Smart Textiles as Innovative Interface for Commercial Vehicles

potential solutions for comfort, safety and security improvement in driving vehicles

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INTRODUCTION

ABSTRACT

“Smart Textiles as Innovative Interface for Commercial Vehicles” is a project about potential solutions for comfort, safety and security improvement in a driving vehicle.

This thesis is done in collaboration with Volvo Technology as a part of an innovation project looking 15 years ahead in truck design and production.

The main features of the project are in-depth research about truck driver’s job, analysis of driver’s visual perception, light and colour, research on and experiments with smart textiles, electrical circuits and programming, prototyping, design and development of three smart textile interface concepts for truck interior.

Smart materials are studied and used in prototypes as possible production proposals. Electroluminescence wire and panel are used for light applications and thermo-chromic ink for colour change applications. Those materials are developed as textile interface together with programmed electrical circuits.

Expression for the designs is inspired by dynamics and movement and constructed of basic geometrical shapes. Lines and circles are starting point for creating patterns. Colours are chosen from anthropologic perspective: black, white and red are used as basic colours in the project.

Three concepts are developed in the current project:

Eco Driving — electroluminescent light pattern on the steering-wheel to inform the driver about his/her ecological driving performance.

Fatigue — dynamic pattern to notify the driver about his/her physical condition. Thermo-chromic pattern on the dashboard changes colour when the driver gets tired or sleepy.

Light Curtains — Electroluminescent wire curtains which create ambience light in the truck interior. Curtains are adjustable for preferred light conditions.

KEYWORDS

Automotive, electroluminescence, interface, smart textile, thermo-chromic, truck

TABLE OF CONTENTS

AIM

The aim of this project is to find functional and aesthetic solutions using smart textiles to create an interactive interface between the driver and his/her environment.

The outcome of the project is a collection of textile samples which respond to stimuli and by lighting up or changing colour communicate information to the driver.

SCOPE OF WORK

Research about truck driver's job, smart textiles and recent developments of smart material applications in automotive field is carried out using literature, personal experience of following a driver for a day at his work, interviews with the drivers, logistics company, and variety of people at Volvo, study visits, and information search.

Previous research and artistic projects about perception of space, crowdedness and small environments are extended as an industrial project in the current project. Further research is carried out for specific applications in the automotive field. Textile prototypes are developed for small truck cab space.

Previous knowledge about smart textiles is extended by studies about textile electronics, circuits and programming, participation in wearable electronic's workshops and further research in smart textiles field. The prototypes are developed as potential smart textiles production samples.

Artistic expression is based on the previous research about human perception of space and extended into concept of movement. The patterns are inspired by driver's visual perception and motion. Patterns are dynamic due to smart materials which change colour and light up.

VOLVO TECHNOLOGY (VTEC)

This is a thesis project in collaboration with Volvo Technology as a part of an innovation project looking 15 years ahead of truck design.

Volvo Technology is the centre for innovation, research and development in the Volvo Group.
The mission of Volvo Technology is to develop a lead in existing and future technology areas of high importance to Volvo. The focus is on both hard and soft projects within a system approach framework.

The customers are all Volvo Group companies and Volvo Cars but also some selected suppliers. Volvo Technology participates successfully in national and international research programs involving universities, research institutes and other companies. Volvo Technology is located in Gothenburg and at Volvo's establishments in Lyon, France and Greensboro, USA.

This thesis project is done at the Human Factors department which performs applied research and development with focus on developing the interaction between the user and the system in order to create safe, environmentally friendly, efficient and satisfying products and services.

PREVIOUS DESIGN PROJECTS

In my previous design projects I have made research about human perception of space, focusing on differences between Eastern (Arabic world, Japan) and Western (Europe, USA) perception. My main interest was perception of small spaces, both, small in size and also crowded spaces.

Today urban environments grow rapidly. Overpopulation restricts persons' behaviour and forces them to relationships which might cause emotional outbursts which can be stressful for others. Due to increasing level of stress, sensitivity to crowdedness rises. Therefore people need more space for themselves, despite that the amount of free space is decreasing. Living organisms move and therefore require a certain amount of living space. Every living organism needs a certain territory and defends it against other species.

Previous projects:

Concept for an artistic installation "Smallness in a Small Space" is able to evoke strong visual and tactile experience of a small space. The installation consists of large-scale textile air bags which are inflated when a visitor enters the space. Air bags are inflated within a short period of time, fill the space around the visitor, and deflate shortly after that. The installation creates a short and intense experience of a crowded and dense space.

Group project "Integrity" explores relationship between the wearer and its surroundings. The outcome of the project are garments which provide the wearer an opportunity either to hide him/herself, to create his/her own private space and/or share this space with others. On the field trip to Japan those garments explored urban space in one of the most crowded cities –Tokyo– metro, streets and parks.

Previous projects are artistic and experimental, questioning perception and space related problems. Density, intensity, small space, crowdedness and population growth, interaction and communication between human being and his/her environment were the themes I worked with.

The relevance of earlier projects to the current prioject:

The challenge of the current project is to work with earlier investigated perception and space concepts, to implement previously gained knowledge and to develop solutions for industrial production. The current project deals with problems related to small truck environment which is simultaneously a working and living environment for the driver.

Truck cab is an extreme space, small in size and volume, consists of a range of functions and the driver must perform variety of work and leisure related actions there. First, the challenge of the project is to add new functions into the truck space without adding extra physical products. Secondly it is important to challenge performance and rethink perception and actions, communication and interaction methods between the driver and the truck environment. It is also important to maintain attention on driver's psychological condition.

METHODS

The following artistic and design methods were used in the current project:

RESEARCH

Truck driver's profession

In-depth research about truck driving was the starting point of the given project and gave an overview of the driver's job.

Secondly, anthropologic research was done about trucks in other cultures – Pakistan and Japan – which gave an insight into cultural differences and variety of characteristics related to artistic expressions of truck interior and exterior design worldwide.

Case study

Following a driver at his work for the whole day confirmed previously gained knowledge by research. Experiencing the truck driver's job personally, helped to understand activities related to work and leisure and helped to understand how the cab space is perceived while performing those actions.

Studying the driver's work and discussions with the driver gave a great input into the following design process. This method helped to discover and map problematic aspects of the job. That was a useful hands-on approach to find the themes to work with and problems to solve.

It occurred that the driver is highly involved with visual information: road condition, weather, signs, gauges etc. Therefore it was decided to analyse visual sense and to re-think possible visual communication methods with the driver.

Smart Textiles

Research about light and colour smart materials and their technical characteristics gave an understanding how those materials could be used for truck interior applications. Technical data was collected about electroluminescence and thermo-chromic materials to explore the production possibilities of those materials.

Research about existing smart textiles applications in concept cars gave an understanding of the direction of interest of those materials in automotive field.

ANALYSIS

Analysis about colour, light, seeing and vision gave an understanding about visual perception in general and how it is related to truck driver's work. To challenge visual interface communication methods, it was decided to work with colour and light smart materials.

The driver is constantly in motion and therefore his/her vision is mostly blurred. Dynamic patterns with motion graphics were chosen to work with for artistic expression.

LEARNING SMART TEXTILES

Learning and experimenting with smart materials in the workshops added hands-on approach to the theoretical basis.

Theoretical knowledge and experiments with smart materials gave a good basis to continue with the design process in the prototyping phase.

BRAINSTORMING

Brainstorming was made in form of sketching. Sketching was done before and after the research knowledge was gained. The results were collected, compared and analysed. Ideas were modified, blended and partly eliminated.

DEVELOPMENT OF SCENARIOS

After brainstorming, the results were systemized and categorized into scenario groups: safety, security, work and living. Categorization helped to get an overview of collected ideas and made it easier to introduce the proposals at the VTEC meeting.

BRAINSTORMING AND DISCUSSIONS AT VTEC

At VTEC meeting smart materials were introduced, ideas for truck interior brainstormed and the outcome analysed.

RANKING AT VTEC

After brainstorming, the participants of VTEC meeting ranked the ideas and chose the most favourable ones.

Thereafter three themes were chosen from the top voted proposals to continue with in the prototyping phase: Light Curtains, Eco Driving and Fatigue.

PROTOTYPING

Three themes: Light Curtains, Eco Driving and Fatigue were chosen to develop in the prototyping phase.

Defining the problem

The problem of the theme was discussed in detail. The concept was defined.

Fabric samples

Possible textile materials and textile techniques were explored. Expression and colour was decided.

Smart Textile samples

Experiments with smart textiles were performed. Final smart materials and textile techniques were chosen for prototypes.

Technology

Technology was developed for the prototypes, circuits programmed.

Reflection

The prototypes were reflected upon and discussed whether materials, technique or the technology should be improved for further development and production.

EVALUATION AT VOLVO 3P

In a meeting at Volvo 3P prototypes were presented and discussed. Finally the design proposals were ranked and analysed.

FINAL EVALUATION

Final evaluation of the project.

RESEARCH

ABOUT RESEARCH

Focus of the current project is on the long distance truck drivers who work and spend their rest and recreation time in the truck.

The research is done about everyday life of the truck driver from sociological and anthropological perspective to understand truck driver's work performance, leisure activities and social aspects. The investigation is also done about truck aesthetics worldwide. Extreme examples from Pakistan and Japan are explored.

The research is carried out by using literature, personal experience of following a driver for a day at his work, interviews with the drivers, logistics company, and variety of people at Volvo, study visits to Volvo Museum and Truck and Bus Forum in Gothenburg, and information search.

Figure 1. *Spending a day with a truck driver.*

THEORETICAL RESEARCH

DRIVING

The driver must learn series of complex, co-ordinated tasks involving both hands, feet, vision and hearing. This co-ordination must be learned to a point where it becomes semi-automatic so that the driver can safely operate in traffic.

The driver must learn to make judgments of changing space-time relationships. The factors of foresight, planning and appreciation of hazards must be involved to a major extent. Despite technological development, motor vehicle drivers need to pay increasing amount of attention to driving, apparently more than other operators (airplane pilots e.g.) of transportation. Driving skill requires high sensory ability, particularly visual sense, quick reaction and co-ordination.

Physiological preparedness for driving improves with experience. Yet, sensory abilities decline when people get older. Quite often eyesight worsens with age, the same applies to reaction time. On the other hand, emotional stability seems to increase in time due to knowledge acquired with experience. Elderly drivers are often more accurate than young drivers in predicting and avoiding potentially dangerous situations.

Driver's responsibility and experience are the most important criteria for road haulage firms when they select new employees. Management representatives regard driving experience with various types of vehicles as being of primary importance when considering someone for employment. Freight forwarder Liisi Pukk (2010) stated that drivers need to be responsible in their job.

Skilled driving requires the individual to be quick in thinking as well as acting. A good driver is a careful individual, who uses his/her experience, is reliable and predictable.

TRUCK DRIVING

Truck driver's job does not only consist of sitting in a cab and driving from point A to point B. A truck driver is simultaneously a driver, a mechanic, a clerk and in some cases even an owner and manager of his firm. The passive time, which truck drivers spend while waiting for up- or downloading in factories, docks and warehouses, is also considerable.

The hazards and responsibilities of the occupation make truck driving difficult. It is difficult to navigate the truck to its destination on crowded roads which increasingly seem to be full of drivers with inadequate skills. A further difficulty is the way how weather can alter the road conditions, particularly in winter, from hour to hour. The driver might encounter difficulties also when he is loading or unloading: he has to obtain the correct amount of loaded goods, load his truck securely and manage smooth interaction with customers.

Long distance driver usually has no set route and he does not know where his next work will take him. He collects a load and loads his vehicle himself, making the work physically more exhausting. There may be several drops for loading on the route. He has got more variety and less regularity in his work if compared to local drivers. Long distance drivers might spend several weeks away from home and his truck becomes his second home – there he eats and sleeps after his day's work.

To an outsider, the job of driving day after day might seem to have the possibility of becoming a routine. But for the truck driver, the job is not just driving around. He is on his own and is solely responsible for his load and vehicle at that particular point or period in time. Freedom and physical mobility is the basis of truck driver's job satisfaction. Consequently he sees himself as someone who can and does make decisions. (Hollowell, 1968).

WORKING HOURS

The nonstop driving hours of European Union drivers may not exceed 4.5 hours. After 4.5 hours of driving the driver must take a break period of at least 45 minutes. However, this can be split into 2 breaks, the first being at least 15 minutes, and the second being at least 30 minutes. The weekly driving time may not exceed 56 hours. In addition to this, a driver cannot exceed 90 hours driving in a fortnight (Truck Driver, 2009).

Back disorders, heart diseases, stress and social isolation are linked to the time spent on driving. Working hours' regulations affect the physical condition and stress level, improve the road safety by reducing fatigue and drowsiness of the driver (Anker and Dahl, 2009).

HEALTH

Truck driving is not physically very demanding nowadays, but drivers are still exposed to whole body vibrations, compulsory physical inactivity, monotony and stress, depending on road conditions and traffic. They have a high risk factor to start smoking and get diabetes. Physical inactivity might also contribute to obesity.

Opposite to long-distance drivers, those drivers who drive only within urban areas do not have the advantage of spending more time away from toxic emissions.

DANGERS

Truck driving is a dangerous occupation to some extent due to the possibility of accidents. The three major crash cause categories are: human 93%, environmental 34% and vehicular 13%. The total percentage of the causes is bigger than 100% because mostly more than one cause is involved in the accident (Roger and Knipling, 2007).

The other big danger of truck driving is that of being beaten up and, perhaps, even murdered by thieves who are out to steal the truck-load (Hollowell, 1968).

The truck driver has the responsibility to see that the vehicle and its load are safe. The driver must make sure his load is put securely on the vehicle and covered with canvas sheeting and rope so that it will not slip during the journey.

There is a big risk of stomach disorders because of taking meals at odd times or eating too much of fat food which transport cafes provide in large quantities and relatively cheaply.

Truck drivers' main job dissatisfaction is caused by amateur car drivers. On the other hand, car drivers see trucks as something what makes roads dangerous.

Truck drivers are five times more likely to die in a work related accident than other workers (Trucker, 2009). Highway accidents accounted for majority of truck driver deaths, most of them caused by confused car drivers who are unfamiliar with large trucks.

LEISURE

Majority of truck drivers have their weekends off from work and are therefore able to spend some time at home. Yet, several drivers work in weekends as well. Long distance drivers spend more nights – quite often more than a week – away from home than short distance drivers. Long distance driving is the worst type of driving job from the point of being away from home.

