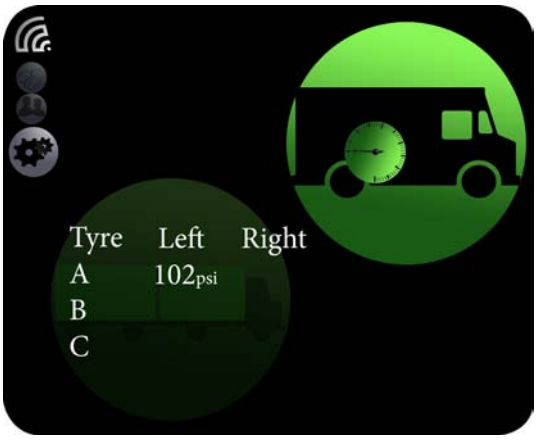
- Phone: whenever the driver is driving, is able to receive calls and talk on the speaker. Also, the driver could make quick calls that are saved on the screen. Other times, the driver is able to use it as a simple phone to call colleagues, back-office, or home.

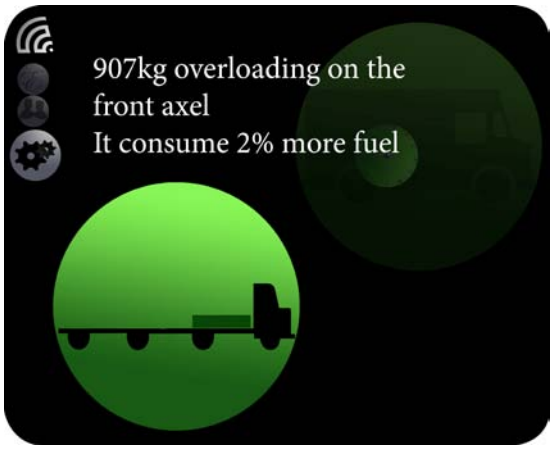


Picture 36: Real-time advice displaying from left to right: idling icon and overload icon

Technical mode

- Load: when the driver loaded on the truck, if it is overloaded the related icon will be lit up. So, if the driver does not know exactly on which axel or how much the truck is overloaded, then could goes to this information menu and review all information in details.





Picture 37 & Picture 38: Tire pressure and load, two examples of the technical mode that could be viewed in details while not

Each of these icons enlarged by touching it and can show the whole information about the icon. Other icons are also available on the top of the opened window to quickly back whenever it is needed. All icons similar to the other placement's icons are designed in a simple and user friendly way considering the fact those icons and their properties such as color and form are the main way of the user interaction with the system aforementioned in the theory chapter. Moreover, their known forms support the top-down process for older drivers to easily use the interface.

10.3.3 Exterior placement

In addition to two other displays, an exterior item was designed. It is important that you can show to other drivers that you are an eco-driver. However, some drivers felt stressed if it is

automatically activated and others could criticize them. Therefore, it is an optional item which can be turned on/off by the driver.

The item consists of two parts made of small LED lamps. They are designed in the "E" letter shape which stands for eco-driving and could be placed on the truck's superstructure or on the cab top-back surface; it lets drivers behind and to the side of the truck recognize the sign. In this way, if the driver is driving slowly, others by seeing the "E" letter would understand the situation and would respect the driver's manner to a greater extent.

The system has two modes with two different colors: eco-mode in green color and city-mode in blue color. When the driver turns on the eco-mode for the exterior, LED lamps gradually become greener if the driver is driving in eco manner. Vice versa, gradually the lighted lamps reduced if the driver is not considering eco factors in his driving. The blue color is designed for driving inside the city. This would not change like in the eco-mode and stay the same just to notify other driver. This function is designed since it was discussed during one of the focus group meetings that sometimes when they are inside the city, they cannot be as eco-driver as they want. This function would let the drivers to observe eco factors in their driving easier and without being worry about other divers' judgment. Also, it was thought that in the future the trucks might be equipped to hybrid system that would let them changing the power and fuel resource to the more eco-friendly one inside the city.

Picture 39: Green LED-lights placed on the cab exterior indicating eco-driving

Picture 40: Blue LED-lights placed on the cab exterior when inside city borders

10.3.4 Final concept overview in cab

In Picture 41 two of the three different placements are placed in their thought position in a truck cab model of today.

Picture 41: Showing real-time feedback on steering wheel with: pending voice message, eco cruise control activated and comparing to company average. The large display is placed to the right of the steering wheel showing the six basic icons.

10.4 Assessments of the final concept

10.4.1 Assessment based on List of demands

The List of demands and desires resulting from the user study and theory research has been used to secure that the final developed concept fulfills all demands, see below.

The system should	**Fulfillment**
Function with every truck type and Volvo truck model	Fulfilled; since all models have similar interior cabs
Present real-time eco-driving information to the driver	Fulfilled; real-time feedback on the steering wheel
Have drive safety in focus	Fulfilled
Not interfere with other instruments in the driver environment	Fulfilled; the system cooperate with other systems
Allow for driver attitude and education skills to come first	Fulfilled; the system wants the driver to be independent since it indicates a simple icon not complete text
Be integrated with an eco-driving education program and follow-ups	Fulfilled
Add extra value for the users	Fulfilled; shows clearly fuel consumption and other data the driver needs
Feel quick and responsive	Fulfilled
Appeal to the economic and truck-caring side of the driver	Fulfilled; shows the money saved in the detailed display
Function with driver when under time-pressure	Fulfilled; time is apposite to the fuel save and the driver always have the eco-driving in focus
Be selective when displaying information to driver	Fulfilled; the system has the real-time
Have functions that are possible to disable	Fulfilled; voice commands
Have a user-friendly design	Fulfilled
Not be repetitive in order to not irritate the driver	Fulfilled; the system is not repeating advices in an irritating way
Take road conditions, weather, load, route choice and the	Fulfilled; different icons

current traffic situation into account	shows information related to each function
Predict topography and turns of road into account	Fulfilled; the system should consider for example the virtual partner for different roads
Have function for accelerator and brake use	Fulfilled
Have function for driver to anticipate road ahead	Fulfilled; but there is a conflict with the driver's freedom if the driver wants to turn it off
Display fuel consumption per specific unit	Fulfilled
Display average speed per specific unit	Fulfilled; information is available in detail in the large display
Enable for truck driver, back-office and customer to exchange information at anytime	Fulfilled; there is a function that back-office could send information at anytime to the truck, the driver could listen to the voice message and read and answer the text while not driving
Be failsafe	Fulfilled
Be cheap and easy to repair	Fulfilled
Function well in a dirty environment	Fulfilled

10.4.2 Assessment based on desires expressed:

The 5 score is the best score.

The system is desired to perform:	**Importance score**	**Fulfillment score**
Provide information regarding load to driver	3	5
Display carried weight per specific unit	2	5
Contain a positioning system and a map	4	5
Present best possible routes to the driver	5	5
Have function for planning routes and loading/unloading sites	5	5
Provide comparable eco-driving information when driving the same route	5	5
Provide driver with traffic information like road blocks, accidents and bridge heights	4	5

Work together with electronic infrastructure systems in roads, buildings etc	3	0
Be integrated with phone usage	3	4
Include a social network	5	3
Enable communication between users regarding eco-driving	4	2
Allow for drivers to show their skill in various eco-driving branches	5	0
Indicate with different colors	3	5
Provide a screen of sufficient size, if a screen exists	4	5
Be as simple as possible during driving	5	5
Show how much money you save (through eco-driving)	5	5
Record fuel and emission data and make this information possible to dispatch (to clients etc.)	4	1
Provide an automatic fuel consumption report service for truck owners	4	0
Explain reasons for why a behavior is bad	4	0
Provide advice a long time ahead of action	4	3
Give pre-trip advice for idling for example	4	4
Display driving history within defined periods	4	5
Appeal to the competitive side of the driver	3	4
Provide deeper drive statistics and feedback post-trip	4	5
Provide positive feedback or reward system	5	0
Show comparative improvement for a specific time period	5	0
Work together with trip computer to add or deduct drive time depending on eco-driving results	2	0
Have limited forcing functions; only concerning overload and alcohol lock use	4	5
Allow for each driver to be anonymous	5	3
Enable sporadic truck positioning	5	0
Enable drivers to make comments on road conditions when driving – to share with other drivers and collaborators	4	0
Enable customer to make quick delivery changes and notify drivers	5	2
Enable back-office to make quick route changes and/or notify drivers	5	4
Enable back-office to decide right truck type for each assignment	5	0
Be composed of 100% recyclable material	5	4
Present information as compact as possible	3	5
Have a “static display-mode” for information when driver is overloaded	3	5
Be designed considering choice of colors, strength of lighting, contrast and angle of vision	4	4

Provide good vision and auditory support considering the top-down process for older drivers	4	4
Consider aging and weakness in auditory and visual senses	3	3
Hand-over functions to other senses to prevent overloading of the visual sense	3	3

10.4.3 Heuristic evaluation

In this evaluation, a small group of evaluators examine an interface to see if it is fulfill the recognized usability principles. Evaluators assess the design based on the different factors. (Noyes, 2004)

The table below shows the assessment to see to which extent the interface meets basic usability requirements

Visibility of system status	Yes, especially in the real-time feedback the driver could get advices quickly
Match between system and the real world	The cab interior has not changed so much The system introduced new icons but it has been tried to make them as simple and familiar as possible to the driver's world The icons remind of similar systems like i-phone
User control and freedom	As many parts as possible are designed to be deactivated whenever is needed except for those parts that are important for the safety issues Some parts like fuel consumption indicator cannot be deactivated but it has been tried to design those functions in a way that is not irritating for the driver based on their desires that were discussed in the interviews
Consistency and standards	Each icon stands for one function and action
Error prevention	The user might need some time to get familiar to the new system with the new icons but it has been tried to make them as user-friendly as possible
Recognition rather than recall	Icons are always visible though they fade away and shrink compare to the active icon while that icon is in use
Flexibility and efficiency of use	The menus of the display are designed in a way that is shallow enough so the user does not need short cuts
Aesthetic and minimalist design	It is designed as minimalistic as possible. The real-time display has the most important information and the larger display has those

	information that the drivers were interested most in the interviews
Recognition, diagnosis and recovery from errors	The main purpose of the designed system is to give advices so it gives the driver the possible solutions at the time. For instance, the real-time feedback shows the acceleration icon by upside flash to advice the driver to accelerate more at the time
Help and documentation	The driver gets more information on driving manners that would help him to improve his eco-driving in the future

10.5 Final solution - Discussion

The final concept of this project is expected to interact both physically and mentally with the driver based on what has discussed in the interaction part in the theory chapter. The driver would send and receive information by physically working with the system. The system also displays information and messages in form of graphical icons and voice messages, which means it involves the driver by using different senses that was an important issue in user interface interaction in the theory chapter.

One of the senses that could be used in transferring information to the user is the haptic sense. In the early stages of the concept creation, some ideas like green ray that warms the steering wheel were sketched. Later on, these ideas along with other ideas were discussed with the drivers that were not so welcome.

Therefore, the system interface designed for this project supposed to give necessary information in the shortest time and in the most accurate way to the driver. Reducing the mental workload for the user also should be considered since the capacity of the working memory and attention is limited. In addition, to keep the driving safe, salient features prevented in the design to not distracting the driver.

The designers wanted to make the system able to compare different trucks based on their general engine and gear box state but to compare different truck types is not do-able as so much affects this; for example engine type and gear box. Engine friction during the first 40 000 km's also affects the comparison between truck types.

During the whole development process the main aim was to design a concept that can communicate in the best way with the user in order to develop his or hers eco-driving skills. The resulting concept from this project will, if implemented in the correct manner, change

truck driver behavior and thus lower fuel consumption within the transportation industry. The concept is aimed to be produced about twenty years ahead in time, when knowledge about eco-driving, environment-friendly techniques and communication technologies are likely to be higher than today. It is hard to predict and imagine how the life of a truck driver and the concept surroundings will look like in the future. The main focus of this study was on the user of the interface, the truck drivers, who according to the research made in this study have a lower freedom of mind and acceptance of futuristic changes than product developers. Therefore, the concept is designed in a way that balances both sides. Thus, the final concept is designed in respect of the drivers' level of acceptance and wishes for the future.

From the meeting with the other students of the Industrial Design Engineering program, the idea of developing an interface that is communicating with other drivers was generated. During the development of the concept, it was decided that the way the driver implements eco-driving should somehow be displayed to the outside in order to motivate both the driver to work better and others to take the same action. The best ideas for this solution included some form of green light or green ray in the windscreen that is visible all the time while at the same time not bothering the drivers. However, it was discussed that it might not be legal and/or safe to have different lights displayed at the front of a truck and that only standard lights could be utilized (e.g. white light in front and red at the rear). Looking at similar eco-driving advisory systems the conclusion was that it is possible to have different lights inside the driver cab if it is not so distracting. One other problem with lights was the light bulb's lifespan, some drivers considered it too expensive to add lights to the truck exterior and always worry about changing them. The placement of LED-lights on the truck exterior could prove to be a slight problem if not having a superstructure with clean walls like on a distribution truck or a long haul truck. Dump trucks or hook lift trucks must place these lamps somewhere else, for example on the top rear part of the truck cab to stay on the same truck when changing containers or to avoid lamps to break as in the dump truck case.

Whether this will in fact be the case is most uncertain. When looking at the placements, factors and communication alternatives for the system, everything boils down to the truck driver and whether he or she might in fact be inclined to actually use this system. During the work examples have emerged from the drivers interviewed that there exist systems on the market with great flaws which systems drivers in general state to be unjust or wrong. A system with major faults will never be used as it was supposed to, or not at all.