Long distance truck drivers have a dual leisure pattern. At work they spend their free time with other drivers. At home their leisure activities are mainly family centred due to long absence from home. Drivers try to compensate their absence by staying home or taking their families out.

One of the truck drivers interviewed by Hollowell (1968) stated: "At nights when I'm away, I go drinking, or to the pictures or playing billiards and snooker. When I'm at home I like to take the wife out but most of the time I'm happy just to stop in with her."

Quite often long distance drivers spend their vacation days in bed. In one of the interviews made by Hollowell (1968), a driver commented on his leisure activities: "I sleep, I have no hobbies".

FAMILY LIFE

The truck driver's hours and conditions of work leave him very little time for domestic life. This means that the wife will often do the tasks which normally would be done by her husband if he were at home. Accident worries, night work, and the irregularity of working hours are other major sources of wives' unfavourable attitudes. Absence from home means that drivers will not see their children as much as they normally would. Drivers are not able to do household works regularly.

Drivers often state that they started long distance driving for financial reasons. Drivers as husbands attempt to compensate their absence by a more intensive effort to do household works and give companionship when they return home for weekends (Hollowell, 1968).

Many drivers think that a truck driver should be single because of the difficulties in family life. However, most of the truck drivers are married. Married drivers are responsible in their job and that is the reason why employers prefer married drivers. The second reason why a driver should be married or have a partner is that then he has someone who waits for him at home and takes care of him.

SOCIAL LIFE

Truck driving has a strong effect on the truck driver's social relations with family, friends as well as colleagues. There is a high level of contact between truck drivers while they are at work in spite of spatial isolation.

One of the drivers in Hallowell's (1968) research was asked if there were a lot of communication in driver's work. He answered: "Yes, when you go in the café and start talking to another truck driver. You've never seen him before and you'll probably never see him again, but you talk about loads and where you are going."

Much of the conversation among truck drivers is gossip and jokes, but much is conversation about difficulties in loading some kind of material and the problems of driving certain type of trucks. It is in the interaction with other drivers that the driver learns the specific use of language (i.e. drivers' slang) and communication methods for getting along with people in factories, docks and warehouses (Pukk, 2010).

The more regular paths the driver drives the more likely he is to have stable interaction with other drivers. Many drivers travel in groups, stopping at cafes with other drivers from the same firm.

In general, interaction during work is irregular except where there are groups of men travelling on the same route and who are from one particular firm. Nevertheless there is evidence of interaction systems among truck drivers, indicating a collectivity which, as a consequence of their conditions of work, produces distinctive patterns of behaviour.

TRUCK DRIVERS' LANGUAGE

Truck drivers use codes to communicate with each other. They flash headlamps and exchange messages during hours of lonely driving. One driver in Hallowell's (1968) research stated: "It's not lonely since someone flashes you and you don't feel lonely."

One of the consequences of such interaction amongst truck drivers is that of producing a common sentiment and value orientation. The sentiment is expressed through language with which the occupational group is more or less familiar whereas the outsider is not.

In spite of spatial separation, truck drivers interact and socialize as a group with a specific identity.

LONELINESS

There is a great deal of interaction in truck driver's job. Yet, at the same time there are considerable indications of isolation. Some drivers feel very lonely at work. "You adapt yourself to it. It's lonely when you're driving but you can call in a café and mix with people, but even on driving you can meditate and work out dozens of problems" stated a driver in Hallowell's (1968) research.

The drivers who say that their job is not lonely give reasons such as the possibility of meeting a variety of different people. Other drivers say that loneliness does not emerge because of the need to follow road and traffic conditions. Hollowell (1968) interviewed a driver and asked about if he felt lonely. The driver answered: "No, not so much these days because there's so much traffic on the roads that I haven't got time to be lonely."

Some drivers like that in isolation they have time to meditate and work things out.

The compensations for loneliness that majority of drivers experience, are mainly social. Drivers meet fellow drivers in cafes, meet different people during the course of their work, or pick up hitch-hikers.

Other types of compensation indicate preference to individual activities. Some drivers say that being their own boss is an adequate compensation. Truck driver Ago Pukk (2010) stated: "Yes, it's a lonely job, but you are independent."

JOB SATISFACTION

Truck drivers in general have a high level of job satisfaction. Long distance drivers are most satisfied among truck drivers (Hollowell, 1968).

Autonomy is the biggest job satisfaction factor among drivers. That reflects not only in freedom of authority (i.e. not having a boss at close distance), but also in the truck driver's realization of his freedom (decision making).

If a truck driver is given a task to make a delivery at an appointed time in a specific destination, he is free to decide how to fulfil the task. He is limited only by the time in which he has to make the delivery. He may vary his route and he may stop his truck whenever he likes and chat to his fellow drivers on route. He is autonomous in that he can control his technology in a way in which the assembly line worker cannot do. He is not hemmed by the four walls of the factory as the factory worker is.

For long distance drivers it is the variety of places he visits, which gives him job satisfaction. A long distance truck driver in one of the interviews made by Hollowell (1968) was positive about his occupation: "You get a variety of experiences and get into contact with different people. You get different views of scenery and the country you are in. It gives you a chance to see around; the time goes quick when you're out on the road."

Several factors of truck driving profession make it unsatisfactory. Truck drivers dislike ordinary, unprofessional road users. That is the main stress reason for daily drivers' work. Also weather affects drivers' performance. The task of sheeting and roping a load in wind and rain is uncomfortable.

Generally truck drivers have high level of job satisfaction due to freedom from direct supervision. Truck drivers like their autonomous role and expect to be left on their own while working.

PRESTIGE

Truck driving is usually seen as a low prestige occupation. Truck drivers are often seen as a danger in traffic in spite of them being more professional then majority of other drivers. Yet, it is true that trucks may cause dramatic damage and casualties if involved in accidents, and are therefore regularly headlined in press.

A widespread stereotype of a truck driver describes him as a middle-aged, fat and ugly man. In 1960's truck drivers were elected as the worst dressed men in Britain (Hollowell, 1968). That opinion has probably not changed even today.

COLOUR AND LIGHT IN THE TRUCK WORLD

PAKISTAN

In Pakistan trucks are the primary form of transportation for the majority of the population. Only the 2.5% elite bourgeoisie owns cars, leaving the remaining 97.5% to rely upon other forms of transportation. Therefore, the vast majority of goods in Pakistan are moved by truck and majority privately owned truck is decorated in highly detailed, extravagant and colourful manner.

The Pakistani truck decorations allow viewers to learn a great deal about the current social, political and religious attitudes of society, and more specifically of the owner.

The front of the truck contains cultural references. The section above the windshield contains religious imagery and text, and the section below the windshield usually contains poetry and text. The side of the truck contains the truck's company name and any additional information relating to its commercial use. The back of the truck contains the most varied subject matter. Artists adopt more playful designs and insert humorous sayings and popular culture references and text on the back designs. The choice in images depicted on the back makes visible how the current society's mood and trends are changing (12g Salon, 2010).

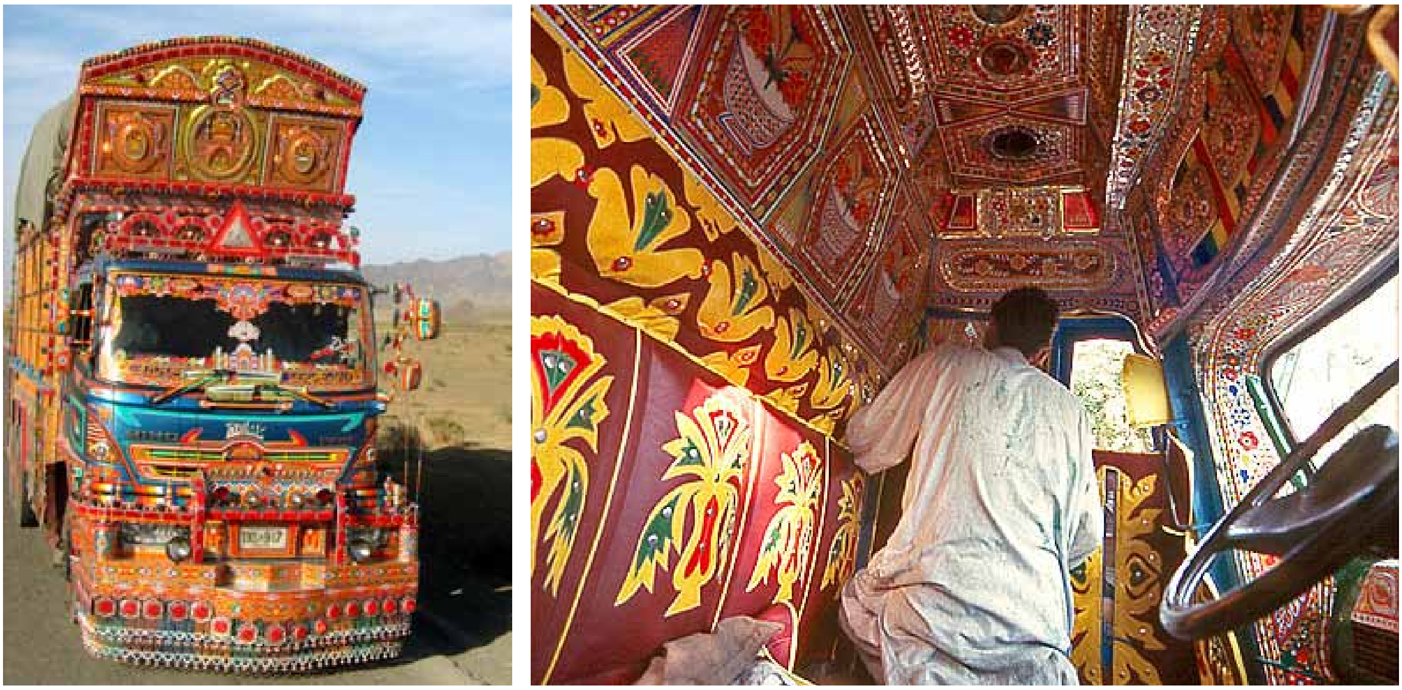


Figure 2. *Trucks in Pakistan*

JAPAN

In 1975, a movie called Truck Guys featured a protagonist trucker who drove his highly decorated truck all over Japan. This movie was a big hit and caused a wave of Dekotora popularity around the country (Hemmy, 2008).

The Dekotora is a loudly decorated truck in Japan. Dekotora commonly have neon and ultraviolet lights, extravagant paints, and shiny stainless or golden exterior parts. These decorations can be found on both the cab and the trailer, and not only on the exterior but also in the interior. Dekotora may be created by workers out of their work trucks for fun, or they may be designed by hobbyists for special events. Dekotora does not refer to vehicles used for advertisements, political campaigns or propaganda.

The large scale decoration installations can change the length, height and weight of the truck. Therefore the decorations of dekotora trucks have to pass inspection to be approved for highway transportation.

Those colourful and lightful truck examples from Pakistan and Japan catch the viewer's eye because of the expressive theatrical aesthetics. Furthermore, the decorations could also be seen as an important safety feature, because colour and light makes the trucks more visible on the road, especially Japanese Dekotora trucks which are also visible during the night. Other drivers notice easily how big the Dekotora truck is and where the truck is. Colour and light features also break down the monotony and reduce boredom on the road.

Figure 3. *Dekotora Trucks.*

A DAY WITH A TRUCK DRIVER

I spent one day with a truck driver Ago Pukk in Estonia in December 2010. This was my first experience of driving in a truck. Until this experience I knew about truck driving from talking to people and reading literature but not actually experiencing and spending time in a truck myself. Therefore I consider this experience significant for my design project.

The experience of following a truck driver for a day was an educative experience for me. Along the journey I was able to observe the truck driver's work performance and ask work related questions.

The foundation of that experience was a trustful relationship between me and the driver. We were strangers in the morning we met. We were both Estonians and that made our communication easier. This was the reason why I did not choose to spend a day with Swedish driver and speaking English. Speaking Estonian, our mother tongue, made the communication smooth, comfortable and relaxed.

Ago Pukk has 14 years of experience driving a truck. He has done variety of driving related jobs. Before driving a truck he was a fire-fighter, a construction equipment driver and a taxi driver. He has worked for several companies and since 2010 he is running his own company with two other drivers.

The day I spent driving with Ago Pukk was long. We started driving at 9 AM and returned 9:30 PM. On that day the driver was working for 12, 5 hours. This was because of extremely bad winter weather conditions. The roads were very slippery, snowy and partly misty therefore we were driving slowly. We also spent long hours waiting loading deliveries.

On that day we were driving across the whole Estonia. We started in North of Estonia in Tallinn with an empty truck. We drove to Muuga harbour close to Tallinn to pick up a trailer with sofas to transport them to Tartu in South of Estonia. From Tartu we drove with empty trailer to small town Rõngu where we picked up metal construction parts. There we had to wait for 3 hours until the delivery was loaded. After that we headed to Paldiski harbour in Northern Estonia and left the trailer there. We drove back to Tallinn with an empty truck.

I was present and could observe majority of work related actions during that day: driving, loading and unloading goods, paperwork, eating, communicating with other drivers and work related people. I was also able to find out more about the driver Ago Pukk in person, why he choose to be a truck driver, what are his thoughts about his job, what has he done in his career as a driver.

Truck environment is very complex and consists of many different features. My aim was to find troubling and problematic aspects of truck driving and by the end of the day I had learned a lot about what could be done better to make the truck driver's work more pleasant.

Drivers do not want to have any extra functions; instead existing environment should be improved. I discovered that truck driver's needs are mostly basic and practical. There are many significant matters that could be improved, for example illumination and heat distribution in the cab.

Spending a day in a truck made the cab space comprehensible. After this experience it was easier for me to understand and perceive the size and the shape of the cab and how different activities are performed in a truck.

After a day spent with a truck driver I was filled with huge amount of new information which needed to be systemized and analysed.

ANALYSIS

CONTEXT

Truck drivers in the western countries are more concerned with functionality and usability than styling and visual harmony of their trucks. Practical usability or functionality is the first priority and visual harmony attributable to styling comes as second. In Asian countries visual aspects of truck as an environment are more dominant. Truck drivers in Asia pay a lot of attention and effort in decorating their trucks and making them more personal. For them, the trucks feel more like home. Most extreme are examples from Pakistan and Japan.

Traditionally, interest in human factors of automotive interior systems focused on packaging anthropometry and dynamic reach, control and display usability, interior system comfort, and micro-environmental ergonomics (Zhang and Shen, 1999). Additionally to human factors and ergonomics, emotional aspects should also be considered for the product development.

Emotional satisfaction of driving a vehicle depends on the perceived harmony, which is associated, but not equal to, the functionality, usability, performance and reliability of the vehicle. To create overall harmony for automotive interiors it is important to take into consideration functionality, perception, visual and emotional aspects together. Factors for visual harmony are: colour and emotion, geometric shape and spatial arrangement.

To design a harmonic environment for the driver, requires, first, a thorough understanding of their emotional needs and expectations, and second, an accurate translation of those feelings into design elements of the interface.

Figure 4. *Truck Interior.*

I have worked in automotive field previously and designed colours and textiles for car interiors. Therefore I assumed that working with trucks would be similar and familiar working environment for me. It emerged, that truck design differs from car design. Trucks are used for business, that is, to earn profit. Cars are consumer products which follow trends and users' taste and needs. There is a fundamental difference between the production and use of cars and trucks, even though those products may appear similar at a first glance.

Truck industry has thus far mainly focused on functionality and less on emotional side of driving. The current project concentrates on both, functional as well as emotional aspects of truck driving.

VISUAL INFORMATION IN THE TRUCK

From the technical point of view the truck environment is filled with huge amount of visual information. The driver has to pay attention to the screens and gauges, to the road for traffic and weather conditions.

Light and colour affects emotional aspects of the driver. Truck driver is on the road with various weather conditions, during different seasons and during day or night. Natural light changes dramatically during the driver's working period.

Automobiles have isolated humans from exterior conditions (road surfaces, air temperature and noise e.g.). Therefore humans in vehicles have lost their sense of movement. Driver on the freeway moves in a stream of traffic while visual details at close distances get blurred with increasing speed. The kinaesthetic and visual senses are separated from each other: soft springs, soft cushions, soft tires, power steering, monotonously smooth pavements create an unreal experience of the earth. Edward T. Hall (1990) states that driving an automobile is like "floating on a cloud above the road". Cars isolate humans not only from natural environment but from human contact as well.

Truck drivers are overloaded with visual information. The current project concentrates on analysis, design and development of alternative visual communication methods in truck driving.

SEEING

Seeing is highly influenced by culture and cannot be generalized to all human beings. Scientific experiments show that the way how humans see varies according to geographic location and cultural background.

The eyes of someone born and raised in Japan have a tendency to immediately grasp the entire image and spend the initial moments to noting and decoding the background. Western people approach the main subject of the image directly, and it is only afterwards that a contextualisation is made. In other words, a Japanese person takes in the totality of a situation, whereas a Western viewer focuses on the main objects. These differences are grounded in the different patterns of society and culture (Eliasson, 2006).

VISION

Nowadays public environment is heavily coded with visual information. The only sense that is fast enough to keep pace with the technological world is sight. Eye is the organ of separation and distance, it controls and investigates. French philosopher Michel de Certeau (1984, cited in Pallasmaa, 2005)) states: "Our society is characterized by a cancerous growth of vision."

Emotional well-being is largely dependent on visual perception. Imagination and daydreams can be simulated by dim light and shadow. The homogenous bright light paralyses the imagination, but the mist and twilight awakens the imagination by making visual images unclear and ambiguous (Pallasmaa, 2005).

Olafur Eliasson made an installation "The Weather Project" (2003) in Turbine Hall, Tate Modern, London where he worked with human perception and dim light. Eliasson used humidifiers to create a fine mist in the air with a mixture of sugar and water, as well as a semi-circular disc made up of hundreds of monochromatic lamps which radiated yellow light of single frequency. The ceiling of the hall was covered with a huge mirror in which visitors could see themselves as tiny black shadows against a mass of orange light.

"The Weather Project" evokes spiritual and emotional experiences of the surrounding environment and enables to reflect on one's own identity. It is an experience of timeless peace which makes you highly aware of your own existence as a physical and mental being among others.

Figure 5. *The Weather Project.*

EXPRESSION

The expression of the current project is based on visual perception of moving object. The inspiration for expression collected by filming and photographing visual field of a moving car.

Figure 6. *Visual Field of a Moving Object.*

The documentation was developed into abstract graphic patterns by drawing and folding 3D shapes. The outcome of sketching was the starting point for developing the final structures and patterns for prototypes.

Light Curtains prototype structure is inspired by high speed movement. The higher the speed the more abstract gets the visual field. The visual detail gets blurred in the stream of movement and it is perceived as lines in different colours and widths. Pleated lines in different widths are used for curtains structure.

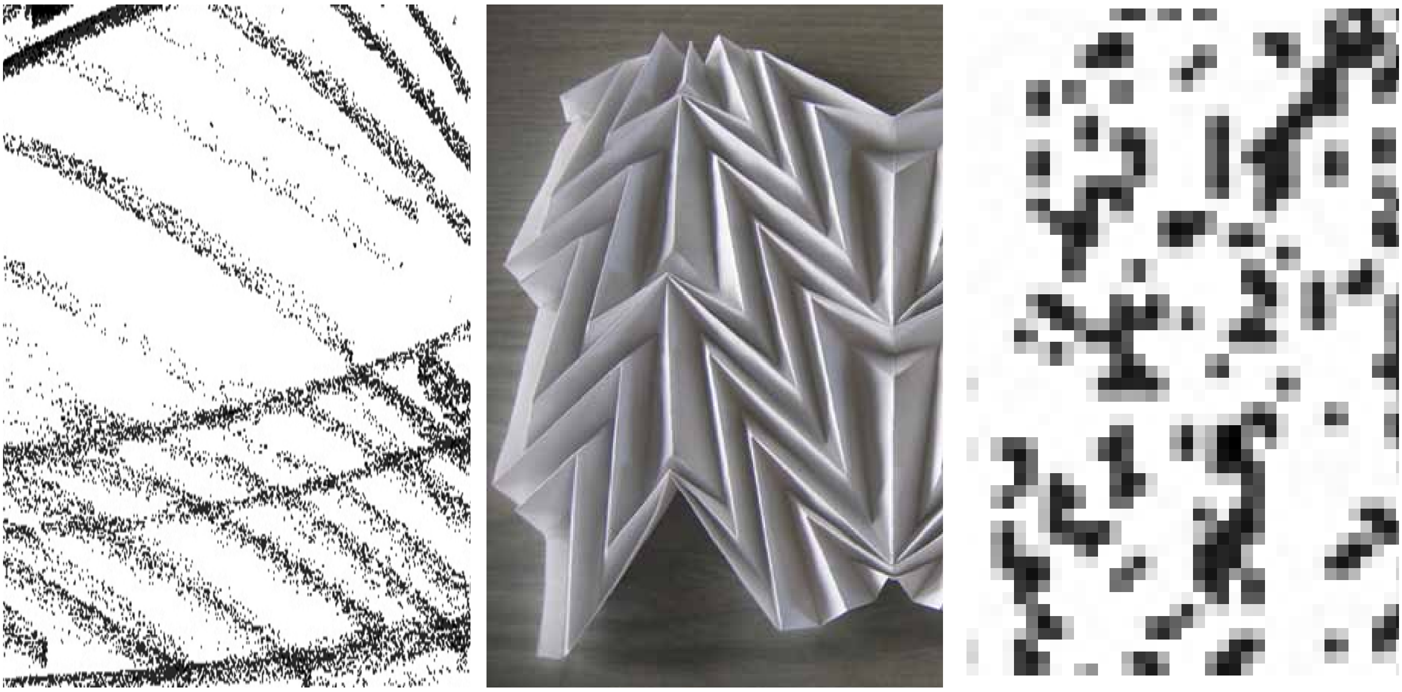


Figure 7. *Sketching Movement.*

Fatigue protoype is inspired by dotted expression of snow falling on the window of a driving vehicle. The pattern is developed using layered dotted patterns creating optic expressions.

Eco Driving has floral and dotted expression. Floral pattern is used to express the fragile character of nature. Abstract floral pattern has pixeled and dotted expression.

LIGHT

Light affects our physical and psychological state. Each situation requires different light conditions. Poor lighting might cause eye fatigue and headaches. Absence of natural daylight triggers depression and weakens immune system. Bright light stimulates us, while low levels of illumination quiets our senses. Harsh contrasts produce eyestrain. Too much artificial light and overly-bright rooms hurt our eyes and make us feel jittery. Insufficient lighting is linked to emotional stress and to physical ailments.

COLOUR

Colour perception is closely related to perception of light and cultural background, linked with memory and recognition. Our perception of colour is mainly derived from our cultural habitat. The Inuit, for instance, have only one word for red but several for white (Eliasson, 2006).

Anthropologists Brent Berlin and Paul Kay made a study in 1969 about worldwide colour naming. They argued that these differences can be organized into a coherent hierarchy, and that there is a limited number of universal "basic colour terms" which are used in individual cultures in a fixed order. Berlin and Kay based their analysis on a comparison of colour words in languages around the world (Bachelor, 2000).

Their analysis showed that, in a culture with only two terms for colours, those terms would mean roughly dark or black and bright or white. All languages with three colour terms would add red or warm as third colour term to this distinction. Thus, the three most basic colours are black, white, and red.

Figure 8. *Thermo Chromic Samples.*

Additional colour terms are added in a fixed order as a language evolves: first green or yellow then blue. All languages distinguishing six colours contain terms for black, white, red, green, blue and yellow. These colours roughly correspond to the sensitivities of the retinal ganglion cells, leading Berlin and Kay to argue that colour naming is not merely a cultural phenomenon, but is also constrained by biology. Berlin and Kay discovered that language is, at least partly, shaped by perception.

Black, white and red were chosen for the current project. Thermo-chromic inks are used to change from one colour to another.

SMART TEXTILES

The given project aims to challenge the visual information distribution in the truck interior by creating alternative ways of communicating visual information to the driver. Instead of signs and symbols on the dash-board, visual information is communicated through textile surfaces in the cab.

The truck cab is a small space where the driver spends both, working and leisure time. Cab is like a small home. The interior of the cab consists of textile surfaces: seats, bed, walls, ceiling, carpet, door panels, walls etc. Therefore one could say that almost the whole interior space is filled with textiles. That gives an opportunity to apply smart textiles on most of the surfaces.

In order to develop visual interfaces for truck interiors, visually responsible smart materials were chosen to work with: electroluminescence wire and panel for light and thermo-chromic ink for colour change applications. Those materials were studied and used for prototyping.

Driver spends most of the time lonely and is alienated from the surrounding environment. This leads to boredom and drowsiness related problems. Working with light and colour gives a possibility to adjust the emotional state of the driver.

Electroluminescence and thermo-chromic materials are dynamic and together with electronic applications it is possible to create interactive interfaces which react to driver's actions and respond to them.

Working with colour change and light applications challenges the monotonous truck environment aesthetics by adding dynamic patterns and materials to interior design.

Figure 9. *Electroluminescent wire.*

SMART TEXTILES

THE WORLD OF SMART TEXTILES

The world of textiles is one of the fastest growing and expanding design fields today. Emergence of new textiles has fundamentally changed the way we think of textiles nowadays. New textile field of smart textiles creates objects and environments that combine textiles with electronics and sensors. This is dramatically changing the way we relate ourselves and our senses to new textile products and environments.

Technology gets more and more involved into our everyday life, this makes us more familiar and trusting towards technology. A large amount of our living environment consists of textiles. Textiles are familiar, soft, friendly and tactile. Adding high-tech technology to textiles should not make the products more complicated. New technology should become seamlessly integrated into everyday objects, without altering their character, and enhance their function (Baurley, 2004).

Textiles are tactile, sensorial and visual. Those qualities can be adjusted, modified or even expanded when technology is added to textiles. In this way the passive textiles become active and interactive.

Intelligent materials give the designer new creative possibilities. The current project deals with colour changing and light emitting materials. The dynamic character of those materials adds a new dimension to the whole design process because smart light and colour materials interact with the surrounding environment and communicate with the user. That creates a totally new framework for the textile designer.

Traditional way of working with textiles is changed. It is important to investigate how people use, perceive and communicate through smart textiles. Sometimes the intelligent textiles even let the user become a co-creator. Much more important than the final product is the process of how the product is being used continually.

Communication between user and environment becomes more significant. Users require more intense experiences and meaningful relationships with the surrounding. Therefore also the product development focuses on human perception. It can be seen as a rebellion against purely material culture.

An intelligent world is one in which interactions with products become more intuitive, using materials and systems that are responsive to our communication (touch, body language). Intelligent materials will improve our control over our material environment and facilitate our creative interaction with it as we see to be co-creators, tailoring experiences to correspond to our various moods (Baurley, 2004).

It is important that designers investigate how people use, perceive and communicate with objects and environments. The field of smart textiles creates possibilities for collaborative work that creates a new platform for innovative design solutions.

COLLABORATION

Designing with smart textiles is largely a product of interdisciplinary collaborations. Architects have always collaborated with specialists of various fields (engineers, city planners, fabricators e.g.). The creation of smart textiles is performed in the similar way (Bonnemaison and Macy, 2007).

To create innovative design it is necessary to understand other disciplines such as material science, electronics, interaction design, ethnography, sociology etc. In the field of smart textiles collaboration between science and design creates possibilities for new solutions. Meta design collaborations create unique interdisciplinary knowledge sharing conditions where new products and environments can be developed.

Volvo Technology Human Factors department consists of specialists with variety of professions, for example: electronic engineer, sound engineer, computing engineer, doctor, psychiatrist and interaction designer. This is a meta-design environment where professionals with different knowledge and background collaborate and work together. In my design project I am pleased to exchange knowledge with people with variety of backgrounds.

SUSTAINABILITY

Environmental concern has been highly significant issue in the automotive field in past years. Cars have been one of the most environment polluting products and many developments have been done to change that situation.

Development has been done in automotive life-cycle phases of design, manufacture, supply chain management, use, and disposal management. The contributions are also set into the broader context of research into the global automotive industry, also the economic, social and environmental pressures confronting the industry. It is difficult to achieve a sustainable automotive industry, but several developments are in progress towards that difficult goal. Electric transportation and eco-fuels are one of the few examples that show the progression in automotive field towards sustainability.