As a result, it was decided to have the exterior eco-driving display formed as an "E" shape. It might not be the best possible sign but the shape is reminding its term, eco-driving, and prevents misunderstanding with other lights, this "E"-shape is also positioned at the rear part of the truck as opposed to the front where greater clashes are probable. Also, that LED -

technology will be used in the lamps, which is a less expensive and more durable technology in comparison to lamps used today. The last but not least concern in displaying eco-driving information on the outside of the truck was the freedom issue for the drivers in their daily work. In this case, the final concept design lets the driver deactivate the outside display part of the eco-driving advisory system whenever he or she wants to, this to not inflict too much on the freedom of the truck driver profession that is one of the basic factors in the job for a truck driver.

To reduce the fuel consumption and thus CO_2-emissions, a real-time feedback advisory system for the truck driver was a top priority. The placement of the real-time feedback to the driver was a big issue during the development process; real-time feedback needs to be placed where is in the driver's focus, closed to other related functions such as gauge meter, in order to be both seen and understood easily and this without distraction. Different placements: in the windscreen, on the right-hand instrument panel, in the gauge meter and on the steering wheel were discussed and for the final concept the steering wheel was selected. The placement is located furtherer down from the road view than both the windscreen and the gauge meter placement are would have been. This decision was motivated by drivers indicating this was a good placement, but also that placing new information in the gauge meter area would conflict with traditional information displayed there. The windscreen placement was not selected because of the too futuristic design and the input from drivers that stated that information displayed here needed to be more important than eco-driving advice as it could conflict with the driver's overview of the traffic situation. The selected placement contributed to the necessity of the information displayed and icons designed to be easily and quickly perceived and understood by the users in the target group. Besides the clash between the traffic overview and the new information placement, the current airbag position was discussed and how it could be solved placing some form of interface in the same area. Using the fabric material would solve this problem while the design of the actual interface icons on this surface would still be able to attract to the traditional side of the drivers.

Finally, it was a concern that drivers might not be able to work with the large touch screen display when wearing gloves and if the screen might get dirty since the cab interior is not so clean area and the driver also might have dirty hands. New touch screen technology today shows a higher sensitivity that lets the user use the product even without the direct contact of the finger's tip. The aesthetical part of the dirt issue is not easily solved without cleaning, but new touch screen technology makes the display inaccessible to larger dirt particles that might destroy or lessen the touch screen function.

The possibility of adding numerous systems in one large display on the instrument panel removes the need of the pop-up screen containing back-camera and navigation systems today,

seen in Picture 8. It also removes the need for a center display in the gauge area. The implementation of the developed eco-driving advisory system will leave extra space on the otherwise cluttered instrument panel.

10.5.1 Final concept in comparison to the Scania Driver Support System

As in the "Competitive analysis" chapter under the title of "Existing eco-driving advisory systems in trucks" was mentioned, the Scania considered as the main competitor for this concept designed for the Volvo.

This concept will be used in Volvo trucks in about twenty years and during the development process it was always a concern if the concept is futuristic enough both from the future developments point of view and the competitor improvements or not.

The main advantage of this project's concept in compare to the Scania Driver Support system is the communication between the driver and back-office personnel.

The system in comparison to its current competitor provides its user with more information about different functions. This is because of the aim of the interface, which is giving advices to the driver. Also, the system takes more parameters into the account for the eco-driving score. Moreover, the system gives the driver a comparing score that motivate him or her to do his or her best. At last but not at least, the speed limit is applied on the system that will alert the driver if s/he drives upper its limit. This is one of the important eco-driving parameters although it could be irritating sometimes that does not exist in the current competitor's system.

11 General discussion

11.1 User study

One of the main constraints during the user study has been the limited time users have been able to give up to meet for interviews and observations. Questions posed sometimes got too general answers to help in the specific concept development. This also shows that their work environment is very time-dependent.

During the first interviews, some questions were too unspecific: for example one question that treated the general truck cab interior and which functions the drivers liked the best. This made the driver unsecure in the interview situation since the question was too general. When modifying these questions, removing them or rephrasing them, the interview guide changed and thus all interviewees did not receive the same questions. This might have affected the result as not all interviewees had the same opportunity to share their knowledge. The questions added were more specific and had alternatives that the interviewee could choose from, this made the result from the interviews richer. More questions with alternatives and scales would have given more detailed interview groundwork.

To take notes in a truck is not easy, and took time if the driver had much to say, maybe it could have been better to record the interview, but then one would have to handle the problem of noise in the background and the time consuming transcription. Having to handle the writing and posing of questions at the same time might have made the interviewer to miss out on some information.

11.2 Relating to research questions

The concept of this project needs to function in an uncertain future environment with future technological solutions - and what the transport laws and road environment will look like in 20 years time is very hard to say. To secure the optimum function of the system together with the driver, multiple user-tests need to be performed. What can be said is that the truck driver role will change but exist in the future, and in order to affect fuel consumption, the behavior of the driver is one key factor.

The needs and requirements of an eco-driving advisory system for trucks in the future that have been identified and fulfilled by the developed concept can be shown in the list of requirements on page 42. Some requirements conflict with each other. One is that the very existence of this developed concept conflicts with the need for safety focus and attention of the road of the driver. This conflict of attention has been tried to be kept at a minimum through the placement and design of the system.

No difference has been identified between the truck drivers need in different work areas. One thing that all drivers wanted was a level of freedom intact, not yet another surveillance system integrated in the truck. Automatic functions are good, but to let the driver deactivate functions is even better. This creates a conflict with the existence of an eco-driving advisory system, because if it is not activated it can show no advice and the main goal for this system is to improve eco-driving behavior. But the user study shows that to force a desired behavior on truck drivers is not a constructive way to improve eco-driving behavior and thus some functions in the final concept have been made deactivate-able. The added cost of this system for the haulage company should be motivated by the good-will generated by the exterior displayed use of this system as well as general gain for society when more trucks are equipped with this kind of system. To not design this system with leafs, flowers and the excessive use of green colors and to keep it as simple as possible is also important for the acceptance of the system in particular and the acceptance of eco-driving in general. A well functioning eco-driving advisory system in the truck cab makes the eco-driving easier to implement for the single truck driver and gives drivers and co-workers a hands-on everyday result from an environmental driving manner that could be hard to accept and seen as necessary or even serious.

Experienced users today are older and not so accepting towards the eco-driving concept, they drive as they have always been driving, while younger drivers are more integrated with the eco-driving concept. In twenty years time, obviously the drivers that are young today will be older and it is believed by us that the eco-driving manner will be more generally accepted. Therefore it could be said that it will be easier to implement an eco-driving advisory system in the future, and the drivers will be more accepting. But maybe it is not that simple, even younger drivers today showed signs of a similar attitude towards eco-driving as the older drivers had. Truck drivers want to be independent and not be told what to do, stress in the everyday work environment and bosses attitudes affect to a great extent. Younger drivers might be more inclined to adapt and learn a system to give advice, since it will be a new technical system and they might show less skepticism.

Since the design of this eco-driving advisory system has not treated the menu design to a great extent, the use of the menus is hard to predict. Experienced users could be said to have an easier time using extensive menu “trees”. The design of the larger display has considered this and made it as shallow as possible. Therefore, both new and experienced users could be said to use this menu just as good. As straight-forward a design as possible has been used when choosing icons used in both the larger and the real-time display this has been done considering the importance of both new and experienced users to understand them quickly.

The user study and following concept evaluation showed that truck drivers put great pride in their work. Resulting from what drivers said, the eco-driving advisory system has to be simple and not add any unnecessary functions. For example, the idea of having incentives to reward the driver when driving in a good eco-driving manner was developed as we thought this would make drivers appreciate the system more. However, this idea was not seen as a good solution when letting drivers evaluate the sketches. To let the system be as highly accepted and appreciated by drivers as possible, the system should be as allowing as possible for the individual driver, not bothering him or her with added games and extra features, but letting the system melt into the cab interior.

Whether there are any conflicts between the needs of immediate acceptance and long-run acceptance of the eco-driving advisory system is hard to tell. The system has been designed to function with as high acceptance as possible for the target group and drivers have evaluated sketches of concepts and stated which ones they, during a specific moment, liked the most. Acceptance in the long run needs to be evaluated after the creation of a functioning concept.

The truck drivers working "on board" create the main target group; these are the only users of the real-time eco-driving advisory system. Drivers can access statistics about their eco-driving behavior in the main display and this information is available to their bosses as well. Drivers generally stated that their bosses' access to this information was a necessary evil, some drivers wanted to be more independent than others. We believe that the issue here is understanding, understanding between the driver in charge on the road and the people working indoors making a lot of decisions. The boss and people working at the back-office might not have a driver's license and this lessens their understanding for the drivers work conditions out on the road. How a certain boss works in his/hers company is what affects the drivers' work conditions. Back-office employees do not wish to handle eco-driving information at all. The fact that they have no truck driver's license makes them wanting to keep their ground. All they want is a direct channel to send quick information regarding route choice and customer issues to selected drivers through the system.

12 Conclusions

This has been a work focused on the future from the very beginning, finding the important factors that an eco-driving advisory system should contain for best acceptance by the user. The future environment has an uncertain status that could just be predicted based on the current situation in comparison with the past. In the truck world, not so much changes in 20 years and it might be the same in the future as well. The final concept is designed based on the driver's expectations today in a conservative environment; both older drivers and the younger generations' opinions have been taken into account. When designing all functions and placements the aim was to put the user's needs in focus to increase their acceptance and the possibility of practically using the system in the future. This was accomplished.

One other important goal for this project was to reduce the fuel consumption according to the driver's behavior. This thought can be seen behind designing all icons and functions in the system (more detailed information about each function and the reason of choosing them can be find in the "Final concept" chapter). The fuel consumption and information related to it are explicitly shown on two of the placements and in a way that communicate best with the driver. Different advices received from the system are expected to improve the driver's manner regarding fuel consumption and therefore improve eco-driving behaviour.

In combination with all data gathering and evaluation sessions in development process of designing the interface, the probability of using the system could significantly increased by testing the concept with the driver and as an actual prototype. However, still based on the comprehensive information gathering and evaluation sessions, designers could claim that the concept take into consideration important parameters needed for the system and its user. Therefore, the system and all of the functions it provides would most probably be accepted and used by the drivers.

Beside this interface development project, to lower the effect of the transport industry on the environment, the government in each country, truck companies that develop new technologies and user understanding will work together for a better future. It is the duty of the truck companies to develop new techniques and the industry has a long way to go, but what is important to emphasize is also the duty of each individual driver.

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14 Appendices

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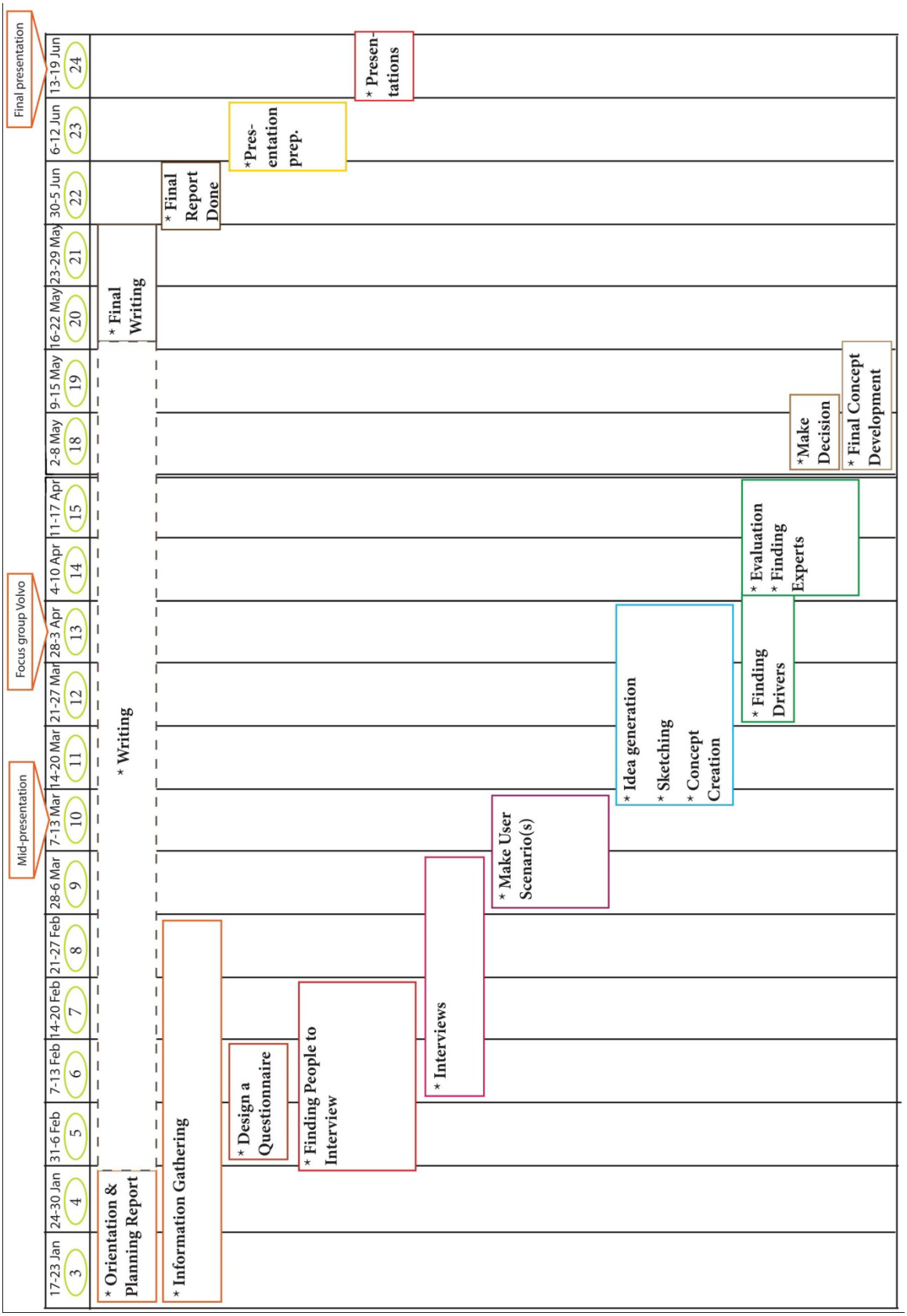
Appendix 1- Gantt chart



Appendix 2 – Interview guides

Questionnaire Truck Driver

Age:
Years of experience:
Truck type:
Current truck model/year:
What kind of company do you work for? What size is the company? What do you do?