Textile production has been one of the most unsustainable production fields. About one half of the world's wastewater problems are linked to the production of textile goods, also many chemicals used in the textile industry harms human health. There is no such thing as ecological textile production when it comes to mass production. To recycle textile composites and components is a big challenge for the future.

There are measures that can make this situation to change positively. Alternative ways of textile design, production, consumption and waste open up new opportunities for textile field. Research of new and less damaging textiles has lead into development of new fibres like Tencel for example, which is an artificial fibre produced in a closed loop system with no water or air pollution.

In designing with intelligent technologies and smart materials, designers are immediately confronted with the energy consumption and the longevity of the product. For example the development of wearable computing has been seriously hindered by the need for batteries to power the garment. Until this issue is addressed by technologists and designers, such products run the risk of being short-lived electronic gadgets (Collet, 2007).

Working with textiles in automotive field seems to be the most unsustainable design field. Yet, the last rapid developments are changing both fields to become more sustainable. Consumer pressure and governmental regulations, developments in automotive and textile production are changing this situation.

My design project proposals are prototypes which visualize design ideas and are therefore not ready for the production stage. The materials and the technology should be considered further for the production regarding the sustainability issues.

DEFINITION OF SMART TEXTILES

Smart textiles are materials that sense and react to environmental conditions or external stimuli, such as those from mechanical, thermal, chemical, electrical, magnetic or other sources (Tao, 2001 cited in Worbin, 2010).

Smart textiles are categorized as:

Passive smart materials – can only sense the environmental condition or stimuli, e.g. fire insulation materials.

Active smart materials – can sense and react to the condition or stimuli e.g. shape memory alloy.

Very smart materials – can sense, react and adapt themselves accordingly e.g. textiles with sensors.

Intelligent materials – are those capable of responding or activated to perform a function in a manual or pre-programmed manner e.g. textiles with pre- programmed sensors.

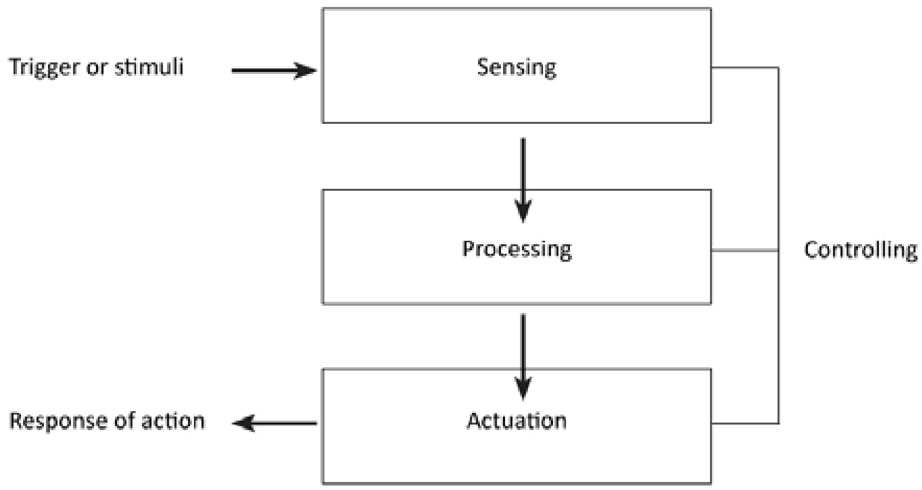


Figure 10. *Intelligent Materials.*

CONDUCTIVE TEXTILES

Conductive materials conduct electrical current very well. Conductive textiles are fabrics which can conduct electricity. Conductive textiles are made with metal fibres woven into the construction of textiles, metal coated fabrics or electrochemical impregnated nonwoven textiles.

Semiconducting textiles are made by impregnating normal textiles with carbon- or metal-based materials.

Conductive fibres consist of a non-conductive or less conductive substrate, which is then either coated or embedded with electrically conductive elements, often carbon, nickel, copper, gold, silver, or titanium. Substrates typically include cotton, polyester, nylon, and stainless steel to high performance fibres such as aramids and PBO.

Conductive textiles have good flexibility which accommodates the irregularities in the coupled surfaces and that ensures electrical continuity.

Conductive textiles used together with insulating textiles which have no conductive abilities create the possibility to make soft circuits directly into textiles.

THERMO CHROMIC INK (TC)

Thermo chromic screen inks are coloured below a specific temperature, and change to colourless or to another lighter colour as they are heated through a defined temperature range.

Thermo chromic effect was discovered in 1909 in Prague by chemist Hans Meyer. In the Thermo chromic ink the molecules arrange themselves in a special helical structure. As the crystals heat up the orientation of helices changes. Helices react on other wavelength of light. Therefore to our eyes it is seen as colour change. When the crystals cool down they go back to their initial arrangement. This makes the chromic patterns reversible depending on the temperature (How Stuff Works, 2009).

The inks are available in various colours and activation temperatures. Standard activation temperatures are: +8 ˚ C, +15 ˚ C, +27 ˚ C, +37 ˚ C and +47 ˚ C. Other activation temperatures range from -5 ˚ C to + 65 ˚ C.

Activation temperature is defined as the temperature above which the ink has completely changed to its final clear or light colour end point. The colour starts to fade at approximately 4 ˚ C below the activation temperature and will be in between colours within the activation temperature range. The colour change is reversible – the original colour will be restored upon cooling.

The inks have the same printing characteristics as normal water based screen inks. Therefore the chromic inks can be mixed with screen inks. In this case new colours can change from one colour to another lighter colour – the chromic ink disappears and screen ink is visible as the activation temperature is achieved.

Sensitivity

Thermo chromic ink is sensitive to long exposure to UV and fluorescent light; this can degrade colour intensity and change characteristics of the ink.

Extended exposure to very high temperatures, over +40 C, can degrade the pigment. The effect is time and temperature dependent.

Chromic materials are sensitive to chemical exposure. Because of the softness of the ink, it has excellent anti-alteration properties.

The chromic inks should be stored in a dry, cool place, away from direct exposure to light, especially sunlight.

Activation

The chromic colour is changing due to temperature change. In case of combining the chromic textile prints with conductive materials, e.g. conductive yarn, it is possible to apply electrical current to achieve the colour change.

ELECTROLUMINESCENCE MATERIALS (EL)

Electroluminescence converts electrical energy into light without generation of heat.

Electroluminescent phosphor was discovered by George Destrian in Paris in 1936. Electroluminescence is an optical and electrical phenomenon in which a material emits light in response to the passage of an electric current or to a strong electric field. Electroluminescence is the result of radiative recombination of electrons and holes in a material, usually a semiconductor. The excited electrons release their energy as photons – we see that as the light (Luminous Film, 2010).

EL- WIRE

EL- wire is a light emitting capacitor. The capacitive structure is developed with the light emitting electroluminescent semiconductor layer sandwiched between two conductive electrodes.

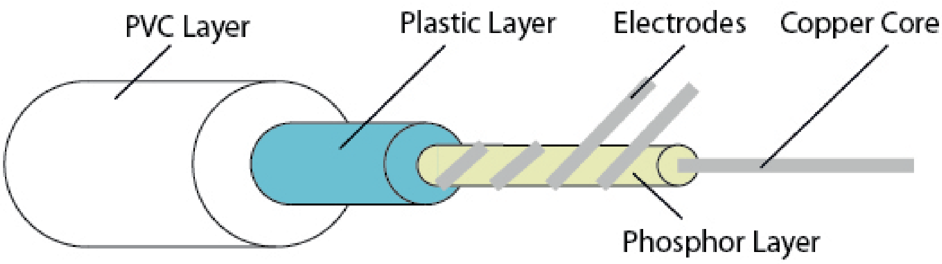


Figure 11. *EL- wire.*

EL- wire is a layered material:

1. Copper core which is the conductor for EL- wire alternating current (AC) power system.
2. Coating of electroluminescent phosphor which emits light after encountering an AC electric field.
3. Two electrode wires wrapped around phosphor.
4. A pair of plastic and PVC sheaths which protect phosphor material from moisture and the user from electric shocks.

Copper wire is a core electrode and is coated with several layers of dielectric and semi-conductor materials which together form a coaxial construction. A transparent conductive layer is then added with two thin copper wires which serve as the second electrode and when AC voltage is applied between two electrodes and exceeds a well-defined threshold value, the semi-conductor material between the two electrodes emits light.

EL- wire is flexible, durable and tough. Wire can be twisted into almost any shape and form, can also be cut into arbitrary lengths. The wire is available in a wide range of colours, it can dim or flicker. Some wires can change from one colour to another (e.g. green to blue) depending on the current given. The wire is also UV- resistant.

The wire emits no heat and therefore is cold to touch. Its operation is nontoxic and safe.

EL- wire is an efficient material due to low energy consumption. It can be operated from 220/110V AC with AC to DC adaptor or from a DC battery source 1.5 – 24 V DC.

The brightness of the wire can be varied by changing the voltage and/or frequency. The brightness of the wire makes it ideal for indoor or outdoor dark and semi-dark environment applications. Due to its low working current, it has no harm to human body.

An inverter should be used to convert DC into AC power. Multiple wires can be connected in parallel to a single inverter. For the greatest efficiency the inverter must be matched to the characteristics of the EL- wire: battery or mains operated, wire length, required brightness, expectant lifetime.

EL- wire can be programmed and animated with sequencer circuit board.

Lifetime

The wire does not fail to light suddenly; instead it will gradually loose its brightness over a long period of time used. The lifetime of the EL- wire is affected by voltage, frequency, temperature and humidity. Depending upon the drive circuit used and the minimum brightness required in the application, the lifetime may be as much as 25000 hours or more, when connected directly to 50/60 Hz. Repeated turn ON and OFF cycling does not affect the EL- wire performance. In contrary, at lower frequencies, even an improvement of up to 30% of useful lifetime can be achieved.

EL-PANEL

EL- panel is basically the same material as EL- wire but in the shape of a flat sheet. Electroluminescent panel is paper thin, flexible, light-weight. The panel generates no heat and is not affected by vibration. EL- panel is landfill

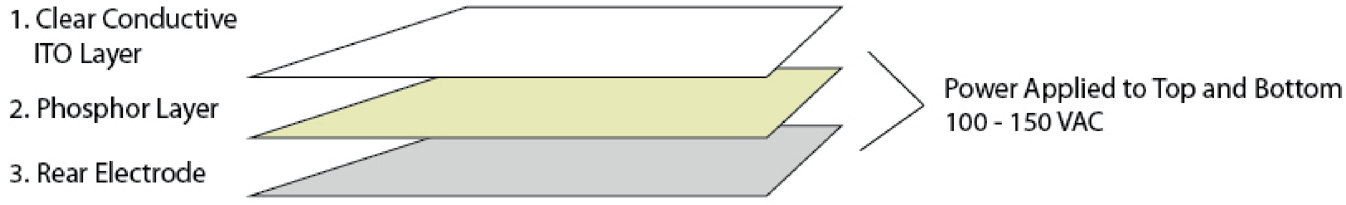


Figure 12. EL- panel.

friendly and consists of no hazardous materials.
EL- panel consists of a rear electrode, phosphor layer and a clear conductive ITO (indium tin oxide - transparent conducting oxide) layer.

EL- panel light is visible from long distances, yet it does not function as a light-source. The wavelength of the light is rather short and therefore the panel cannot be used as a lamp. The panel is highly visible in darkness, pleasing to the eye, easy to look at and does not impair night vision.

The panel does not burn out suddenly and consumes low power. The higher the voltage and/or frequency, the brighter the light, but the shorter the life of the panel. Turning ON and OFF will not affect the operating life time of the EL- panel.

Colour can also be adjusted by adjusting the frequency. Blue and green phosphors tend to have the longest life and brightness. The quality of the phosphor depends on the supplier.

Some suppliers encapsulate the phosphors. Encapsulated phosphors have each microscopic phosphor particle surrounded by glass-like protector. This protects the phosphor from moisture. Lamination adds extra protection to EL- panels.

The panel can be cut by knife, laser or plotter. The panel should be sealed after cutting to prevent moisture invasion or electric shock.

Electroluminescent panels have a recommended working voltage of 100 V at 600 Hz.

Lifetime

The quality of the EL-panel depends on the quality of the phosphor and manufacturing factors.

EL is technically a permanent light material but the decreasing luminance level in a particular application indicates when it is no longer useful.

The decreasing luminance is more rapid in the beginning and extremely slow later in time, which is also greatly affected by how the phosphors are powered: the inverter's output, voltage and frequency. By air temperature; cold temperatures yield better results than warm temperatures.

By increasing the voltage it is possible to increase the lost brightness level of the panel. In one test for example, samples were run at 25, 50, 75 and 100% starting voltage. After 2 years of running 24/7, and continuously increasing the voltage, the panel started at the 25% level was the brightest of the 4 samples and the other 3 were virtually the same (Luminous Film, 2010).

SMART TEXTILES IN AUTOMOTIVE FIELD

Automotive design has always been striving towards innovative and spectacular designs. Several car companies have developed smart textile concepts for show cars. Unfortunately no smart textiles have been mass produced in automotive industry. Yet, the development of smart textile technology is evolved rather far and therefore it is predictable that smart solutions are soon mature for mass-production.

Rinspeed Senso

Swiss automobile manufacturer and tuning company Rinspeed developed a concept for Senso model in 2005 in Geneva. That concept car has a system for detecting and influencing the emotional state of the driver. The idea behind is that a positive stimulus from the car should make the driver drive more safely.

A biometric watch measures the drivers pulse, a mobile eye-camera records the drivers driving behaviour and thereafter a computer evaluates the measured data and offers the driver visual, acoustic and olfactory stimuli which depend on the driver's current state of mind. Interior LCD monitors and electroluminescent surface finishes illuminate in different colours: orange red to excite, blue to calm etc (Ritter, 2007).


Figure 13. *Rinspeed Senso.*

Citroën C-Air Lounge

Brochier Technologies developed the first luminous fabric for car interiors to improve the passenger's comfort. Citroën C-Air Lounge concept car was shown in Frankfurt in 2003. For comfort, the passengers of C-Air Lounge could choose between different lighting environments which totally transform the passenger compartment from floor to roof. The car furnishings become active lighting parts thanks to optical fibres and video projectors placed in the carpet and armrest upholstery (Brochier Technologies, 2003).

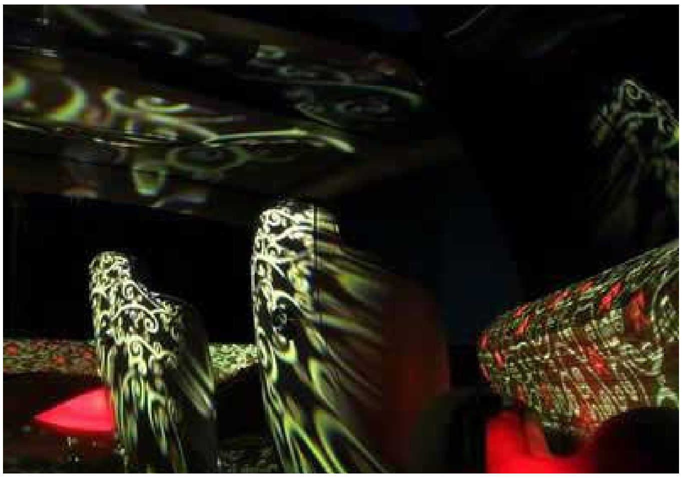



Figure 14. *Citröen C-Air Lounge.*

BMW Gina

BMW presented an innovative exploration in car design, a concept car Gina in Munich in 2008. Instead of the traditional steel and plastic body shell, the outer skin is made entirely out of textile fabric which is pulled around a frame of metal and carbon fibre wires.

The skeleton of the car is controlled by electro-hydraulic devices and can actually move and change shape beneath the fabric skin. For instance, the headlights of the concept car can be exposed or hidden by the car's skin just like blinking eyes, and the hood opens from the centre as the fabric parts to expose the engine (BMW USA, 2008).

Figure 15. *BMW Gina.*

If the whole car can actually be made of textiles, it opens up a wide range of possibilities to integrate smart textile solutions in the car. Gina is a grate example of how far it is possible to go with textile design.

LEARNING SMART TEXTILES

Smart textiles is a relatively new and rather small design field. It is possible to learn smart technology by participating workshops, having supervisions with researchers and by learning independently from literature and online sources.

I have used thermo chromic inks, electroluminescent film and wire in my previous projects. The challenge for the given project is to learn about sensors, circuits and programming. Majority of the technical knowledge of the current project is gained from open source recourses, mainly from soft electronics websites (e.g. www.kobakant.at).

Open Source

The term open source describes practices in production and development that promote access to the end product's source materials. Open source knowledge is usually developed as a public collaboration and made freely available.

Arduino

Independent learning of the basics of programming Arduino microcontroller was the starting point of understanding the world of textile electronics. For the given project microcontrollers are used to activate the colour and light patterns in textiles.

Arduino can sense environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language which is based on Wiring and the Arduino development environment which is based on Processing. Arduino projects can be stand-alone or they can communicate with software running on a computer (Arduino, 2010).

Arduino is an open-source electronics prototyping platform which is used by artists and designers. Arduino hardware designs have open-source license therefore everyone is free to adapt them to their needs. The software can be downloaded for free.

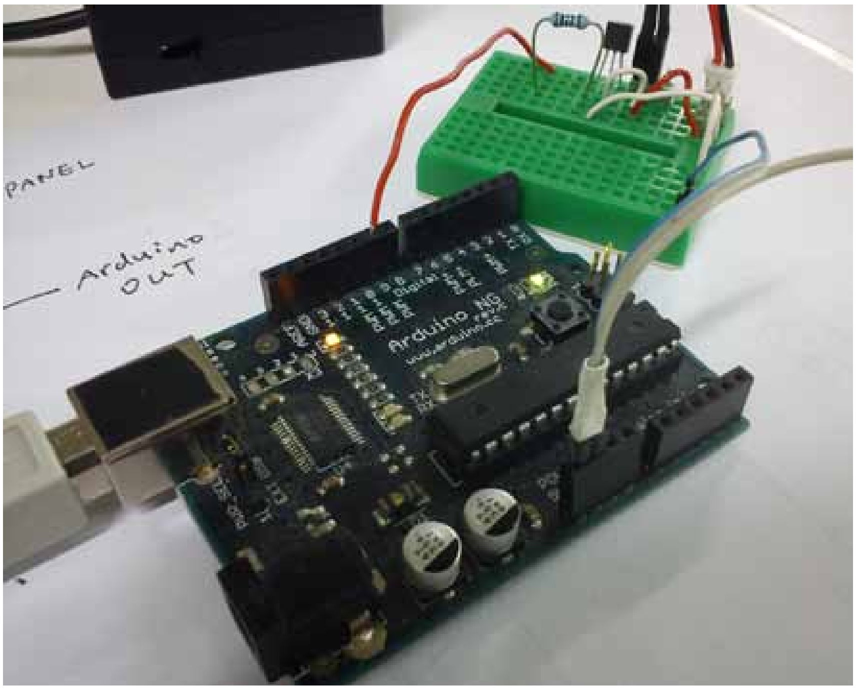


Figure 16. *Arduino.*

Sharing

Collaboration and knowledge sharing is a very common working method when it comes to textile electronics. Many projects are documented and shared introducing interesting techniques and possibilities of working with textile electronics and soft circuits.

Learning from others by studying and following their projects was a continuous method for current design process. Throughout learning the technology I was studying about other projects using similar technological solutions. For example a Heartbeat Straight Jacket is using animated electroluminescent technology – that was a starting point to learn about programming of EL- panel in current project (Sparkfun, 2010).

Workshops

The most efficient way of learning smart technology is participation in workshops. This is a very efficient hands-on approach to study from people with specific smart textile and electronics experience and knowledge. Workshops gave a great input for learning smart technologies.

Following workshops helped to understand and learn about smart textiles and technology:

"Wearable Technology" workshop at Espira in Borås led by 1scale1
3rd of February 2011

1scale1 is a Critical Research Studio which is developing interactive media solutions for architecture, event production and prototyping of new digital artifacts for projects in industry, education, culture and research. 1scale1 is also involved in educational activities through the generation of conceptual and technical workshops all around the world (1scale1, 2011).

Workshop was led by David Cuartielles who is also a co-founder of Arduino. The workshop covered the basics of Arduino programming, making of textile sensors (button, pressure and zipper sensors) and building of circuit boards for the sensors.

"Thermo Chromic Colours" workshop at THS led by Marjan Kooroshnia and Mika Satomi
16th- 17th of February 2011

The basics of thermo chromic colour mixing and printing was covered by researcher Marjan Kooroshnia. Printing on the fabric with conductive thread, building a circuit for the fabric and programming was covered by researcher Mika Satomi.

"Syntjuntan" workshop at THS led by Syntjuntan and Linda Worbin
21st – 22nd of February 2011

Syntjuntan is an ensemble of female composers, musicians and instrument builders. Linda Worbin is a researcher at THS.

The workshop covered the building of textile synthesizer, experiments with different conductive textiles and yarns.

"Fabric Electronics" workshop at THS led by Mika Satomi
16th – 17th of March 2011

The workshop covered making of fabric sensors, button and pressure sensor, reading sensor values with multi-meter, reading of sensor values with Arduino board, introduction to Arduino programming.

BRAINSTORMING

SKETCHING

Brainstorming, using sketching as a fast method, was based on the information gathered during research, analysis and from the experience of spending a day with a driver.

First sketching phase aimed to express all ideas that came into mind. This method was used before research and without significant knowledge about the trucks.

The first sketching phase opened the artistic design process. The outcome was experimental and less related to specific truck driving functions. The second sketching phase followed after research. This sketching phase was more conscious and related to actual truck environment.

The first phase of sketching was free of constraints whereas the second phase was more restricted by actual truck environment.

Results were analysed, reflected upon and arranged into three scenario categories. Ideas were modified, blended and some of them eliminated.

DEVELOPMENT OF SCENARIOS

The outcome of the sketching phase was divided into three scenarios groups:

1. Safety (active + passive)

Active safety technology is used for assisting crash prevention. Passive safety features are components (primarily air bags, seat belts and the physical structure of the vehicle) which help to protect occupants during a crash.

2. Security

Security technology is used against robbery, danger and damage. It is also a system to notify driver about his drowsiness.

3. Work and Living.

Work and living related features in the truck.

Categorization was used to manage brainstorming results and to have an overview of the design proposals.

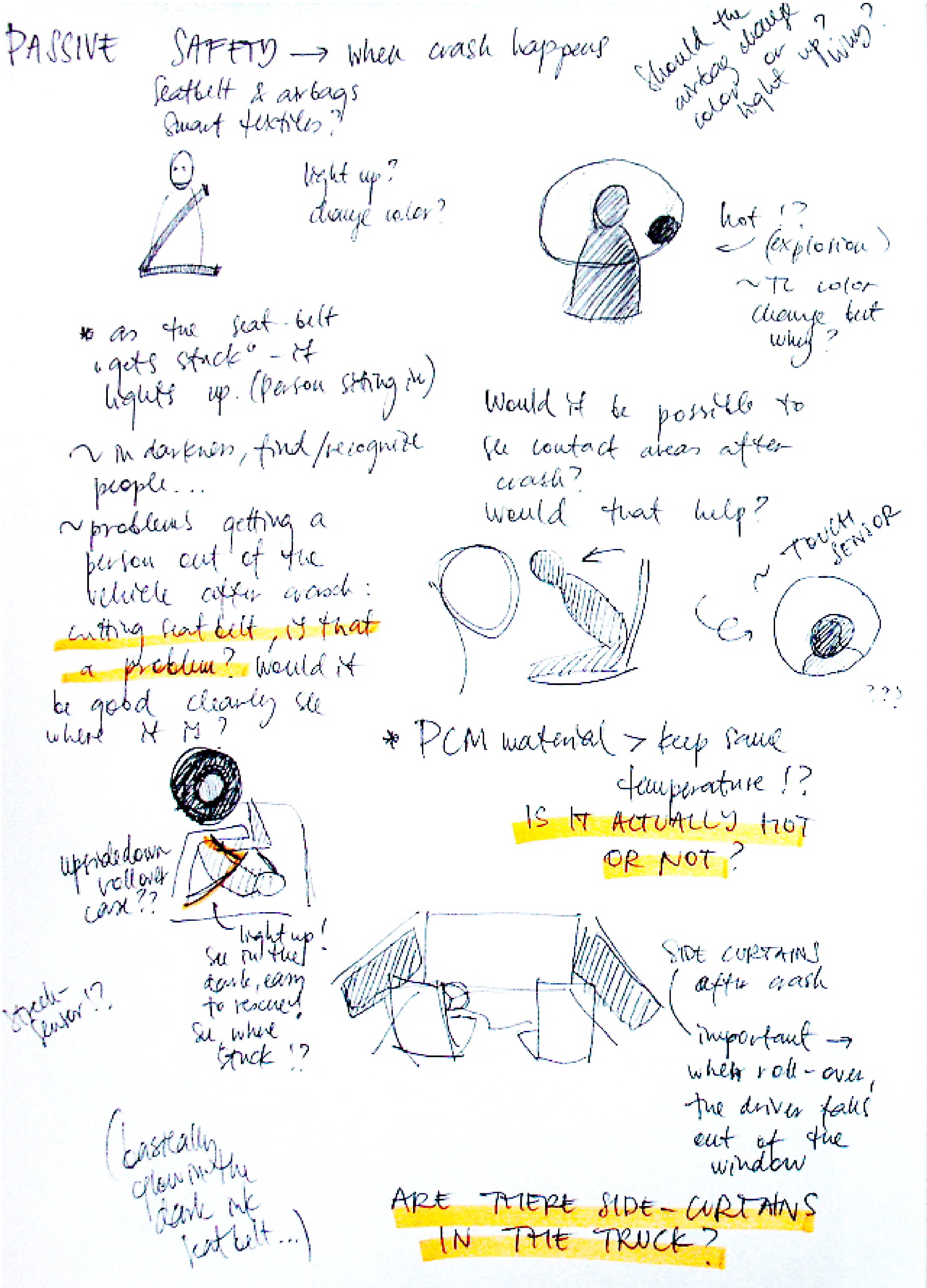


Figure 17. *Sketching.*

BRAINSTORMING AT VOLVO TECHNOLOGY

The aim of this meeting was to introduce smart materials, textile techniques and possible application areas for truck environment together with Volvo Group departments. Another aim was to get feedback for design ideas and run a discussion about smart textile solutions for Volvo products.

The meeting started with a brief smart textiles introduction and presentation of smart material examples. After the short presentation the participants wrote down the first design ideas that came to their mind. Everyone could propose their own concepts how it would be possible to implement smart textiles into truck environment. Those new ideas were attached on the wall and categorized under the scenarios: safety, security, work and leisure.

Figure 18. *Ranking at VTEC.*

RANKING

The outcome of the voting was analysed and systematized according to function. Most interesting smart textiles solutions were about multifunctional surfaces, hidden information and integration of interface in existing fabrics.

Summary of the voted ideas:

21 points – Ambience light distribution in the truck
11 points – Information on the steering- wheel (speeding, weather, eco-driving)
10 points – Integrated buttons in the gloves
8 points – Detection when the driver becomes ill or sleepy
6 points – Key that glows in the dark
Door lights up when door is open
Shape- memory alloy curtains which can change the shape
5 points – Seat adjusted to driver's body temperature
3 points – Blind spot detection
Seat belt informs to use the seat belt

Finally three themes were selected to continue with in the prototyping process: Light Curtains, Fatigue and Eco Driving.

The questions about cost, durability, industrial production and life- span of smart textiles were discussed. Further investigation needs to be done to answer those questions.

It occurred that smart textiles have a great potential to be used in automotive field. Smart textiles could add new possibilities with new techniques and add values on existing products. They could also give financial and competitive advantages to the vehicle industry and opportunities to start new business-related collaboration with organisations and research centres.

Organizers:
Sagesjö Marjukka (Human Factors Volvo Technology)
Esberg Ida (Human Factors Volvo Technology)
Heyden Anna (Human Factors Volvo Technology)
Kisand Marta (Swedish School of Textiles)

Participants:
Carin Eriksson (Thesis worker CAB)
Helene Fredäng (Textile Engineer Volvo 3P)
Karin Göpfert Agrenius (Thesis worker CAB)
Ulrika Hjulströ Ohlin (Designer Volvo 3P)
Jonas Nordquist (Feature Manager Volvo 3P)
Hannele Nurmi (Feature Leader for Material and Environmental Impact and Fire Safety Volvo 3P)
Åsa Rudberg (Design Volvo 3P)

PROTOTYPING

Three themes were chosen for developing prototypes: Eco Driving, Light Curtains and Fatigue.