1. What education do you have in eco-driving?
2. What is your attitude to eco-driving?
3. What kind of attitude do you think truck drivers in your field of work have towards eco-driving?
4. How do you think you and your truck could save more money – just by the way you are driving?
5. Could you name any system for eco-driving/fuel economy installed in trucks?
   What do you think about it?
6. How would you like to get help to drive more eco-friendly?
7. Could you name 3 situations in your work where you could affect fuel economy the most?
8. How do you think a system to help you with environmental driving would look in 10-15 years time (if anything is possible)?
9. What do you think about this help-system being active before trip?
   What should it do here? Advice from previous trip? Challenge for the day?
   Numbers, graphics, text, voice, other?
10. What do you think about this help-system being active during driving?
    What should it do here? Drive tips?
    Numbers, graphics, text, voice, other?
11. What do you think about this help-system being active after trip?
    What should it do here? Reward? Advises for what to do better next time?
    Numbers, graphics, text, voice, other?
12. What is your stance looking at systems where the truck takes over and handles some things automatically? For example adjusting to optimum speed to the drive- and resting times for the day, or sending information about economic driving automatically to the office.
13. How would you like information from and regarding your driving to be transmitted between the office and your truck?

Finally, how do you best like your information to be presented?

Compiled over a longer period	or	for what's happening right now?
Information available for you to activate	or	activated automatically?

Questionnaire Back-office personnel

Age: Years in profession:

Size of company (number of trucks):

Company service area:

1. Which is your task in relation to the drivers? How often do you communicate with them?
2. Have you received any information or education in eco-driving? What sort of info/edu? Do you talk about eco-driving at your company?
3. What system do you have today to show how eco-friendly/fuel efficient the trucks/drivers drive? Do you have any system to show fuel economy, positions of the trucks or service intervals for the trucks? How does that work?
4. What do you think about a system for sending and receiving eco-driving information between office and trucks? Why?
5. Would you like to use a system to help the drivers to improve their eco-driving behavior - or use a system to increase the fuel efficiency of the trucks? How could a system help you?
6. Which information on eco-friendly driving could be most useful to transmit between the office and the trucks?
7. How do you analyze and/or react on the information received from the drivers, today?
8. In 10-15 years, if anything was possible. How would you like the communication between you and the drivers to work to increase eco-friendliness?
9. When would this communication occur? Before, during or after trip?
10. In what form would you like to receive information from the trucks? Text, figures etc.

    - In what form would you like to send information to the trucks?

Finally, how do you best like your information to be presented?

Compiled over a longer period or for what's happening right now?

Information available for you to activate or activated automatically?

Questionnaire Experts

Age:
Years of experience:
Truck type driven before:
What kind of company do you work for? What size is the company?

What do you do?

1. What is your experience and attitude of eco-driving?
2. What kind of attitude do you think truck drivers in your field of work have towards eco-driving?
3. How do you think drivers could save more money – just by the way they are driving?
4. Could you name any system for eco-driving/fuel economy existing today, installed in trucks? What do you think about it?
5. How do you think an in-cab system should be designed to help drivers to drive more eco-friendly?
6. Could you name 3 situations when driving, where a driver could affect fuel economy the most?
7. How do you think a system to help you with environmental driving would look in 10-15 years time (if anything is possible)?
8. When should the system be active – showing data to driver and/or office? Before, during or after trip?
   - **Before** - What should it do here? Advice from previous trip? Challenge for the day?
   - What do you think about this help-system being active **during** driving?

   What should it do here? Drive tips?
   - What do you think about this help-system being active **after** trip?

   What should it do here? Reward? Advises for what to do better next time?
9. Which information on eco-friendly driving could be most useful to transmit between the office and the trucks?
10. In what form would you like to receive information from the trucks? Text, figures etc.
    - In what form would you like to send information to the trucks?
11. What is your stance looking at systems where the truck takes over and handles some things automatically? For example adjusting to optimum speed to the drive- and resting times for the day, or sending information about economic driving automatically to the office.
12. What do you think about information from and regarding your driving to be transmitted between the office and your truck?

Finally, how do you best like your information to be presented?

Compiled over a longer period	or	for what's happening right now?
Information available for you to activate	or	activated automatically?

Questionnaire Truck driver education

Age: Truck models driven:

For how long have you had a truck license? For how long have you been learning to drive a truck?

1. What kind of work tasks will you do with your truck?
2. What does eco-driving mean to you? Which associations do you get?
3. How would you like to get help to drive more eco-friendly?
4. When would this help be active? Before, during or after trip? How? Numbers, figures?
5. How do you think a system to help you with environmental driving would look in 10-15 years time (if anything is possible)?
6. What do you think about a system for sending and receiving eco-driving information between office and trucks? Why?
7. How do you think help systems for eco-driving could increase truck driver wages and the truck driver status?

Finally, how do you best like your information to be presented?

Compiled over a longer period or for what's happening right now?

Information available for you to activate or activated automatically?

Appendix 3 - User study visits

Here all user study meetings; interviews and observations will be presented chronologically. When not interviewing truck drivers in their cab, consequently no observation could take place.

The first truck company visited was freighting timber in the Dalsland-area of Sweden and owned a number of 6 trucks and had some 5 employees. The two first driver meetings were held at this company and in the drivers' trucks, the interviewers went along with them driving, unloading and loading the trucks. The two drivers interviewed were the owners of the company and were aged 64 and 29 respectively, both male.

The second truck company visited operated in the local area of Kristinehamn, but also had longer distances to drive. They had six trucks of various working area; construction, timber and hook lift trucks. The driver was interviewed in his truck driving. The driver was male, 38 years old and a part owner in the company.

A third truck company was visited in Mölndal, they mostly had garbage trucks and owned about 25 of those. The work of these trucks was situated in urban areas around the city area of Göteborg. Two male employed drivers were interviewed here, outside of the truck cab; the drivers' age was 35 and 55. As they were not driving their trucks no observation could be made.

The next interviews were held at the truck stop at Björkäng situated south of Varberg along the E6-highway. There, drivers at the site were asked if they wanted to be interviewed. Here, 4 male drivers doing mostly long-haul were interviewed. Their ages were: 24, 62, 67 and 54 years old. Three of them were employed at a contact hauler owning between 10 and 25 trucks, while the fourth driver owned his own truck together with a partner. As they were not driving their trucks no observation could be made.

One female back-office employee, 36 years old, was interviewed at a recycling company in Sölvesborg situated in the south of Sweden. This company had 10 to 15 trucks performing various work with container trucks and hook lift trucks. The interview was conducted in office.

A fourth truck company was visited in Hässleholm in south of Sweden. They were doing construction work with 29 dumper trucks with or without jig. Two male drivers at the age of 23 and 25 and two back-office personnel aged 43 and 23 were interviewed. Here the interviewer went with the trucks while loading and unloading at the customer.

The driver education at Stora Holm in Göteborg was visited and three students aged between 18 and 19 were interviewed. They were studying their final year to be educated to truck drivers and had experience from driving many types of trucks.

Two expert interviews were also made: The first expert was male, 63 years old and working as an environmental- and quality manager at an economical association for contract haulers. The second

expert was also male, 44 years old and working as a marketing director for eco-driving also performing heavy eco-driving education with truck drivers.

Appendix 4 - Interview Transcripts

Transcript Driver 1

64 years old, 46 years of experience, has driven mostly Volvos before. Current truck model: Mercedes 2651 (26 tonnes) (510hp): 2 years old, 230.000 km

This company owns a total of 6 timber trucks. Soon, they get a new Volvo and a new Scania truck. Timber trucks usually are purchased new because they are subject to excessive wear; they usually last for about 5 years which corresponds to 1.000.000 km. After that they are sold abroad.
As a hauler I buy what drivers want, they usually care for their own truck and this increases the pleasantness of the company. One wants to have a strong truck, but an overly strong engine does not pay. I usually buy trucks with most of the extra equipment - the best cab - then let the drivers remove what they do not want.

- [We are sitting in the cab with the driver at Håby and waiting to start - the time recorder permit this within 10 minutes. The engine is on; idling.] *"I never turn off the engine" "…it is not environmentally-friendly because I shut the engine down for 10 minutes".*

Which are you main tasks? Drive timber, was driving alone at night for 30 years, but now only daytime - (2 x 4,5 hours driving time). I'll get the lumber in the woods, leaving at various locations, can be very different. There are various problems to solve. "You do not think, driving a trailer truck (long haul)." I drive myself as well as distributing haulage driving time to the other drivers in my company. My wife takes care of bookkeeping. Weekends are spent on [office job] and to manage transport banknotes. We haul for a forest company - they are clients - every Monday we'll receive our haul missions for the week, I divide them to different trucks. It's all about putting together the return cargo.

Which is the best part with your job? It is varied, things happen, time goes fast, always fun, but not if the economy does not add up.

Data that takes most attention when I drive: The road, of course! The side of the road, animals, there is a lot of animals up here [in the forests]. One reads the road, looks far ahead; have to plan more than driving a passenger car. Have to be observant of the load.

- [We drive north on Road 165 from Håby towards Halden, Norway, to unload timber - it's icy on the road, colleagues are calling and warn - that they could not stand up on the road at a break] "*That they do not salt! Trafikverket has cameras, and then they sit in the office and give orders, it was not like that a few years ago".* [Also points out the problem of "East European Trucks" in Sweden], they put themselves deliberately across the road when they suffer from slipping and not going up a hill for example. Then they get free towing if deemed by the police as a traffic hazard. Their truck companies do not pay salvage.

Areas of the cab as the driver attaches the greatest attention: [Looks at display in center]. Flashing indicators. Have two now, one that is solid and one flashing. Side marker light - "even though only one lamp is broken." Brake pads (flash) "will soon enter service," "nothing I can do about it now", "nothing urgent". What I want here is a clock, fuel gauge, coolant liquid gauge, gas meters and a simple trip odometer, it is important as we pay per km and m^3. Trip meter should be able to show easily and

quickly. In Volvo trucks it requires a lot of pushing buttons. A lot of electronics that is sensitive means that you get error messages - messages about controlling things. In Norway, we must not drive with error messages. This truck has automatic transmission, so you do not bother on the big roads, but on small forest roads you drive manually, so [the truck] does not gear up / down unnecessarily, and then the gear indicator is important.

What senses do you think makes you most alert? Eye, Sensory - stability in the car. Smells makes you vigilant.

How do you work together with the office when you're driving? How would you like it to work? I use the mobile phone all the time. I'm talking to our client and the other trucks. I have hands free that I can use in Norway [where we are now] it is statutory to have it there. Volvo, I have seen have good speakers in the backrest which works as a hands free. I have my own phone [loose] and a mobile belonging to the cab. On Mondays, it is more communication. There is a computer and printer in several of our trucks, but not in this one. There is no good place to have it. It receives orders for the trucks that have them. A good mobile, fixed, is all I need.

What major changes do you think will happen in the truck segment in the future? Better developed data networks. More efficient communication.

Questions related to eco-driving:

What is eco-friendly driving for, in your opinion? What I think about is the economy, I think about me being economic. I do not think about the environment, but the economy and environment are interrelated. The speed, I know that it affects.

What is your experience with eco-driving? Nothing - it goes in cycles. You must accelerate quickly to the right speed. I have been involved in competitions in eco-driving, where I got 2nd place in the Bohuslän/Dalsland area. Everything falls on the driver - saving fuel is to save on everything.

What kind of training do you have in eco-driving? Although you think you are good, you need to take courses. I have taken an eco-driving course. It's a lot of demands now on certification and stuff, where for example oils need to be approved. Our fleet is now part of our client's certification. We are submitting emission data to them. Fuel consumption is off course important, and for that lighter trucks are needed.

Would you like more information on environmentally friendly driving? No, but maybe it would be good. But not too much [information] - nothing that will flash and howl!

What do you do to become a green driver? Gain cruising speed fast. Know that there is a limit at 78 km / h where the fuel consumption goes up.

Which systems for eco-driving, have you seen in cars and/or trucks? None [was not aware of Scania´s system].

Do you have a system for environmentally friendly driving installed in your truck? No.