During the brainstorming sessions several ideas emerged which regarded steering-wheel as a good surface for communicating driving safety issues. Smart textiles could be applied for communicating safety information, e.g. speeding, to the driver. Those safety notification aspects are punishing – the pattern appears when driver does something wrong. For example, when the driver is speeding, the pattern lights up. The danger of that kind of application is that the driver might start speeding up on purpose to see the pattern changing. Therefore I chose to work with rewarding applications instead, e.g. eco driving pattern that lights up when the driver starts to drive ecologically.

ECO DRIVING

Problem

Ecological driving is one of the major rising issues in the automotive field today. Car and truck producers are aiming for more ecological products, production and environments, but personal contribution is also important for the environment. Detailed observation of every single driver's behaviour helps to understand what could be done better to improve individual driving performance.

Marie Ingemansson and Nafiseh Mahdavian did an in-depth research about eco-driving attitude among truck drivers and developed suggestions on how the concept of an eco-driving interface should be designed specifically for trucks. They interviewed truck drivers, office personnel, experts and truck driver students.

The attitude towards eco-driving is similar for the employed driver who does not own the truck and the driver who owns a truck. Economical aspect is the most concerning for the truck owner since he/she has to maintain the business. Economical pressure creates both, positive and negative opinions towards eco-driving. Employed drivers want to be trusted and not monitored from the back office or being punished for higher fuel consumption.

Although drivers are positive towards eco-driving, they never think of it when they are working. Automatic gear shift handles by itself and drivers focus on engine indicators which tell them if something is wrong with the truck. They expect the truck manufacturers to construct better trucks and develop better fuels. Eco-driving is ambiguous to many drivers, it goes too slow when driving eco friendly, they say, "it does not always work" is the attitude and they believe that many drive faster to save time – which is money (Ingemansson and Mahdavian, 2011).

It appears that drivers have different opinions on how eco-driving should be communicated to them. One common opinion is that the system should be as simple as possible since there are many aspects the drivers need to concentrate on while driving.

Majority of the questioned drivers preferred real time communication instead of information that is compiled over a longer period of time. At the same time not too much of information should be communicated in real time, just the most important aspects (e.g. traffic conditions).

The question regarding how the eco driving system should be activated, either automatically or manually, was equally answered. Almost half of the drivers preferred automatic response and another half manual one.

The best solution would be a system that is manually adjustable so that the driver has the freedom to choose weather he/she wants to receive eco-driving information. The system should immediately and in real time transmit the most important information. Detailed information should be possible to receive afterwards.

Design

Eco-driving interface as an electroluminescent light pattern on the steering-wheel which informs the driver about ecological driving performance.

The proposal for eco-driving interface consists of two systems. First, a simple pattern on the steering-wheel that communicates a summary of driving to the driver. This gives the driver an idea of how well he/she is driving. The pattern lights up step-by-step the better the driver is driving. Secondly, it is possible to look at a detailed account of driving from the computer that measures and calculates all driving aspects in detail.

The system should be manually activated when desired. The driver should be able to maintain and adjust the parameters he/she wants to know about driving.

Figure 19. *Eco Driving Sketch.*

The pattern is located on the steering-wheel. This is a large empty surface in front of the driver that is not used for communication purposes. Inside the steering-wheel is the air bag and applying smart fabric on top of it will not affect the air-bag function since the fabric is thin, lightweight and flexible.

Interface communication methods were explored for the light up pattern. Instead of making a small diagram or a sign on the dash board a larger pattern for the whole steering-wheel surface was developed. A huge circular pattern and spread pattern were investigated. For the final prototype spread pattern was chosen.

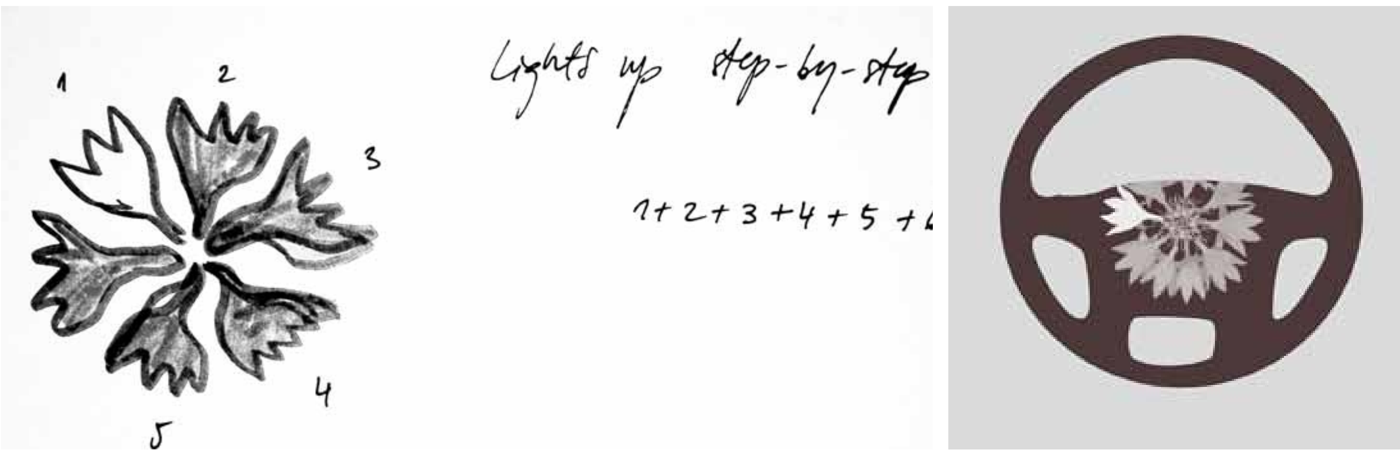


Figure 20. *Circular Pattern.*

Figure 21. *Spread Pattern.*

The spread pattern is challenging the drivers' visual perception. Instead of small step-by-step growing diagram the pattern is spread on the whole steering-wheel. The pattern lights up randomly and the driver perceives the steering-wheel surface as a whole.

Expression

The pattern on the steering-wheel consists of graphics which light up in several steps. If nothing is lit up, then the driver is not driving eco-friendly. When the driver starts to drive ecologically, the pattern starts to light up step-by-step. If the whole pattern has lit up, it means that the driver is driving very eco- friendly.

Black color was chosen for background and white colour for light surfaces. Dark and light contrast makes the pattern well visible and the driver receives information easily.

Proposal A is a pattern inspired by linnaea borealis flowers. The flower is the provincial emblem of Småland province in Sweden; some sources refer to it as a Swedish national flower. Small, fragile and slender flowers were chosen to represent Swedish nature as an eco-driving symbol. Fragility of the plant represents the fragile character of nature.

Figure 22. *Linnaea Borealis Pattern.*

The pattern of linnaea is developed into pixelated abstract graphics and therefore not directly perceived as floral pattern. Yet, the pattern maintains its organic character. Graphics lit up step-by-step which is perceived as movement/growing.

The blossoms of the flower light up one-by-one when the driver starts to drive ecologically. The pattern grows and develops according to the driver's performance.

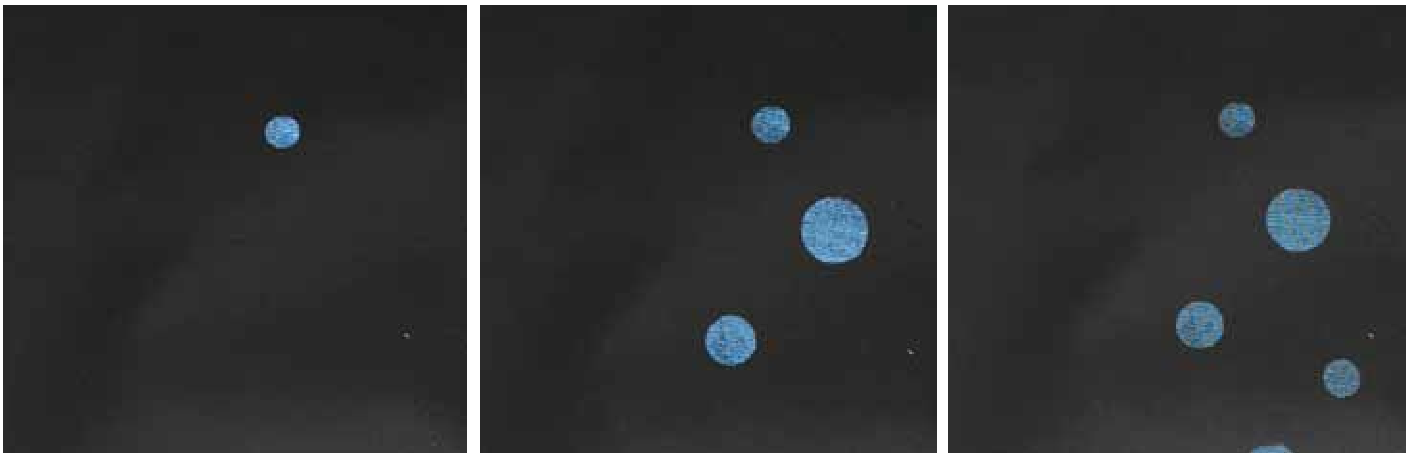


Figure 23. *Plain background dotted pattern.*

Proposal B is a pattern which occurs from plain background. Graphic pattern lights up as white and becomes visible from black background step-by-step.

The pattern is simple and geometric. Dots in various sizes become visible as the driver drives ecologically.

Technology

Polyester fabric is printed with transfer print technology. Pattern that lights up is cut out from the light proof fabric. Polyester and lightproof fabrics are hot melted together with polyfilm sheet at 180 C for 45 seconds.

The EL-panels are glued on the holes where the light up pattern is cut out. The panels are connected to the EL-sequencer, inverter and 9 V battery.

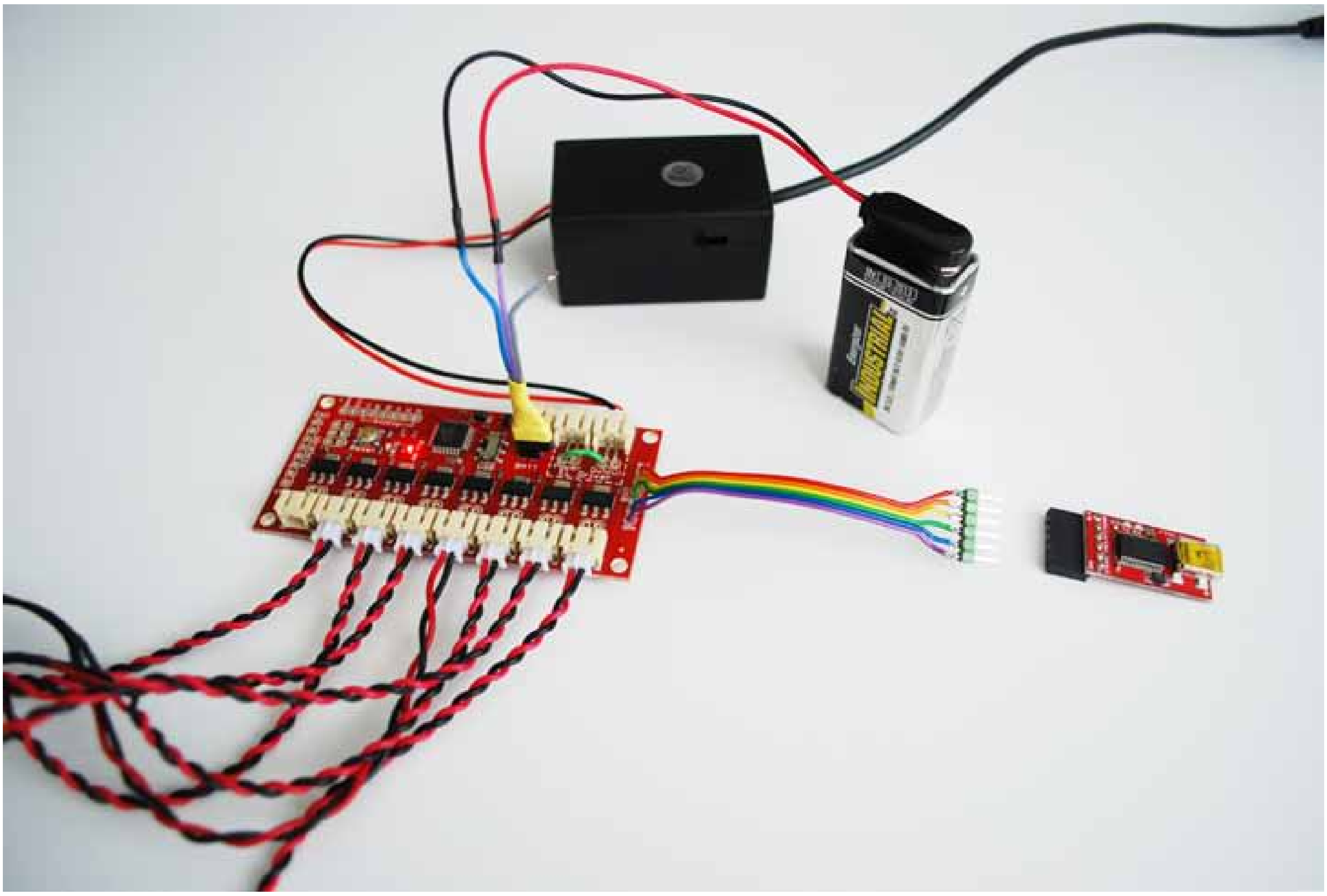
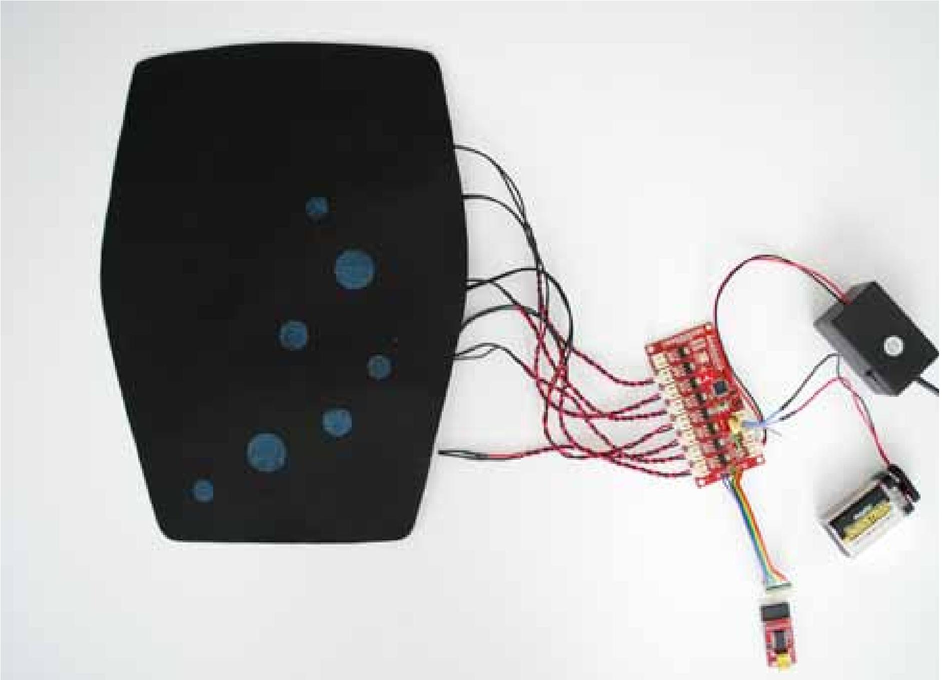