How would you like to receive advice / reward / punishments for environmentally friendly driving? Today I check fuel consumption every day, but it is difficult to compare different drivers and trucks. All drive different routes and have different loads. It is difficult to show for each cargo how good you've driven – if you drive on a good, big, smooth road then consumption drops [compared to when driving on a small, poor road]. You have it in your head what kind of road you drive on and how much fuel to consume. Fuel consumption can be 6 liters/10km on the roads up here [in Dalsland], we were in a study that showed that our trucks use more fuel up here than compared to trucks in Småland, in the south of Sweden. I'm using this road even if there is a better one - this is a shorter drive, so I have to run it. It is harder control at Svinesund [passing on the European road] - and the truck is really 20-30 cm too long and a bit too heavy. With the computer in the truck we can see consumption per month. You cannot go to the driver and ask why the truck takes so much fuel - it depends on so many other things.

I would like to have a function that shows during driving: fuel consumption over the last 50 km's, for example - it is a good distance. I want as little information as possible that shows when you're driving - no gear indicator. It should be "closed down" – no lights, irritating.

Which focus / what role do you think eco-friendly driving has in the future? The demands are of course set on the haulage contractors. Emissions are set to be reduced every year. We must follow this. Fuel and Emission Reports are being sent from the trucks.

How do you think advice for environmentally friendly driving is presented to the driver in the future? Demands come from above ... but of course we think of the fuel economy all the time.

Transcript Driver 2

29 years, 11 years of experience, has driven the Volvo FH12 and Mercedes models before, all timber trucks.

Current Truck Model: Volvo FH16. Soon six years old.

The son of a haulage contractor, that soon takes over the company.

Main duties: Freight timber, repairing trucks in the workshop. Drive the truck but also does office work.

What's the best part of the work: To be an entrepeneur. To get rid of Volvo's workshops - they have forgotten who the customer is. The workshop in Dingle is good – there you get service and they listen. Scania has a better service - they have a function with free environmental monitoring for your truck. A paper is automatically sent by mail to you, that shows fuel consumption. Now with this Volvo I fill in myself manually in this binder [show a binder with tables of] amount of fuel, and mileage driven at each refueling.

Tasks that takes most attention when I drive: To be efficient and fast. The driving situation flows on. Navigation and maps take much time. Transportation Structure – where to, from where, how and when the cargo should be loaded and unloaded. I work maybe a little bit different than my father [Driver transcript # 1] he takes each load one by one and take each day by routine – as it comes. I plan weeks in advance what I'll do each day. I need to think more when I plan.

Areas of the cab that the driver puts the greatest attention: The phone, constantly. You need a real phone that has to work. Other things: small irritating failures, system errors, diagnostic lights, cable failures. You get too much information, much that you do not need to do something about at that moment. Chairs are a different matter. Volvo's seats are crap - I think it was 2002, I could not sit in them and got back problems. The door mirrors are also very large in a Volvo - you have to look around to see [behind them]. Trip meter - when to reset it, it requires a lot of pressing. It should be easy with a large button.

Which senses do you think makes you most alert? Sight, hearing, feeling with the throttle and so.

How do you work together with the office when you're out driving? How would you like it to work? There is no office - everybody drives. We are six trucks that are all working on our own. We use the telephone to communicate and collaborate. The computers we have in the other trucks announce jobs-through transportation vouchers.

What major changes do you think will happen in the truck segment in the future? It is put on Volvo to develop trucks that "not just to please the eye". They should build for the hauler, it should be cheap, easy to repair. I am a part owner and think less of the looks. It should be fun to buy a Volvo. They need to develop things like a better half light - the bad half light has secondary effects on the environment. Need system that simplifies - Environmental monitoring that is automatic [for the hauler]. The trucks

should be light and able to load a lot. Volvo must let go of the design and build working vehicles. Develop a computer desk that integrates the computer in the cab. A computer showing transport orders, maps and books fuel reports. No systems in the cab - it is enough with a mobile phone that handles mail and phone numbers.

Questions related to eco-driving:

What does eco-friendly driving stand for, in your opinion? There is nothing you can influence. The truck "runs" as much as it wants. You might set up your drive schedule time as efficiently as possible and drive with full loads, but that is nothing new. You refuel for 4 million a year, it is always in focus, you always keep your mind on the fuel. You cannot have too small engines. You try to drive fuel efficiently, of course.

- [Drive up a steep hill on a narrow forest road, accelerates at max] "*Cannot do this differently*".

Volvo has to produce more environmentally friendly trucks.

What is your experience with eco-driving? Makes little difference. More expensive for those who take it too seriously. Wrong to go in for saving too much fuel. When it goes too slowly, it costs time, then you don't perform enough. Eco-driving is the wrong way to go. Eco-driving does not give the entitled, positive image.

What is your education in eco-driving? You've taken courses ... you go one day and drive a test drive with the course's truck - not your own. "Then it is an old man there who says you should run lean."

Would you like more information on environmental- friendly driving? What, for example? Drive-tips-programs that for example shows that when you run up to 90km /h, then you have to switch earlier. You should have stars like that as a reward system, as in that system I saw ... Continous indications keeps the driver alert. The hauler can have a computer program that shows how the driver follows the system - or do not care about it. A system in the truck that indicates when to engine break. It could be a system on a neat screen [to the right of the driver]. It should be easy to read and understand. All-in-one, a display of system / advice. We that freight timber drive on so many different roads every day – here, you cannot install a system that says how the truck should run [on many different roads]. A GPS could provide advice if approaching a hill and that you should accelerate a bit more before and roll down.

What do you do to become a green driver? [No response]. Eco-driving is the wrong way to go. Economically driving, is the right name - or something similar. Not environmentally friendly ... would never buy a system that is presented as an environmentally friendly drive system - but a system that is presented as a system that lowers my costs for economical driving. If you have a full load or an empty truck, so of course it affects how environmentally friendly you can run.

Which systems for eco-driving, have you seen in cars and /or trucks? Have test driven Driver Support System from Scania, which I was impressed by. Think there were different colors too. EcoFlex from Scania provides information from the truck's computer back to the computer in the office. Displays the total weight and average load. Had Dynafleet from Volvo, but disabled it – never used it.

Do you have a system of environmentally friendly driving installed in your truck? No.

How would you like to learn about advice / reward / punishment for environmentally friendly driving? Percental improvement over a day. Fuel advices. Simple stuff that affects the driver for the moment. Engine braking, brake usage, fuel efficiency, ice warning, traffic safety, gear shift technique - up / down and how much you save if you do it. Get feedback in percentage, the driver must see that it will be good. You should be able to see what exactly the truck pulls per 10 kms and get reminders about being better. Weather, wind, rain, humidity - all affect. If it blows hard, the system shall recommend a lower speed, for example 77 instead of 80 km / h.

Which focus / what role do you think eco-friendly driving in the future? Eco-friendly driving has been spoken of since, what, 1998, at least. It must be better. It should be reliable, must be correct otherwise you do not care about it.

How do you think advice for environmentally friendly driving is presented to the driver in the future? "No voices!" It should be voluntary to be informed - as a screen. You should be able not to care. It is my wallet.

Transcript Driver 3

38 years, 20 years experience, has driven Volvo - FH12, 13 and 16.

Current model: Volvo FH16. Bought Dec 2010, 1700 mil. Hook lift with trailer and for this haul: containers to transport wood chips from a place out in the woods to an energy plant.

This fleet has a workshop in Kristinehamn and drive in a radius of 200 km's around the town with the hook lift, up north into Värmland and towards Örebro. Their construction trucks drive shorter distances and more around Kristinehamn. They usually buy new cars. The son owns 50% and his father, 50% of the company, they have six employees. They have five cars, all Volvo - two hook lifts, one construction and two timber. The son sits on the board of LBC. The hook lifts haul chips in the winter and construction jobs in the summer. They can also do road maintenance, it varies with the season.

Timber truck - different tasks every day.
Construction truck - not so much work during the winter (December to April - nothing that is being dug up)

Construction Firms and road communities give assignments to the fleet. This fleet is also included on a list of LBC Logistics - Kristinehamn / Karlskoga, that distribute assignments to fleet operators. This fleet also haul timber for larger timber companies.

It's hard to get hold of people in this business, prices are under pressure.

Very stressful? Oh yeah, all the time.

60 tonnes is the total weight that is loaded - snow builds up on the car and gets weight deducted from the payment.

[The trip starts at a field 30 km's southeast of Kristinehamn. Then went about 65 km to Eon in Örebro and unloaded chips, then back the same way to load more on the same field.]

1. What does an average day look like for you? It's different every day. We run in shifts, every other week in the mornings and every other at nights. The car goes off the shift along with the driver, but continues with new drivers if there is a lot to do. I drive this car for 10-12 h per session. There is a lot of loading / unloading.

2. What's best about your job? The freedom.

<u>The driver cab environment</u>

Interior, you get to pick among the standard packages when buying a new truck. You pick the best. It is important with the chair and such.

3. When you drive - what draws your attention? What information in the cab draws your attention? The road and surrounding areas. The digital trip recording equipment in the display in the middle. Showing driving and rest periods and the total run time (when it reaches 4.5 hours, you have to rest). The speedometer. The phone, which is removable - I have it always with me, day or night.

4. What senses make you most attentive? Vision and reaction.

5. Which areas of the cabin give you the most important information / do you use most? Is there anywhere you can think of to place new information "? No, nowhere I can imagine. The wheel and buttons I use a lot. The sanding function of these keys, I use a lot now when it snows. Limiter (Spärr-funktionen) function is used in the forest on the small roads. On the main road you have a different attention - more like an overview of the panel, speed, etc.. I have the I-shift so that takes care of itself [when it comes to gear shifting]. I only use manual gear shifting in the woods, it's not that often, but then you do not want that he unnecessarily gears up.

6. How do you communicate with colleagues while you're driving? How is information exchanged between offices and truck? I'm using the phone, I have an Iphone that I can access and read e-mail and transport orders. I have it always with me. There is also a map in it. The timber trucks and the other chips car [hook lift] have a real computer in it with a large screen on maybe 15 inches. I have a rearview camera that I use often [use it when unloading and shunting], but a map sheet will not fit on the small screen (maybe 10 inches). Need map often. Earlier, it was com-radio and paper mail orders that mattered.

7. How would you like the office and truck to communicate? It is good the way we have it with computers that started to appear out in the trucks. A lot of things go through SMS and email.

8. What major changes do you think will happen in the truck segment in the future? How would you like the truck to communicate in the future? Computers will stay for long. Do not know, no.

ECO-driving:
1. If I say environmentally friendly driving, what are you thinking then? Eco-driving. We think of course much of the fuel [in the company]. For a timber truck, the cost is SEK 80,000 per car per month, for a hook lift SEK 40,000.

2. What is your experience / training of eco-driving? Nothing right now. Must start with it, it is a part of the YKB-training that all truckers have to do.

3. Do you think a lot about eco-driving? Well ... too little. These trucks take a lot of time to shunt - a lot of starts and stops, on and off with the containers. Driving time is over in a snap. The speed goes up on the roads [thus].
What do you do to become a green driver? Nothing.

4. Which system of eco-driving have you seen in cars and / or trucks? Nothing.

5. Do you have a system for environmentally friendly driving installed in your truck? You like it? What priority is it compared to other systems? No. Do not think that you could choose to, have not been informed. External systems will be installed in the trucks during the YKB-training. We have trip computers today, where you can see how much he pulls.
I have an alcohol lock on my truck and I am positive, do not understand why there isn't in all cars - it would remove many accidents from the roads. [The tachograph equipment warns at 4:15 in time. It flashes on the display down at the steering wheel and up above the driver. A ticking sound is also heard.] - "Tachograph times is of course to hell!" The alcohol lock, one can accept, but…

6. How would you like to get advice / reward / punishment for your driving? Penalty is one not so keen on ... Difficult for us that have such different haul runs. One would like the chauffeur who drives the cheapest on the fleet to get some money as reward. But it is difficult to compare those who happen to drive the main road that day and those that load and unload all the time. Advice in real time can be positive. Can be annoying, but on the whole pretty good.

7. Do you think eco-friendly driving / eco-driving has a future? Yes, the economy is the important part for us and for the rest is off course the environment [that benefits from it].
8. How do you think advice for environmentally friendly driving is presented to the driver in the future? Voice is good in the beginning.. Or some kind of gauge.

Transcript Driver 4
Age: 35

Years of experience: 15
Truck models driven: Many different within construction and distribution.

Current truck model/year: Scania P230

What kind of company do you work for? What size is the company? What do you do?

Skårdals åkeri AB. Has about 25 trucks. Transport waste disposal and goods.

What education do you have in eco-driving?

I took 3 different courses of about 1 hour each. Both theory and driving a track twice.

What is your attitude towards eco-driving?

It works in some cases – but not always. It is positive, when you can drive eco-driving. But it's hard when for example there is a lot of traffic, then you sometimes have to jam on the brakes.

Do you have any system for eco-driving/fuel economy installed in your truck?

If yes – Do you like it? How does it work?

I just write down manually for each re-fueling, how much diesel and so on…I think I have some program in the trip computer. But I have no time to check it when I'm driving. There are too many settings in modern trucks. It is there somewhere in the sub-menus [, I think].

Which functions do you enjoy/use the most in your truck-cab?

I can see how much there's left on my brake pads shown in percent on a screen.

How would you like to get help to drive more environment-friendly?

Don't know, the traffic is what rules. Different fuel is needed, biogas…

Which 3 things in your driving do you think affect fuel economy the most?

-stress, you just gas…

Nothing more…

How do you think a system to help you with environmental driving would look in 10-15 years time (if anything is possible)?

The truck could drive on its own! Fully automatic. It's hard to change the driver.

When would you like this help-system to be active and how?

Before trip? No
What should it do here? Advice from previous trip? Challenge for the day?
Numbers, graphics, text, voice, other?

During trip? Yes, some things you can do on your own…
What? Drive tips? – Maybe telling…Now you are driving un-economical.
Numbers, graphics, text, voice, other? In a Mercedes there was a lamp that shone red or green depending on how much you accelerated. Voices are nothing…

After trip? No
What? Reward? Advises for what to do better next time?
Numbers, graphics, text, voice, other?

What is your stance looking at systems where the truck takes over and handles some things automatically? For example adjusting to optimum speed to the drive- and resting times for the day, or sending information about economic driving automatically to the office.

Excellent!

You drive with a high tempo. Would not work with adjusting speed as we always drive with full power.

How would you like information on economic driving to be transmitted between the office and your truck? Good– we send everything electronic today – but we have papers also. QPRS(?) system in the truck today that shows how much fuel it pulls.

Finally, how do you best like your information to be presented?

Compiled over a longer period or for what's happening right now?

Information available for you to activate or activated automatically?

- "You want to control some things yourself…"

Transcript Driver 5
Age: 55

Years of experience: 24
Truck models driven: Many different
Current truck model/year: Scania, garbage truck, 19 tonnes unloaded, 26 fully loaded
What kind of company do you work for? What size is the company? What do you do?

Same as no4: [Has about 25 trucks. Transport waste disposal and goods.] Drive around Göteborg, Kungsbacka, Kungälv, Ale

What education do you have in eco-driving?

A few times– but at the driving school where you drive unloaded and a track with no hills – that's no good. You can only tell the difference if you check the whole working day. We drive very different…

What is your attitude towards eco-driving?

Good without time pressure it works. You push the accelerator to keep up [with all the work]. It doesn't work when you are fully loaded, when unloaded you can lower consumption. It takes longer time – anyone telling differently – that is bullshit.

Do you have any system for eco-driving/fuel economy installed in your truck?

If yes – Do you like it? How does it work?

No, trip meter

Which functions do you enjoy/use the most in your truck-cab?

-

How would you like to get help to drive more environment-friendly?

With a system in the cab – if it doesn't take more time. Better fuel is needed.

Which 3 things in your driving do you think affect fuel economy the most?

The stress…There is nothing I can do if I want to make the set delivery and pick-up times. Sometimes-you have more time, but that is not often – then I ease on the accelerator to let time pass, and that is eco-driving isn't it?

How do you think a system to help you with environmental driving would look in 10-15 years time (if anything is possible)?

I think the amount of stress in this kind of work will increase in the future.

When would you like this help-system to be active and how?

- **Before trip?** No – I would just forget it, if I read a message or advice on how to drive at 6 AM – then I will forget it a few hours later when you are busy doing your work. You don't care…
- **What should it do here? Advice from previous trip? Challenge for the day?**
- **Numbers, graphics, text, voice, other?**

- **During trip?** Yes, it must be…yes I would wish for this – it flows better [with eco-driving].
- **What? Drive tips?**
  Numbers, graphics, text, voice, other? Text, to say: release the accelerator a bit. Numbers- to show if you drove better this than last hour. It's hard to compare different trucks – everyone is so different, load, road anything.

- **After trip?** No
- **What? Reward? Advises for what to do better next time?**
- **Numbers, graphics, text, voice, other?**

What is your stance looking at systems where the truck takes over and handles some things automatically? For example adjusting to optimum speed to the drive- and resting times for the day, or sending information about economic driving automatically to the office.

No system that sends information about my driving automatically to the office. That means more surveillance and more stress.

How would you like information on economic driving to be transmitted between the office and your truck?

- "What kind of use do they get from that [information]?" Then they feel even more…

Today they can see where we are on the map and tell us drivers "I know you can haul more".

Finally, how do you best like your information to be presented?

Compiled over a longer period or ~~for what's happening right now?~~

Information available for you to activate or ~~activated automatically?~~

Transcript Driver 6
Age: 24

Years of experience: 2
Truck models driven: Trailer transports within Sweden (betw Malmö and Stockholm)

Current truck model/year: MAN

What kind of company do you work for? What size is the company? What do you do?

Is a driver at a contract hauler with 15-20 trucks.

What education do you have in eco-driving?

Did one course, in connection to when I took my driver's license. It was a one-day course.

What is your attitude towards eco-driving?

It's good I think- when you can save the environment.

Do you have any system for eco-driving/fuel economy installed in your truck?

If yes – Do you like it? How does it work?

No but I use cruise control. In the center display I can see current fuel consumption.

Could you name 3 systems you have in your truck-cab that calls for your attention? Annoying/good.

Air pressure is something that I monitor – if it should fall – it shows in a traditional gauge.

I also monitor the amount of fuel that is used per 10 km's, looking at the current fuel consumption.

How would you like to get help to drive more environment-friendly?

Maybe get more information. It's good to learn how to drive differently – this through some course to learn more.

Which 3 things in your driving do you think affect fuel economy the most?

The amount of load [on the truck] matters a lot. Uphills, when you have to gear down and you consequently get higher engine speed. Cold starting and in the beginning when you drive.

How do you think a system to help you with environmental driving would look in 10-15 years time (if anything is possible)?

That is if the truck drove by itself. The driver is still there, but there are a lot more programs to handle things automatically.

When would you like this help-system to be active and how?

- **Before trip?** No
- **What should it do here? Advice from previous trip? Challenge for the day?**
- **Numbers, graphics, text, voice, other?**

- **During trip?** Yes, it would make it easier to drive, if you know how to drive.
  What? Drive tips? Could say if you should gear up or down.
  Numbers, graphics, text, voice, other? Then, an arrow up like in the car I saw once.

- **After trip?** No
- **What? Reward? Advises for what to do better next time?**
- **Numbers, graphics, text, voice, other?**

What is your stance looking at systems where the truck takes over and handles some things automatically? For example adjusting to optimum speed to the drive- and resting times for the day, or sending information about economic driving automatically to the office.

Sure, automatic driving would be good. I don't think it would inflict, it would be more like a complement. And good if the truck sent information – [that means that] someone more can discover if the truck pulls more fuel [than it should].

How would you like information on economic driving to be transmitted between the office and your truck?

Good with a booklet that you could read to customize yourself into it. New things will come within eco-driving.

Finally, how do you best like your information to be presented?

Compiled over a longer period or **for what's happening right now?** Easiest if something is wrong…

Information available for you to activate or **activated automatically?** Sometimes you of course want to push buttons to get information too. But automatically is better otherwise you don't think it as important.

Transcript Driver 7

Age: 62 Will soon retire…

Years of experience: 40

Truck models driven: long-haulage within Nordic countries

Current truck model/year: Volvo FH12 Trailer

What kind of company do you work for? What size is the company? What do you do?

Is a driver at a contract hauler with about 10 trucks.

What education do you have in eco-driving?

Nothing.

What is your attitude towards eco-driving?

Don't know what it means. Trying to keep the fuel usage down – that's natural for me! Someone from the office instructs you if the truck pulls too much fuel.

Do you have any system for eco-driving/fuel economy installed in your truck?

If yes – Do you like it? How does it work?

No, have never seen one…have an automatic gear box (I-shift).

Could you name 3 systems you have in your truck-cab that calls for your attention? Annoying/good.

You just have a general overview of the panel when you drive. No special system that I monitor.

How would you like to get help to drive more environment-friendly?

I would not like any help.

Which 3 things in your driving do you think affect fuel economy the most?

The gear box handles it all! I use motor retardation instead of breaking to save fuel, tires and break pads.

How do you think a system to help you with environmental driving would look in 10-15 years time (if anything is possible)?

The truck would be computer-controlled. The truck handles itself and the driver cannot affect…

When would you like this help-system to be active and how?

- **Before trip?** No Every [experienced driver like myself] drives after one's ability and ones own head. New drivers need summoned advice before and after each drive how they have driven.
- **What should it do here? Advice from previous trip? Challenge for the day?**
- **Numbers, graphics, text, voice, other?**

- **During trip?** No
- **What? Drive tips?**
- **Numbers, graphics, text, voice, other?**

- **After trip?** No
- **What? Reward? Advises for what to do better next time?**
- **Numbers, graphics, text, voice, other?**

What is your stance looking at systems where the truck takes over and handles some things automatically? For example adjusting to optimum speed to the drive- and resting times for the day, or sending information about economic driving automatically to the office.

No, don't want it; it is too much as it is already. I want to put my settings in by myself. I want to affect.

How would you like information on economic driving to be transmitted between the office and your truck?

The diesel prices are going up…I use manual re-fueling notes to get information of the costs. It is not better to send automatically – then you are being watched.

Finally, how do you best like your information to be presented?

Compiled over a longer period or **for what's happening right now?** But it's good after the drive to check what's happened earlier during the day.

Information available for you to activate **or** **activated automatically?**
This is more needed if you have a manual gear box and you need advice for shifting up and down – I got the I-shift so I don't have to think about that.

Transcript Driver 8
Age: 67 years

Years of experience: 46
Truck models driven: container trucks within south of Sweden
Current truck model/year: Scania 420, year model 2005, manual gear box.
What kind of company do you work for? What size is the company? What do you do?

Own his own truck. 1 truck. We are two people that own this one truck.

What education do you have in eco-driving?

No education, just drive by experience.

What is your attitude towards eco-driving?

You should drive cheap and lean. You think more and more on the diesel prizes that increase.

Do you have any system for eco-driving/fuel economy installed in your truck?

If yes – Do you like it? How does it work?

No, but have cruise control.

The tachometer gives advise – a green field lights up if you lie too low or too high.

Could you name 3 systems you have in your truck-cab that calls for your attention? Annoying/good.

You have the trip computer that comes with the truck – where there are a lot of different functions. You can see current fuel usage and on average how much diesel used day by day.

How would you like to get help to drive more environment-friendly?

I don't need any other help. I doubt that the automatic gear box gives a better fuel usage than a manual one.

Which 3 things in your driving do you think affect fuel economy the most?

The speed, use of correct gear and the obvious, not to break and "kill" the speed you have gained.

How do you think a system to help you with environmental driving would look in 10-15 years time (if anything is possible)?

The truck drives on its own. You only need to start, use the break and steer off course.

When would you like this help-system to be active and how?

- **Before trip?** No
- **What should it do here? Advice from previous trip? Challenge for the day?**
- **Numbers, graphics, text, voice, other?**

- **During trip?** Yes
- **What? Drive tips?**
- **Numbers, graphics, text, voice, other?** Numbers are good…

- **After trip?** No
- **What? Reward? Advises for what to do better next time?**
- **Numbers, graphics, text, voice, other?**

What is your stance looking at systems where the truck takes over and handles some things automatically? For example adjusting to optimum speed to the drive- and resting times for the day, or sending information about economic driving automatically to the office.

Good, when the truck takes over – everything will be right. I have no computer for sending information – automatic sending could be something for larger haulers.

How would you like information on economic driving to be transmitted between the office and your truck?

The diesel prices are going up…I use manual re-fueling notes to get information of the costs. It is not better to send automatically – then you are being watched.

Finally, how do you best like your information to be presented?

Compiled over a longer period or for what's happening right now?

Information available for you to activate or activated automatically?

Transcript Driver 9
Age 54

Years of experience 22

Truck models driven Volvo- Mercedes

Current truck model Scania- Long haul

What kind of company do you work for? What size is the company? What do you do?

Transport food and soda, normal goods

What education do you have in eco-driving?

We had some classes which they had just shown us how the system works and how to manage it.

What is your attitude towards eco-driving?

It is not driving too fast and not breaks so much. Also, I do everything to reduce my fuel consumption. With my eco-driving manner I could reduce my fuel consumption 10 liter per 100 kilometer and therefore I feel I succeed in this way.

Do you have any system for eco-driving/fuel economy installed in your truck?

If yes, do you like it? How does it work?

We have a computer installed on our trucks which shows how eco we drive. We just log in to the truck's computer and then it shows everything.

Could you name 3 systems you have in your truck cab that calls for your attention?

Maybe just mobile phone

How would you like to get help to drive more environment-friendly?

Maybe it is good if we get more education about it. I don't know much about systems. It is good if they do something on roads like installing electronic devices so if I don't drive right, it can stop me.

Which 3 things in your driving do you think affect fuel economy the most?

Speed; I should keep it the same as much as possible. Gear shifting; I should not change it much.

How do you think a system to help you with environmental driving would look in 10-15 years time?

I think there would be some kind of electronic surveillance built in roads which would do the supervising task by itself.

When would you like this help-system to be active and how?

Before and during trip. I would like to know what should I do to be an eco-driver and also it is good to get advices during the trip but not after the trip. When I finish my job I just want to go home and do not get feedback when it is over. Also, I do not want award system because it feels like competition all the time which do not like.

There is no difference between different ways of presenting information as long as they are easy.

What is your stance looking at systems where the truck takes over and handles some things automatically?

It is good if you are aware of its existence and alarms. For example if it has range for something and comes to the end of range suddenly the truck would stop which is helpful and good if you know such a thing exists. Otherwise it would shocke you that what happened and what was that which is not good while driving.

How would you like information on economic driving to be transmitted between the office and your truck?

GSM system currently exists. If everything is all right, then it is good to have it but if not, I don't like it because they can judge your behavior afterward which is not good.

How do you best like your information to be presented?

I would like to see what is happening now and also be able to activate information by myself so I have the control to deactivate it as well whenever I want.