Figure 24. *Eco Driving Technology.*



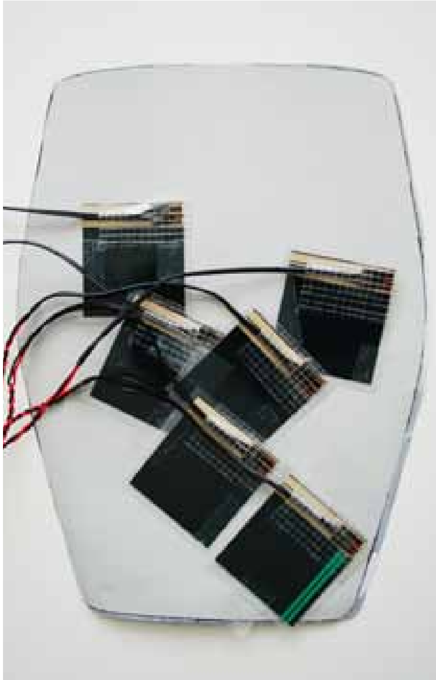


Figure 25. *Eco Driving Materials.*

The pattern is programmed with Arduino to perform step-by-step light up pattern when the pattern is activated. EL-panels are used for this project due to quick reaction time. The panels can light up in real time accoring to the driver's driving performance.

Materials

100% Polyester fabric (Furulunds Modetyger AB)
Lightproof fabric (F.O.V. Fabrics AB)
Polyfilm (Zijdelings)
EL-panel 5 cm x 5 cm, 6 pieces (Thinlight Sweden AB)
Inverter (ThinLight AB)
EL-sequencer (SparkFun Electronics)
Battery 9 V

Figure 26. *EL-panel*

Reflection

The light emitting electroluminescence material is used in the given prototype in the form of a panel. For production, printing with electroluminescence directly on the fabric should be considered. That would avoid using layered textiles; instead one layer of textile with printed EL pattern could be used.

For example, a design and research studio Loop.ph used printed electroluminescence technology for a collection of dynamic display wallpapers Blumen. The pattern is animated and controlled with different sensors – the pattern develops and emerges in response to the environment (Loop.ph, 2004).

Figure 27. *Blumen Wallpaper.*

The Eco Driving protoype should be tested on actual truck with different light conditions. The light up pattern might not be well visible with very sunny weather.

Another aspect that should be considered is whether the pattern might disturb the driver since the prototype is located on the steering-wheel right in front of the driver. Quick changes in the pattern might irritate the driver therefore the pace of the light up pattern should be considered.

Figure 28. *Eco Driving pattern in truck cab.*

Figure 29. *Eco Driving pattern on steering-wheel.*

FATIGUE

Problem

Trucks become more and more automated and drivers need to perform fewer actions while working. In automated vehicles the drivers get bored and that causes problems for traffic safety. Technology has developed so far that theoretically there is no need for human drivers any more.

Google came up with a concept where a car can drive by itself using artificial-intelligence software that can sense the environment near the car and mimic the decisions of human drivers. Google car is using video cameras, radar sensors and a laser range finder to sense the traffic around, as well as detailed Google maps to navigate on the road. This is all made possible by Google's data centres, which can process enormous amounts of information (Nytimes, 2010).

This is an example of 100% automatic car that actually works. Yet, it seems that society isn't ready to entirely trust that kind of technology. We can't go back to fully manual vehicles either. Therefore it is important to find the balance between automatic and manual technologies used in vehicles.

Technological development makes truck-driving increasingly automated. The drivers get bored and sleepy when they don't have enough activities to stay alert. Having discussed the topic with a driver, I found out that for example driving long and straight German highways, the drivers tend to entertain themselves with other actions. Drivers either watch a movie from a laptop or, in a worst case, read a book. That is very dangerous for the surrounding traffic environment and accidents may easily happen.

It is important to find possibilities how to keep the driver alert and energetic without distracting him/her.

Design

Fatigue — dynamic pattern to notify the driver about his/her physical condition. Thermo-chromic pattern on the dashboard changes colour when the driver gets tired or sleepy.

The design proposal is a dynamic thermo chromic pattern that surrounds the driver's visual field. The pattern is located on the front panel, on the pillar and on the driver's door. As the driver starts to get more tired, the pattern starts to change colour. The more the pattern changes, the sooner the driver should take a brake.

The pattern could be connected either to tacograph or to impairment warning system. Tacograph is calculating the time the truck has driven. The drivers need to have a brake every 4.5 hours and the pattern could change according to the calculated time. The impairment warning system can read the driver's eyes and detect driver's drowsiness. The pattern could change according to driver's physical condition.

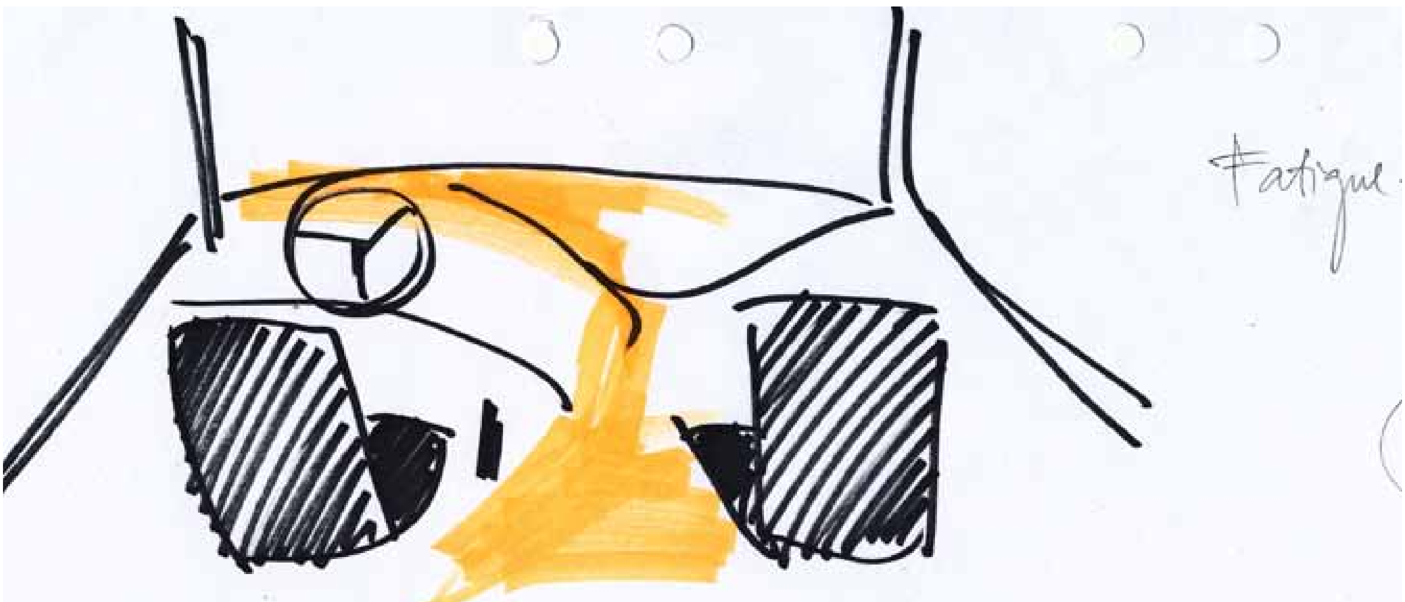


Figure 30. *Fatigue Sketch.*

Graphics

The truck environment is filled with huge amount of visual information. The driver has to pay attention to screens and gauges, has to follow traffic and weather conditions. The driver perceives movement in traffic as a continuous flow and peripheral vision is blurred.

The optic graphics for fatigue theme are inspired by movement, blurred vision and overflow of information. The graphics are constructed of dotted pattern which creates a strong optical effect. This pattern should draw the driver's attention and remind him/her to take a break.

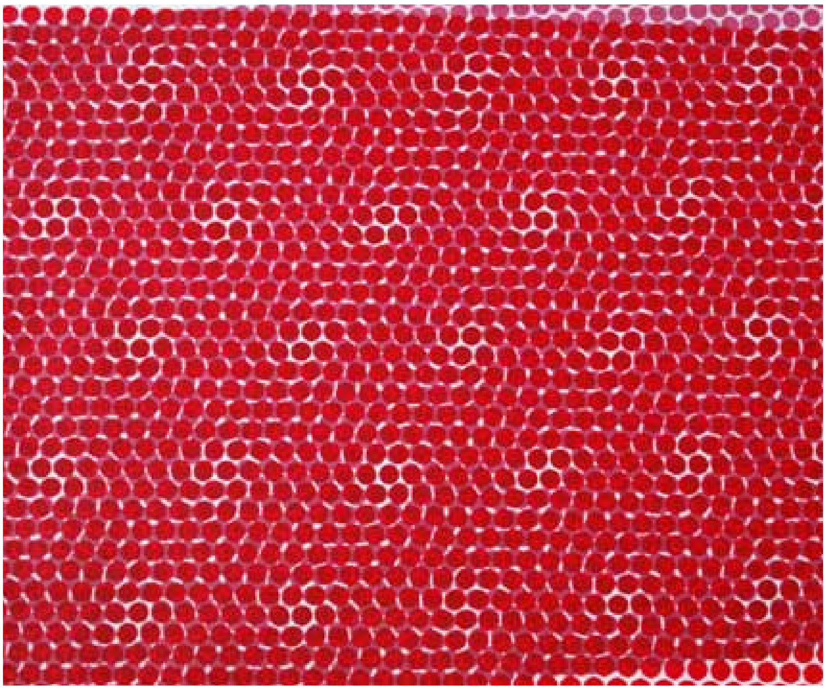


Figure 31. *Dotted Pattern.*

The screen printed graphics are constructed of two layered dotted patterns. Both patterns contain dots in same size but the distance between the dots is slightly different. When those patterns are layered, an optical effect is achieved. Variety of patterns can be created using the same two screens. By changing angle of layered patterns, new expression is created. This method is useful for creating multiple patterns using only two screens.

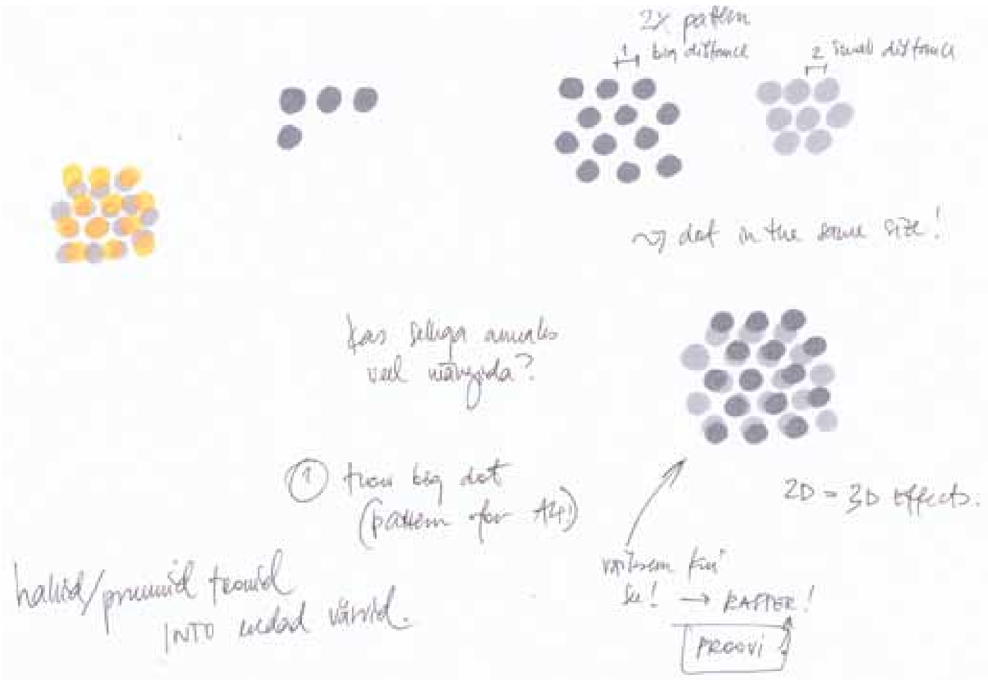


Figure 32. *Sketching Optic Pattern.*

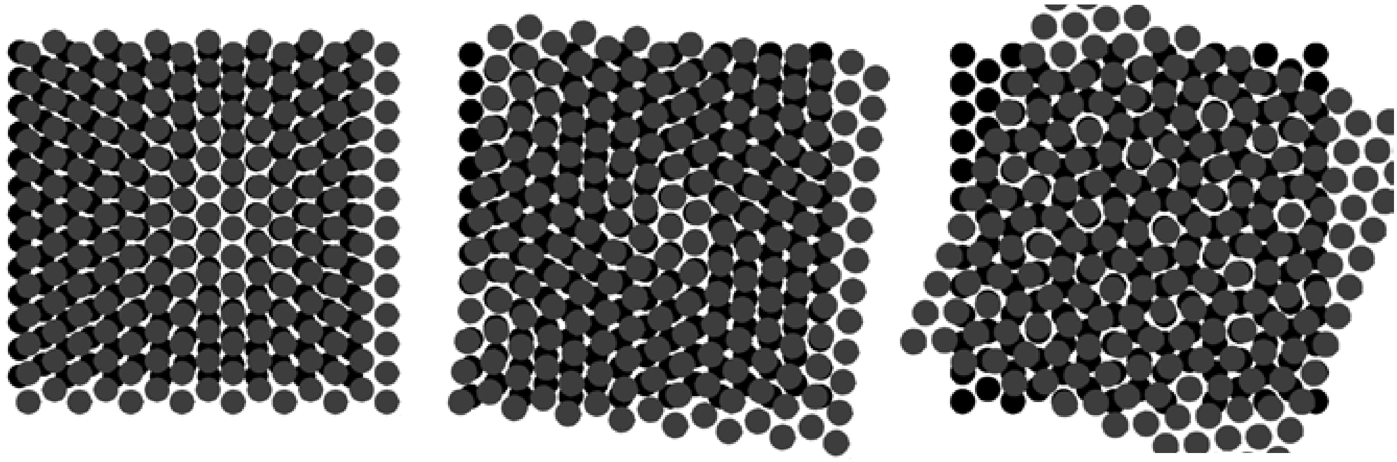


Figure 33. *Two Screens and Variety of Patterns.*

Fatigue detection pattern changes from dark to bright colour. Dark grey and brown pattern turns into red. Red colour is used to catch driver's attention and remind him/her to take a break.