Transcript Driver 10
Age 25

Years of experience 7

Truck models driven Volvo FH12 480, year 2008, 150 000km, I pull 4,3 liters/10km

Current truck model Dumper truck with jig

What kind of company do you work for? What size is the company? What do you do?

Construction company, drives their own trucks, 29 trucks, 16 at work today, drive truck 90 % of my time: gravel and rubble. It's good to come out sometimes and to load with the wheel loader.

What education do you have in eco-driving?

One course in 2006, but that was when I worked for Shell in Helsingborg. There was a guy that went with me for a whole night when driving. And he pointed at what I should do better.

What is your attitude towards eco-driving?

Good, it's good to learn how to earn money no matter if you have your own truck or the company owns it. I generally know how much fuel the truck takes – around 4,3 liters – which I monitor in the trip computer. The automatic gear box manages itself.

What kind of attitude do you think truck drivers in your field of work have towards eco-driving?

Good I think. But there is a time pressure on many contract haulers. Here we don't chase time, if you are too late to make the final load you do it next day instead.

How do you think you and your truck could save more money – just by the way you are driving?

Not much now…How you turn on smaller roads – that could save a lot of wear and tear on the trucks. I have the I-shift so I can't do much. I'm sure that there are ways to affect fuel consumption that you don't think about – nothing I can say right now.

Could you name any system for eco-driving/fuel economy installed in trucks? What do you think about it?

No, nothing in particular, we have the trip computer in the display…

How would you like to get help to drive more eco-friendly?

Updated information, education, someone driving with me.

Could you name 3 situations in your work where you could affect fuel economy the most?

How you plan the overall driving. That the traffic around me does not inflict, so you don't have to make unnecessary stops.

How do you think a system to help you with environmental driving would look in 10-15 years time (if anything is possible)?

You could develop the trip computer so that it indicates and shows when you drive the stingiest.

New engines that do not need this AdBlue – it's sticky and a hell to refuel. Maybe a red and green lamp that shows how you are driving. The time pressure put its demands.

Not too much disturbance in the cab – there is too much beeping as it is.

What do you think about this help-system being active before trip? Good, I think it should be active at all times, but what it should do is hard to say.

What should it do here? Advice from previous trip? Challenge for the day?

Numbers, graphics, text, voice, other?

% of throttle when start/stop.

Lamps that indicate how you are driving.

How you drive in comparison to how you could drive.

What do you think about this help-system being active during driving?

What should it do here? Drive tips?

Numbers, graphics, text, voice, other?

During is good, you don't have so much use for tips before you are driving. Better as you are driving.

Everything is so computerized. The more details, the more parts could break.

Hills – the automatic gearbox gears down in the middle of the hill and then you loose a lot of speed. The gear box should know when to gear down. Need a function for more speed in the beginning of the hill.

Accelerating-something connected to the accelerator that shows that it does not go faster if you hold the gas pedal all the way down. You should get advice on how much you should push the pedal.

What do you think about this help-system being active after trip?

What should it do here? Reward? Advises for what to do better next time?

Numbers, graphics, text, voice, other?

No voice that would make you irritated. Numbers in a display. Maybe you could get a percentage in a menu – but you should decide yourself if and when it comes up.

What is your stance looking at systems where the truck takes over and handles some things automatically? For example adjusting to optimum speed to the drive- and resting times for the day, or sending information about economic driving automatically to the office.

Good with help systems that helps the driver. But people mustn't rely too much on the electronic systems. When something goes wrong they just sit there…you need to know how to act yourself without the systems. Education is always good – good to know how it feels to do wrong.

Sending a lot of information automatically to the office is not good. That creates two camps: company management and the driver and quarrel between them. They do not know anything about driving.

How would you like information from and regarding your driving to be transmitted between the office and your truck?

Nothing. A GPS-signal could be good like when to do with safety like with a valuable transport. But if they can see if you stop for a longer break - no – they have to trust that you do what you should.

Finally, how do you best like your information to be presented?

Compiled over a longer period or for what's happening right now?

Over the day… Both is good…

Information available for you to activate or activated automatically?

Transcript Driver 11

Age 23

Years of experience 3, drove distribution trucks before

Truck models driven Volvo FH12 480, from 2009, year model 2006

Current truck model Dumper truck with jig

What kind of company do you work for? What size is the company? What do you do?

Bröderna Hall, drives their own trucks, 29 trucks, 16 at work today, drive truck 90 % of my time: gravel and rubble. It's good to come out sometimes and to load with the wheel loader.

What education do you have in eco-driving?

None

What is your attitude towards eco-driving?

Yeah it's quite sane-minded to know some of these things.

What kind of attitude do you think truck drivers in your field of work have towards eco-driving?

Good. Many older "foxes" might have a hard time to take in new info. They think they have been driving for so long…

How do you think you and your truck could save more money – just by the way you are driving?

An education of the driver is good so that you know how to drive. But there are fine systems that exist, to show amount of gas used and breaking and that the car is in fine condition.

Could you name any system for eco-driving/fuel economy installed in trucks?

What do you think about it?

Scanias: Driver Support System – don't think that it is standard in all trucks. I haven't test-driven this system but I have read about it and seen a video on YouTube.

It looks like it's a good system. I think it is a battle between money and time. When you save fuel you also save money. But if you save time by driving faster and thus not as cheap – you at the same time escape a lot of overtime – which saves money also.

How would you like to get help to drive more eco-friendly?

Education for the basics. Then – as it is easier to drive eco-friendly on a known road where you can plan for hills etc – some system in the truck to predict/anticipate that a hill will come etc. A GPS-like device. Something that shows height differences – like a map reader in rally.

Could you name 3 situations in your work where you could affect fuel economy the most?

Predict the road ahead when you haven't travelled there before.

Idling driving

Hills – to gas a bit extra before and then let go. I-shift handles it very well to keep the tachometer in the green field. Scania has a dynamic green field that lights up and changes position. Volvo has a firm green area in between 1000 and 1600 rpm.

How do you think a system to help you with environmental driving would look in 10-15 years time (if anything is possible)?

Development of the Scania system. Voices that pushes you – positive feedback, praise! It should take over the truck automatically if it notices it could drive better itself. GPS! (have a back camera today).

What do you think about this help-system being active before trip? Possible I suppose…

What should it do here? Advice from previous trip? Challenge for the day?

Numbers, graphics, text, voice, other?

There is a lot you cannot control in the traffic. It is irritating if the system turns in the wrong direction. There was one system that I read about that measured the time usage of the break and the time you just rolled. But it didn't measure how hard you pushed the break once you did that – so the ones rolling and then throwing themselves on the brakes were the winners in this system – while they were not as eco-friendly as they could have been. This system should both have taken into account the time and hardness with which you push the break.

What do you think about this help-system being active during driving? This is best!

What should it do here? Drive tips?

Numbers, graphics, text, voice, other?

Not talk too much that's irritating. Not give the same tips over and over…for each uphill...it could mention it once in a while.

I'd like some combination of voice and graphics. You should be able to turn the voice off. There are possibilities in the trip computer that exists –to show when you drive most efficiently.

What do you think about this help-system being active after trip?

What should it do here? Reward? Advises for what to do better next time?

Numbers, graphics, text, voice, other?

A summary of what you can improve in your driving.

Careful with this information – it could come in the wrong hands – for example a zealous employer that chases every last drop of diesel.

A troublesome day could give indications in the fuel consumption – that takes a pragmatic boss.

GPS is good from a traffic management view. But it's hard when it sends information to the office – they can see who uses more fuel and take a discussion with that driver.

It is good with response to yourself.

What is your stance looking at systems where the truck takes over and handles some things automatically? For example adjusting to optimum speed to the drive- and resting times for the day, or sending information about economic driving automatically to the office.

Good with a tough control of the driver – but not good that wherever you go, make a turn, stop for a while, then the boss can see you and choose to say.

Good with a supervisory system, like when you start to get tired – it makes a sound when you start to get sleepy. Mercedes and BMW have come far with this in cars.

Like when you panic break – that a system helps me. Sometimes it may be better to not break with all your force – that a system stops this from happening - and run through a pit in the road instead of making your truck and trailer fold together.

How would you like information from and regarding your driving to be transmitted between the office and your truck?

It could come in the wrong hands - important with what kind of information that would show. Not so fun when every position of the truck is monitored all the time. Good for them sensitive to us.

Finally, how do you best like your information to be presented?

Compiled over a longer period **or** **for what's happening right now?** Helps me right now

Both is good…good with some kind of compiled information each week which good things you have done.

Information available for you to activate **or** **activated automatically?**

Transcript Back-Office personnel 1

Age: 36 (female) Years in profession: 1

Size of company (number of trucks): 10- 15 trucks

Company service area: Recycling – takes care of everything

1. **Which is your task in relation to the drivers? How often do you communicate with them?**

The customer contacts me/calls me by phone. I transmit this to the drivers by phone. It consists of a time and place to pick up or place a shipment, or a transport from our base to a customer. I communicate many times a day – by phone. It could be a customer calling with short notice and I call a driver that has had a driving mission to that place earlier that day. But when I call the driver he might not be there anymore, in some other place. So then the driver has to drive back. That's not so economical.

The trucks are owned by the company and the drivers generally drive a special truck but they sometimes switch truck. Other contract haulers are hired by us sometimes to do transports far away,

Out sister company in Göteborg has a computer system for the communication with drivers – maps etc.

2. **Have you received any information or education in eco-driving? What sort of info/edu?**

No, but the drivers have had it. We do not talk about it at the company.

3. **Do you have any system today to show how eco-friendly the trucks/drivers drive? What kind of system do you have?**

No I don't believe so. We can see the driving times -when they are on a break and so on. We have no system to see them on a map or anything. They drive on their own. When they re-fuel they send us the receipts – that's all.

4. **What do you think about a system for sending and receiving eco-driving information between office and trucks? Why?**

Yes, if you could find out a way for it to work then it would be good. I doubt that you could affect the drivers.

5. **Which role do you think you could play for the drivers to improve their eco-driving behavior? How could a system help you?**

To set up the routes in the best way, but it's hard as the customer is our big focus. Maybe we have let the customer steer us too much? The drivers have to take short notice-calls, which might not be the

best, economical route for us to drive. But my focus is the customer, definitely. Would be better if the drivers had a route to drive that could not be broken – but then the customer has to wait…

To give advice during driving would be good, eco-driving is positive. I know our sister company in Göteborg had someone to go with the drivers in the truck to give advice on driving – but I don't know where he came from.

6. **Which information on eco-friendly driving could be most useful to transmit between the office and the trucks?**

-Don't know…

7. **How do you analyze and/or react on the information received from the drivers, today?**

I have a very open dialogue. We help each other – we are a team. I don't have a truck license - so you have to think yourself into their situation.

I plan routes –the driver drives completely on their own besides that.

8. **In 10-15 years, if anything was possible. How would you like the communication between you and the drivers to work to influence the drivers an eco-friendly direction?**

You have to increase the awareness of the drivers - next step for us. Have to get education. The drivers don't want us to interfere in their driving.

9. **When would this communication occur? Before, during or after trip?**

After is good – to get advice how to do it better next time.

10. **In what form would you like to receive information from the trucks? Text, figures etc.**

Text and numbers – it is good to be able to read and if someone else comes into office and has to handle the work for a day or something, then it should not take too much time to gain insight into it all.

- **In what form would you like to give information to the trucks?**

Text.

- **Finally, how do you best like your information to be presented?**

Compiled over a longer period or for what's happening right now? It should update all the time…

Information available for you to activate or activated automatically?

...for the drivers. Otherwise they would not activate it on their own.

Transcript Back-Office personnel 2

Age: 43 (female) Years in profession: 7-8

Size of company (number of trucks): 29 trucks (16 active today, 22 feb 2011)

Company service area: Ballast, gravel materials, we bring material here and sift it, blow up rock material and deliver directly to the customer. Deliver material to concrete production.

1. **Which is your task in relation to the drivers? How often do you communicate with them?**

I am a transport leader, which means that I send the trucks out to their daily assignments. I call them and send them to the customer. I communicate about once per hour to the ones doing occasional driving assignments. The drivers that work for the same customers for a longer time handle themselves. It's mostly in the evenings that you communicate to the drivers what's up the next day.

2. **Have you received any information or education in eco-driving? What sort of info/edu?**

Yes, even if I don't have a driver's license I test drove a truck at the test track in Gbg. I have received some information but not taken a complete class like the drivers. Someone teaching eco-driving was here some years ago and had a simulator with him – I test drove that one as well. He educated the drivers. We don't talk about it so much at the company. I am not into eco-driving it is the drivers that are into it.

3. **Do you have any system today to show how eco-friendly the trucks/drivers drive? What kind of system do you have? Do you have any system to show fuel economy, positions of the trucks or service intervals for the trucks?**

---No, someone else is in control of the fuel usage numbers. (male)

4. **What do you think about a system for sending and receiving eco-driving information between office and trucks? Why?**

The drivers drive on their own, they can handle that and should handle that themselves. They should be in control. They should have the information themselves.

5. **Would you like to use a system to help the drivers to improve their eco-driving behavior - or use a system to increase the fuel efficiency of the trucks? How could a system help you?**

The drivers should get information directly so it doesn't have to go pass us in the office. There are so many different places that we drive on, that it is hard to give unambiguous advice for driving. But it happens that we have one and the same driving for a whole day, and then you could give advice for driving the same route.

6. **Which information on eco-friendly driving could be most useful to transmit between the office and the trucks?**

They [the drivers] drive as smoothly they can – we have some control of the fuel usage. They are busy – with the driving, the customer. I don't know when sitting in here what it looks like out there, where they are driving. They are more in control-know more.

7. **How do you analyze and/or react on the information received from the drivers, today?**

I just say what they should load and handle the weigh-in before they leave with material. Sometimes you get some information from the customer – the driver calls the customer to find the place to unload. They have no GPS, a regular atlas.

8. **In 10-15 years, if anything was possible. How would you like the communication between you and the drivers to work to influence the drivers an eco-friendly direction?**

I would like the information received to go through the computer – so the information does not have to be checked immediately/I don't have to take it directly. You can forget things that are spoken. You may sit in one situation and then having to disrupt that one to take another call.

But the best way is to talk to the drivers, you always call today to explain further.

9. **When would this communication occur? Before, during or after trip?**

In the morning you don't know how the day will look. The evening is probably better, that is the time that we give information today, you give advice on where to go, which route, and say: there it is hilly.

10. **In what form would you like to receive information from the trucks? Text, figures etc.**

No voice. No text – but depends on how much text. A figure (as a graphical form-model).

- **In what form would you like to give information to the trucks?**

A figure (as a graphical form-model)

- **Finally, how do you best like your information to be presented?**

Compiled over a longer period or **for what's happening right now?** More in control…

longer period is also good to look back and check what we did then…

Information available for you to activate or **activated automatically?**

Transcript Back-Office personnel 3

Age: 23 (female) Years in profession: 3,5

Size of company (number of trucks): 29 trucks (16 active today, 22 feb 2011)

Company service area: Ballast, gravel materials, we bring material here and sift it, blow up rock material and deliver directly to the customer. Deliver material to concrete production.

- **Which is your task in relation to the drivers? How often do you communicate with them?**

I lead them to where they are going. I transmit info from the customer to the driver. I use the telephone most often, or face to face.

- **Have you received any information or education in eco-driving? What sort of info/edu?**

No, but have some knowledge from taking my car license. Eco-driving today at this company is a lot about knowing where the truck is and to get the routes together as efficient as possible. There are costs that if they go down are good for both us as a company and the environment. You want to find the quickest solution for both customer and for the effectiveness of the work.

- **Do you have any system today to show how eco-friendly the trucks/drivers drive? What kind of system do you have? Do you have any system to show fuel economy, positions of the trucks or service intervals for the trucks?**

No, we find the smoothest route. You think about it, you want to find the closest, most convenient route. You check on the map, using services on the web, communicate through phone.

- **What do you think about a system for sending and receiving eco-driving information between office and trucks? Why?**

You want the right truck for the best suited work; you have smaller or larger trucks for different types of work. Environmental issues are about costs. Eco-driving would attract more, it comes more and more, is everywhere.

- **Would you like to use a system to help the drivers to improve their eco-driving behavior - or use a system to increase the fuel efficiency of the trucks? How could a system help you?**

A map to see where the trucks are would be good. Would like 2 screens, here is the truck, here is the customer- if everything is up and ready you can act quickly. You want to contact a truck before driving past the site where you just got an order from. It's a lot of work to start calling then and costs more diesel.

- **Which information on eco-friendly driving could be most useful to transmit between the office and the trucks?**

The position of the truck would be most useful to us. Today you talk to the driver and depending on where they live – you give them driving assignments in that area.

To give information to the drivers, the new drivers have eco-driving in the back of their heads, you have to be more careful with the older drivers – try to give info about eco-driving.

- **How do you analyze and/or react on the information received from the drivers, today?**

The road they took might have been shorter but it was very bumpy, and the driving was rather irregular. Then [you decide that] a larger road is better.

- **In 10-15 years, if anything was possible. How would you like the communication between you and the drivers to work to influence the drivers an eco-friendly direction?**

Alco locks are good. The truck should react on overload. The truck should warn – give advice that when the diesel usage goes up, it explains the reasons why to the driver. Like: "through this road-choice you…" The truck could sense the number of stops on different roads – count an average index on a road.

Info meetings about eco-driving are also good. But it's hard to fit when we have a lot to do.

- **When would this communication occur? Before, during or after trip?**

Before is good so that you think before you have done something. Important with eco-driving courses for drivers and to think environment friendly.

It would be neat to pick the truck you want to send a message to – at any time.

- **In what form would you like to receive information from the trucks? Text, figures etc.**

Text would show the more detailed information. Graphical figures would show things that you need to see when you are in the middle of something – should be easy to see when you are busy. Maybe colors to show in red, yellow or green how good something is.
Overall it's good with something small on the dashboard that comes up quickly in real time.

- **In what form would you like to give information to the trucks?**

They think you are tedious; they close you down if you are too repetitive.

I could send out maybe through a small screen that is positioned…that could give information about the road ahead that is sent to all the trucks that are concerned. It could show road alternatives and road blocks, road works and accidents ahead.

Today I check the traffic situation on the local radio and on the Transport authority web site.

Finally, how do you best like your information to be presented?

Compiled over a longer period or **for what's happening right now?**

Continuously, for the moment

Information available for you to activate or **activated automatically?**

You need to be able to trust the system – it should be flawless. Show info on a small screen that is connected to the transport authorities –shows weather and wind. Easy to pass on to the drivers. You send the road info to the truck in the direction that it concerns.

We that work in the office have a lot to do with the customer contacts in the high-season – a lot of sitting on the phone. The system should work with the drivers on its own – to give them information.

Transcript Expert 1
Age: 63

Years of experience: 31

Truck type driven before: all different kind of transports

What kind of company do you work for? What size is the company?

HML (Haga Mölndal Lastbilscentral), economical association with many different contract haulers under its wings, 200 vehicles, 200 drivers (10 women – should be more but is growing slowly). Transport management 50/50. A contract hauler typically has around 30 trucks and typically wife and daughter working at the back office.

What do you do?

Environmental- and quality manager. Responsible for traffic safety education.

What is your experience and attitude of eco-driving?

We have educators in eco-driving here (HML's company area). We started with heavy eco-driving 5 years ago. All member contractors follow out set eco-driving goals.

So, we have our own eco-driving education together with "Yrkesförarutbildningen" in a white house up here close to our area. We have a set route here in Mölndal in real traffic, on both highway and in-town – all our drivers drive this route twice. Once alone and one time with instructor, then they compare result. Drivers also get theory in total 5 h.

What kind of attitude do you think truck drivers in your field of work have towards eco-driving?

Mixed feelings, they might feel awkward that someone will tell them how to drive their truck, but good afterwards, when they have taken the education. You have a sum of money to save and when you present that in a very hands-on way it becomes very positive for drivers.

How do you think drivers could save more money – just by the way they are driving?

To have a pro-longed coasting; see far ahead, plan ahead; to have well-filled tires; plan driving routes.

Could you name any system for eco-driving/fuel economy existing today, installed in trucks?

- **What do you think about it?**

Have seen it, but no system in any of our trucks.

The trip computer handles orders we send out to the trucks today – we will complement this by adding a function for fuel metering.

We go more for the attitudes of the drivers and education. More that, then systems and apparatus. Education, theory about alcohol and traffic safety, slippery course is important.

The meeting between people is the best way to get your message forward. The conversation.

How do you think an in-cab system should be designed to help drivers to drive more eco-friendly?

Very simple, must not take any attention away from the road. Simple to handle and understand. Must not take over the actual driving. Transics; TX-MAX is the system we will install. [Worth while for Volvo to get into this and not just focus on designing trucks?]

Could you name 3 situations when driving, where a driver could affect fuel economy the most?

- Speed – not over 80 kmh – air resistance.
- Avoid idling – you have to accept that it is cold for a while just before start etc. This pulls a lot of fuel. [0,2 enl webpage]
- Plan ahead

How do you think a system to help you with environmental driving would look in 10-15 years time (if anything is possible)?

It will develop further…
Maybe like a fighter pilot with the necessary information in the sight line.

The technical things must not take over the human thinking.

You get used to computer systems – education is important if they fail to function.

When should the system be active – showing data to driver and/or office? Before, during or after trip? Mixed feelings…

- **Before - What should it do here? Advice from previous trip? Challenge for the day?**

You are tired and stressed in the beginning of the day. There are those that are interested in a lot of info here but most would just ignore it.
Good for those that are very active.

- **What do you think about this help-system being active during driving?**
- **What should it do here? Drive tips?**

Then you see what you do wrong. Very simple like a red signal to make you attentive.

- **What do you think about this help-system being active after trip?**
- **What should it do here? Reward? Advises for what to do better next time?**

You should be able to go back and see what you have done. That it is simple during driving and then you can go into it after trip and see in detail. I have mixed emotions about this – rewarding systems give result, but professional drivers should do the right thing without something extra.

Which information on eco-friendly driving could be most useful to transmit between the office and the trucks?

High speeds; Idling time; Very extreme breakings (number of) - this is important for the brand.

In what form would you like to receive information from the trucks? Text, figures etc.

Simple, easy to read tables.

There is a lot of info to get – but you need the time to handle it!

- **In what form would you like to send information to the trucks?**

I want to speak verbally to people – meet people. You should give drivers advice in a kind way without pointers (lecturing).

What is your stance looking at systems where the truck takes over and handles some things automatically? For example adjusting to optimum speed to the drive- and resting times for the day, or sending information about economic driving automatically to the office.

These systems have to work! A lot of drivers would like these functions. The safety is in focus. There are advantages, it is useful, with this kind of functions but it should not take over the driving.

The customer, load, the road is in focus.

There is a change coming with the new generation.

What do you think about information from and regarding your driving to be transmitted between the office and your truck?

If you don't do anything stupid as a driver, you will get no harm by it.

Evidently some companies would get problems with the drivers union – like with Alco-locks.

Finally, how do you best like your information to be presented?

Compiled over a longer period **or** **for what's happening right now?** More useful – you remember what you have done.

Information available for you to activate **or** **activated automatically?**

It should not be able to activate during driving.

O, what does it say there!?

Transcript Expert 2

Age: 44

Years of experience: 14

Truck type driven before: Scania, Volvo

What kind of company do you work for? What size is the company? What do you do?

Marketing director for eco-driving since 2004- Responsible for training- Writing educational materials for teachers- I am now involved in the Euro project "Eco-move", built eco-driving into cars and trucks. Working with HMI for trucks

1. **What is your experience and attitude of eco-driving?**

I am writing and teaching eco-driving. Now just three countries, Sweden, Finland, Switzerland and maybe Holland are practically use it in its real meaning. In Sweden it is theoretical and practical. Other European countries have something called *eco-snakes* and they have eco-driving-learning for it. If you want to see that it works, you should plan it, time it and do it.

2. **What kind of attitude do you think truck drivers in your field of work have towards eco-driving?**

(We will have results of our survey in two weeks about it!)

They are pretty negative. All drivers think as they know how to drive a truck they know everything about eco-driving and they are really sensitive, so you cannot tell them they don't know. But after taking courses, they become positive about it and say thanks, it was the best education I had.

In three or four months we teach them right attitude and behavior about how and when they should do what. But since they are stressed, they forget and don't do it but we should remind them always.

Everyone wants to do a good job. I tell them I want to see if you can think differently I do not want to teach you how to drive. You should never tell them you are wrong! You should just kindly ask them to try to do it in a different way and then they really like it.

3. **How do you think drivers could save more money – just by the way they are driving?**

They should do it in different steps of driving:

Pre-trip: they have to daily check truck (tire pressure, type of tire), prepare where to go and plan the trip, and fill the tachograph before start computer, not idling.

On-trip: start in right gear, accelerate right speed, gearbox using in the right way, shift in the right reverse count.

There are also some conditions that he can't influence although he thinks he can! For example, in rainy or snowy weather he can't do anything and he has to drive, or for loading which is good for company if he is loaded in both ways but it is not good for him an eco-driving.

4. **Could you name any system for eco-driving/fuel economy existing today, installed in trucks? What do you think about it?**

Gear shift system

Pre-trip that you give all information system needs and it plan the driving

Traffic management system in Yugoslavia

Traffic management system

Onboard computer system

5. **How do you think an in-cab system should be designed to help drivers to drive more eco-friendly?**

It should be an adaptive system, self-learning, give advice in advance. Driving is about feeling freedom, therefore the system should not force the driver and should just give them alternatives to be better. Otherwise they get tired and will shut it down.

6. **Could you name 3 situations when driving, where a driver could affect fuel economy the most?**

   Choose the right gear for starting and in driving

   Shift gear at the right time

   Smooth speed

   Rout planning

7. **How do you think a system to help you with environmental driving would look in 10-15 years time (if anything is possible)?**
   It will build into cars. Traffic and drivers would work together. Education would still work and get even more importance as cars and trucks become more complicated and need education. Also, people do not read manual and prefer someone to teach them.
8. **When should the system be active – showing data to driver and/or office? Before, during or after trip?**
   Before trip they should be educated and have enough information. On-trip the system should tell him what is good and where to go but should not force him. Report after trip how he performed and you can have history. Give him information and he will decide what to do.

They are competitors. It is a tough job and they are always supervising. I am worried about eco-navigating which check them each moment. The advisory system should be done in fleet and group meetings not personally.

9. **Which information on eco-friendly driving could be most useful to transmit between the office and the trucks?**
   It depends on what kind of work you do:
   Long haul: pre-trip planning and not drive too fast
   Construction: pre-trip planning, rout planning in advance, which way to go to get destination at the right time.
   Office should choose the best truck for each task.
10. **In what form would you like to receive information from the trucks? Text, figures etc.**
    Visible, additive, haptic. Do it in smart way, right time and safety is our focus.
    In what form would you like to send information to the trucks?
    Some information can be presented through windows since all cars has window! Present different information in different categorize.

11. **What is your stance looking at systems where the truck takes over and handles some things automatically? For example adjusting to optimum speed to the drive- and resting times for the day, or sending information about economic driving automatically to the office.**

    No, it's not a good thing! It is only good when for example you can't see a car is coming and it breaks for you but not in any other case. It is good to tell drivers what to do but not to force them doing something because it is again limiting their freedom.

12. **What do you think about information from and regarding your driving to be transmitted between the office and your truck?**

Good thing, you have to do it.

Finally, how do you best like your information to be presented?

Compiled over a longer period **or** **for what's happening right now?**

Information available for you to activate **or** **activated automatically?**

You have to have both. You need information instantly but office needs afterwards.

I should be able to turn it off.

In some little areas you should force them but not everywhere, for example alcohol lock is good and also seat belt is good to be forcing for their safety, but not anywhere else.

Transcript Truck Driver Education

3 students from the Transport High School - Bräckegymnasiet

Age: 18, soon 19 **Truck models driven:** Volvo, -06, -08

For how long have you had a truck license? For how long have you been learning to drive a truck?

You get B, C, E and fork lift license when you finish school after 3 years. One fourth of the semester is assigned to practical work at a company. We practice driving and driving theory for 2 weeks and then have 2 weeks of core subject studies.

Companies come out here and tell us how they are working. Drivers get payed by the hour; some are payed per mileage and load.

No sound today from the engines – have to lean out to see around the truck when reversing.

1. **What kind of work tasks will you do with your truck?**

Construction x2 – transporting gravel, distribution - food

2. **What does eco-driving mean to you? Which associations do you get?**

Release the accelerator; drive lean; not brake hard; no detour; even gas; trip computer on the highway.

Different fuels. Think we have gas/ethanol in a F16-model.

You must think a lot. Planned driving

3. **How would you like to get help to drive more eco-friendly?**

Think we have a lot of help today. We use the fuel measurement function in the trip computer. We have the Ad-Blue additive in the diesel. The teachers are educated. Everything is about saving fuel.

4. **When would this help be active? Before, during or after trip? How? Numbers, figures?**

Before and during. Numbers better than text. You want to keep your focus on the road. A monitor in the windshield is only disturbing – could maybe work at the highway. After trip is unnecessary.

Good with a display that you can push a button and make go away so you not get stressed, display that you can disconnect. Sometimes you cannot release the gas. No voice – nice with a display.

5. **How do you think a system to help you with environmental driving would look in 10-15 years time (if anything is possible)?**

All drive economical. Eco-driving is routine. Display that shows advice.

6. **What do you think about a system for sending and receiving eco-driving information between office and trucks? Why?**

This is a free profession – you don't want to be watched; the boss might not have the insight – which is the case when they don't have a drivers license. Anything can happen out on the road and then I am in charge. It is important with understanding. You don't want to feel watched if you are on a break for example. But it is good if something has happened. You don't want any shit from the boss. Good if the office knows where the trucks are and that they can see that the truck drives slow and if there is something happening on the road.

GPS – minutes, average speed, diesel usage for the truck is good.

7. **How do you think help systems for eco-driving could increase truck driver wages and the truck driver status?**

If you drive economical nobody knows it today. They should know that you are driving eco-driving all the time. Environmental classified trucks. Show the boss how economical you are driving – no reason for the public to know this – no flashy show-offs on the outside of trucks. That could be a danger in the traffic.

Finally, how do you best like your information to be presented?

Compiled over a longer period **or** **for what's happening right now?**

Information available for you to activate **or** **activated automatically?**

A measurement like a thermometer.

A gauge so that you can see when something changes.

The boss should not be able to check my driving information every day – maybe just some days.

A lot of things depend on the road – muddy, slippery – that matters.

Appendix 5 – Results from interviews and functions expressed

Eco-driving parameters (what the system should take into account)

Speed limit (78-82 km/h)

Pedal use: Accelerator usage – time and force

Brake usage – time and force

Right gear choice

Coasting

Planning ahead

Uphill/Downhill

Idling time

Truck condition

Cold start

Weather

Load

Info-presentation

display compiled information *versus* **display present information**: 5-11

information available to activate *versus* information automatically activated: 9-7

before: 6 **during**: 11 after: 6

Modalities to make information susceptible

Vision: 16 Display: 4

Numbers: 5 Graphics: 3 Text: 3

Colors: 2

Tables: 1

Haptic: 1

Olfactory (smell): 1

Auditory: 1

Expressed functions of the system:

Basics:

The system should…

-present eco-driving advice to the driver.

-ask driver to drive differently.

-alert the driver when driving is not economical.

-have drive safety in focus.

-not interfere with road focus.

-not interfere with other instruments in the driver environment.

-allow for driver to be in full control of the driving situation.

-ensure the acting space of the driver.

-allow for driver attitude and education skills to come first.

-not clash with drivers' own experience.

-provide information that driver interprets.

-be integrated with an Eco-driving education program and follow-ups.

-be based on eco-driving education for all involved.

-add extra value for the users.

-be a tool for more efficient work.

-feel quick and responsive.

-appeal to the economic and truck-caring side of the driver.

-function along with the prevailing traffic situation.

-be better than scania's "driver support system".

-be failsafe.

-be easy to repair.

-function well in a dirty environment.

Practical functions of the system:

The system should…

- -display average speed.
- -provide info regarding load to driver.
- -display carried weight per time period.
- -display information on fuel usage relative to road conditions, load and route.
- -have function for driver to anticipate road ahead.
- -contain a positioning system and a map.
- -present possible routes to the driver.
- -include a simple trip meter.
- -include a computer network.
- -indicate with different colors.
- -remind of daily truck check-ups.
- -provide a sufficiently large screen for maps (>10inches).
- -be compatible with Iphone (or equivalent smart phone) use.
- -show how much money you save (through eco-driving).
- -function for different drivers in the same truck.
- -have a simple and user-friendly design.

Other system design cues:

The system should…

- -not be repetitive, but adapt to driver behavior.
- -be as simple as possible during driving.
- -explain reasons for why a behavior is bad.
- -provide info regarding road condition to driver.
- -provide advice a long time ahead of action.

-give pre-trip advice for idling for example.

-display driving history within defined periods.

-show percental improvement for a specific time period.

-be a system for economy.

-provide deeper drive statistics and feedback post-trip.

-provide positive feedback.

-provide comparison of performance.

-appeal to the competitive side of the driver.

-give no reward or create competition.

-enable driver to make decisions.

-give possibility for driver to adapt and make decisions based on the traffic situation.

-give education-reminding tips.

-be selective when displaying info to driver.

-make driver think eco-driving is not slow driving-but efficient driving.

-mind troublesome work days.

Automatic functions of the system:

The system should… -have an automatic ability to function alongside the active work of the driver.

-be able to store information to be handled later on.

-monitor tire fill-up.

-work together with trip computer-to add or deduct drive time depending on eco-driving results.

-provide comparable eco-driving information when driving the same route.

-be integrated with phone usage.

-record fuel and emission data and make this information possible to dispatch (to clients etc.).

-provide an automatic fuel consumption report service for truck owners.

-have forcing functions concerning (safety belt use,) overload and alcohol lock use.

-be restrictive with automatic take-over driving functions.

-rank info and present with precaution.

-have function for planning routes and loading/unloading sites.

-function with driver in a stressful environment.

System-Integration of collaborators:

The system should… -be anonymous.

-enable drivers to make comments on road conditions when driving – to share with other drivers and collaborators.

-present position of truck for office when in an emergency.

-handle transportation vouchers.

-enable sporadic boss controls.

- automatically transmit extreme behavior like high speeds, extensive idling and hard brakeage to back-office.

-provide information exchange with customer.

-enable back-office to decide right truck type for each assignment.

-enable office to make quick route changes and notify drivers.

-have a function for office to position trucks and get routes together.

-enable for office personnel to pick a truck to send a message to directly.

- display customer information and truck positions simultaneously for office.

-show the boss how good you are.

System Communication:

The system should… -enable communication between users regarding eco-driving.

-enable human-human interaction concerning eco-driving education.

- provide driver with traffic information like road blocks, accidents and bridge heights.

-enable for an open dialogue between drivers, customer and office personnel.

-work together with electronic infrastructure systems in roads, buildings etc.

Appendix 6 – Ideas from Idea generation meeting

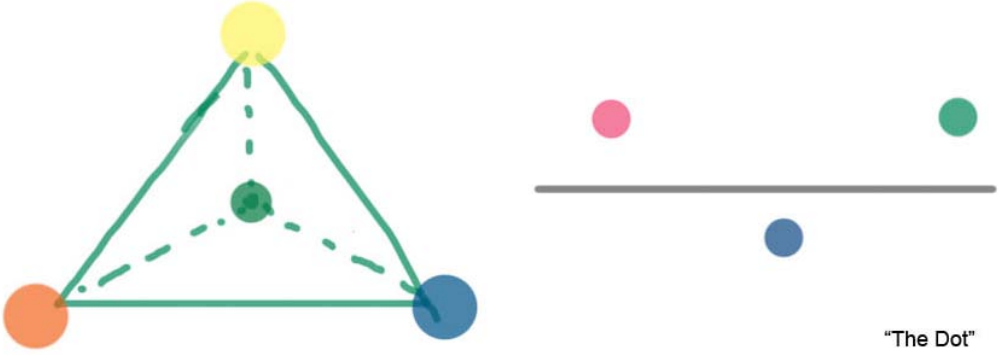
Ideas for design of the system from the idea generation meeting:

- Road train – social to combine trucks
- Ghost Truck projection - like the ski game – "this is how it is done!"
- GPS – maps
- Alarm
- Two-set goal: time frame and consumption frame
- Audio feedback/sound – different signals for different behavior, music, short sound, kid saying something – connects to emotions & locations.
- Weather – complete guide to perfect trucking experience –drive conditions
- Story that fades out- specific stories for specific places – connected to a location, rumor for a specific route.
- How sensitive are they to be interrupted in an audio-book. They could collect parts of an audio-book on the road if you drive eco-friendly.
- During: simple, after: detailed feedback
- Simple feedback – sound of money, changing gear – more than a green field – sad or happy faces.
- Special sign
- Social - Drop things off – leave a star for your friends, leave it on the road you are driving right now
- Display this is the opportunity – what you and/or your company could save in a year or something.
- Eco-strategies; if time is a barrier, then the incentive would be to involve customer and create more time, show time if you gain with eco-driving. Drive times might modify if you drive eco-friendly.
- Competition between drivers
- Optimal drive – how good are you? (a social dimension in this)
- Rewarding system – how close to optimum clear goal
- Friends and enemies in the surroundings of the company – jinx a car, death skull on a car, history creates "car of death", place curse on other cars
- Get money for driving better – game, phone is important today – build on that.
- Radio program - choose the song you would like, or comments from radio host: "now there's someone down there driving good…"
- Displacement on the outside of the truck – how good they drive
- Have the display higher up
- Glass screen
- At truck stops – score boards – free coffee!

Appendix 7 – Input and ideas from Umeå workshop

Input and ideas from Umeå Workshop

- ”The Road book” – A complete concept for a social network between drivers. They decide when to add or share information. It grows and becomes a knowledge-base for the drivers. Could work on many levels – locally, for the firm or nationally.
- Drivers need/should help each other – a freedom for the drivers to act but also an ability to influence organizations etc. It should be fun, feel pride.
- Rewards – (? Doubtful if the drivers wanted this, do they want to show outside the truck they are driving Eco?) “Fika” with the buddies – do they have time?
- Fuel in focus - also complete care of the truck. Optimize the truck – the outside transforms and adapts to outer conditions.
- Optimize the technical performance of the truck for external conditions – road, community, speed, weather, traffic info.
- Boo and Baa-button – Info is gathered during driving, driver can create their own map over road conditions, and for different routes. Just push this button when they pass a special road section. Voice control is an alternative.
- Hidden functions – for as much simplicity as possible. This to maximize the driver performance. But it is important that the driver can notice changes that are automatically made and can make active choices.
- The driver should get more control of break times – reduced waiting time and modified drive times; this off course inflicts on the transport laws. This could be a reward for eco-driving - maybe longer waiting time next break – then the driver has time to take a fika with “Bengan”.
- Communication – to the client regarding a hole in the road that is tricky to pass – the client hopefully understands longer drive times. “Heat map” – where is everybody? Back-office could have access to this function. Haulage contractors could subscribe and pay for the information they want.
- Projections on the wind screen.
- Manual/Auto – I-shift settings give different feedback to the driver.
- HUD-display in the peripheral field of sight. (HUD – is composed of three technical units; combiner (concave or flat), projector unit (above or below) and a computer.)



- Truck communicates with red-lights and road crossings – co-operation with EcoMove-project and other systems. Standard for every truck manufacturer. Law that trucks and busses have priority into roundabout.

Important factors:

- Social dimension
- Time pressure

Appendix 8 – Top concept parameters

Below the concept parameters best liked after the evaluation meetings are presented. One point represents one opinion from a participant, when they were asked to state their top best ideas.

5

Top score: Sending information automatically to back-office and they can decide what to do

3

Integrated system with the phone

Customizable icons or apps

Virtual competitor, compete with your colleagues

Load

Truck labeling on the outside

One display for many systems

System on the steering wheel

2.5

Different packages

2

Choose fuel/time save mode

Icons

Portable system to bring out of the cab

Touch screen

Voice option

Money display