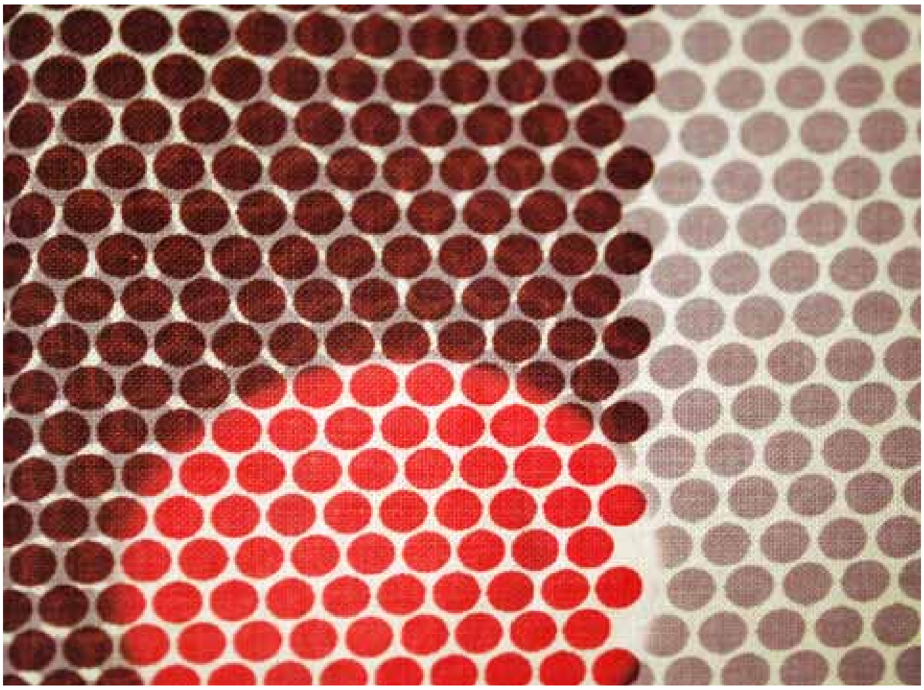


Figure 34. *3D and 2D pattern.*

Dotted bright colourful optic graphics gradually emerge from dark thermo-chromic surface. Pattern changes in colour but also in spatial appearance. When one thermo-chromic pattern layer disappears then three-dimensional pattern becomes two-dimensional.

Technology

First layer of the dotted pattern is printed with black thermo-chromic ink mixed with red water-based screen ink. This mixture of red and black inks create dark brown/grey colour shade. Second layer of black thermo-chromic dotted pattern is printed on top of the first pattern. When the pattern gets heated, black thermo-chromic ink disappears and red water based screen ink on the first layer appears.

Two layers of optic pattern are printed on the cotton fabric. Thereafter copper stickers are combined into sinuous pattern and attached on the back side of the fabric. Stickers in circular shape are cut in half and a resistor is soldered in the middle of the circle. Wires are attached on both sides of the copper sticker and connected to the circuit.

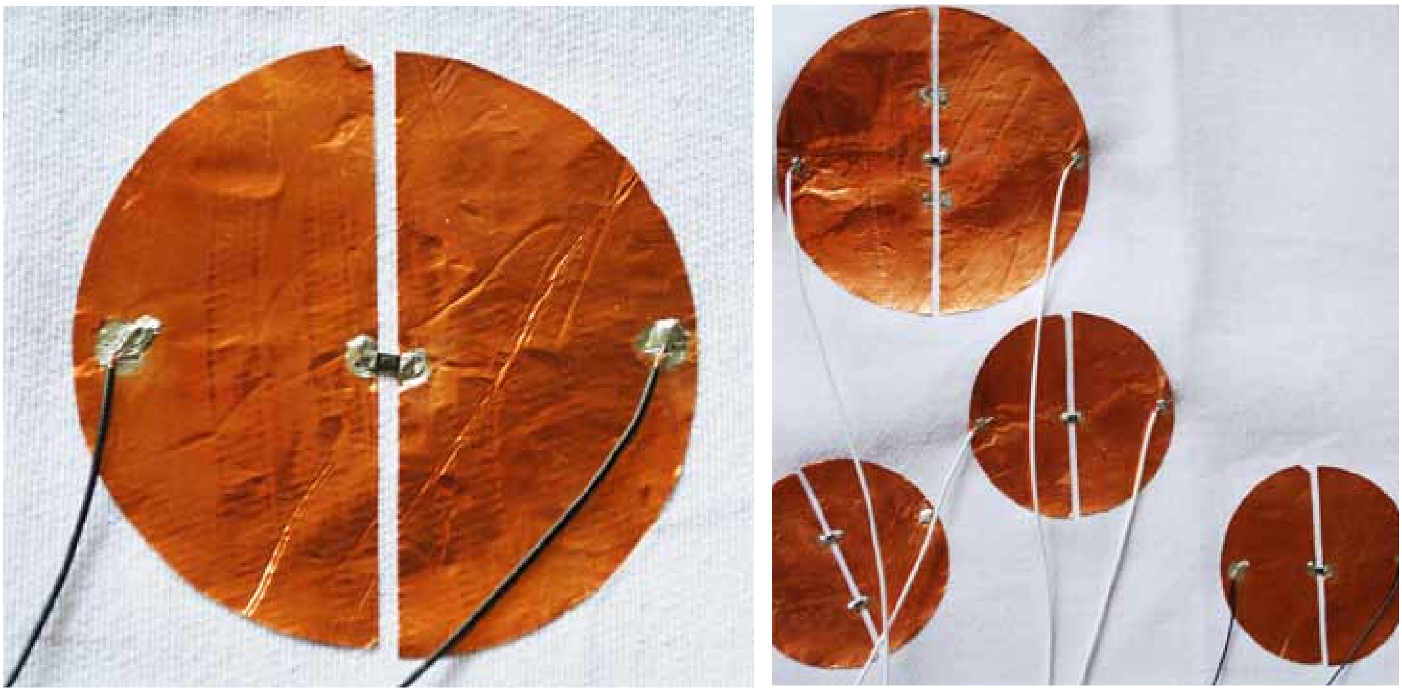


Figure 35. *Copper Sticker.*

The circuit is connected to Arduino micro controller. The pattern is programmed on Arduino to perform smooth colour change. Circular copper stickers heat up step-by-step and red dots appear on the front side.

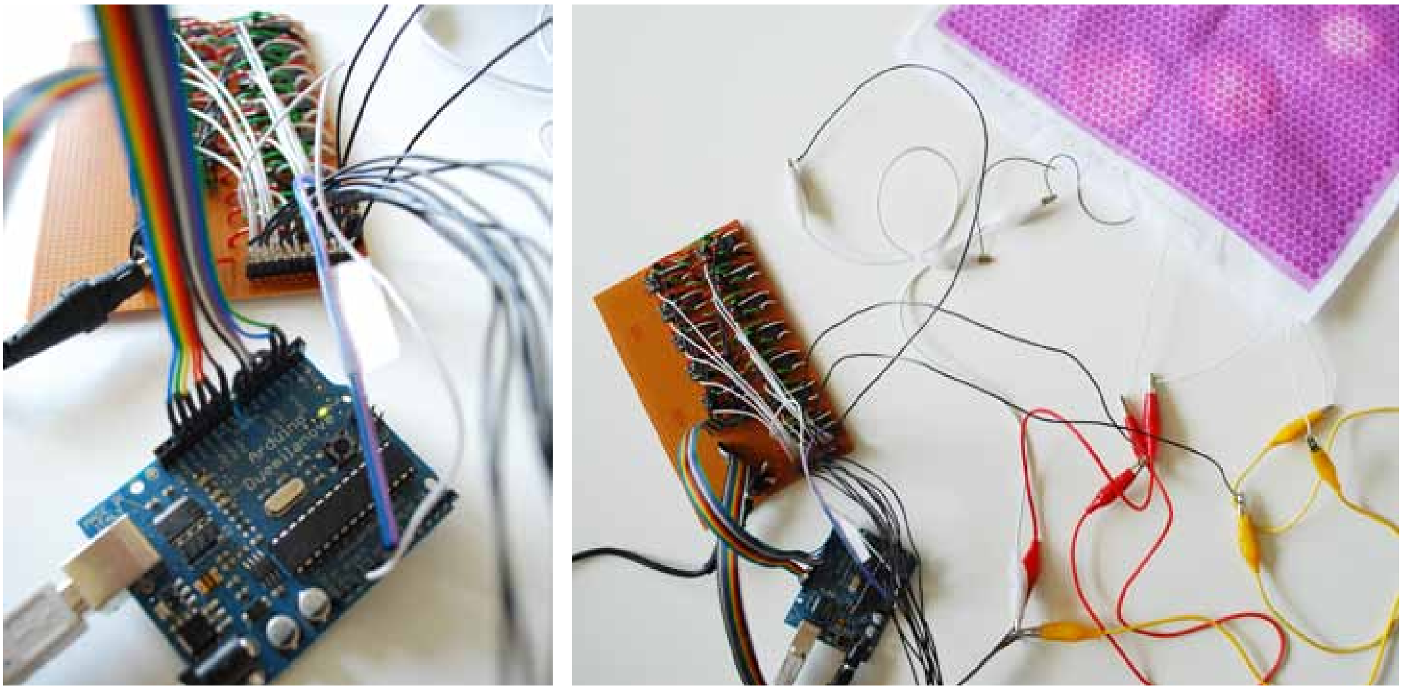


Figure 36. *Fatigue Technology.*

Materials

27° C Thermo-chromic ink, black (Zenit AB)
Water based screen ink, red (Zenit AB)
Copper sticker foil (TechSoft UK Ltd)
150 ohm resistor, 12 pieces (ELFA AB)
100% Cotton fabric (Furulunds Modetyger AB)
Arduino microcontroller (Sparkfun Electronics)

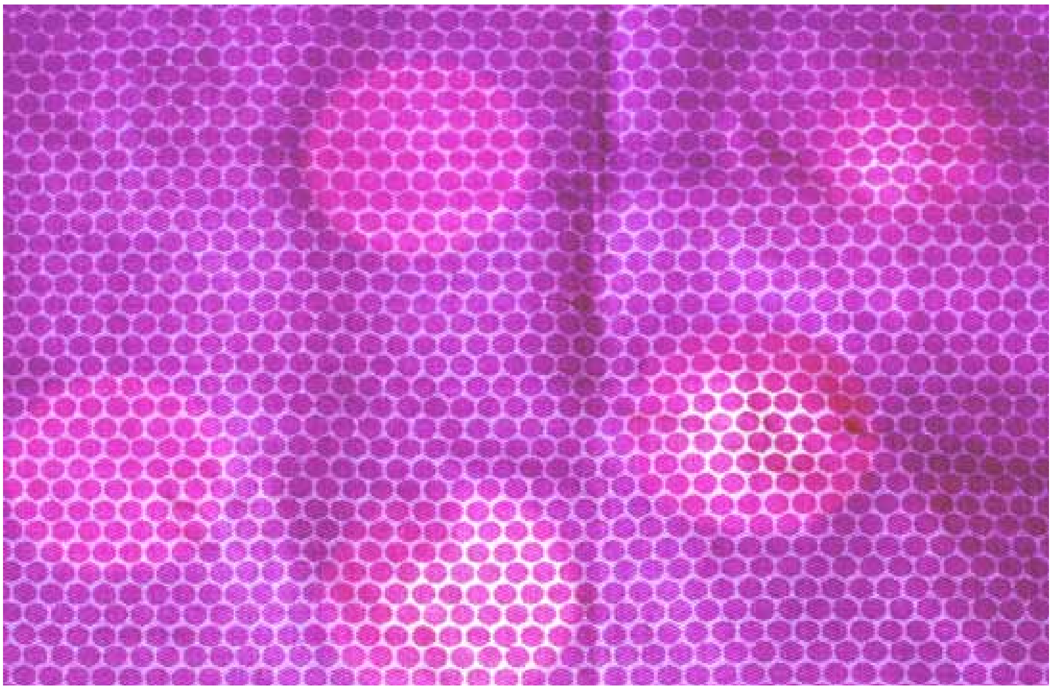


Figure 37. *Fatigue Dotted Pattern.*

Reflection

The 27° C thermo-chromic ink should be re-considered for this application. The activation temperature should be higher (37° C or more) to avoid the ambient temperature affecting the pattern. The activation temperature can not be too high because it might burn the textile.

Copper sticker together with resistors was used to activate the pattern. For production, conductive yarns and fabrics should be considered instead. One possibility would be to weave or embroider the conductive yarn patterns directly into the fabric. That would make the textiles more flexible, thinner and easier to produce.

One example of woven conductive textile with thermo-chromic ink is made by Joanna Berzowska from XS Labs. She developed animated fabric, constructed with conductive yarns and thermo-chromic inks together with custom electronics components woven on a Jacquard loom (Fibre Quarterly, 2011).

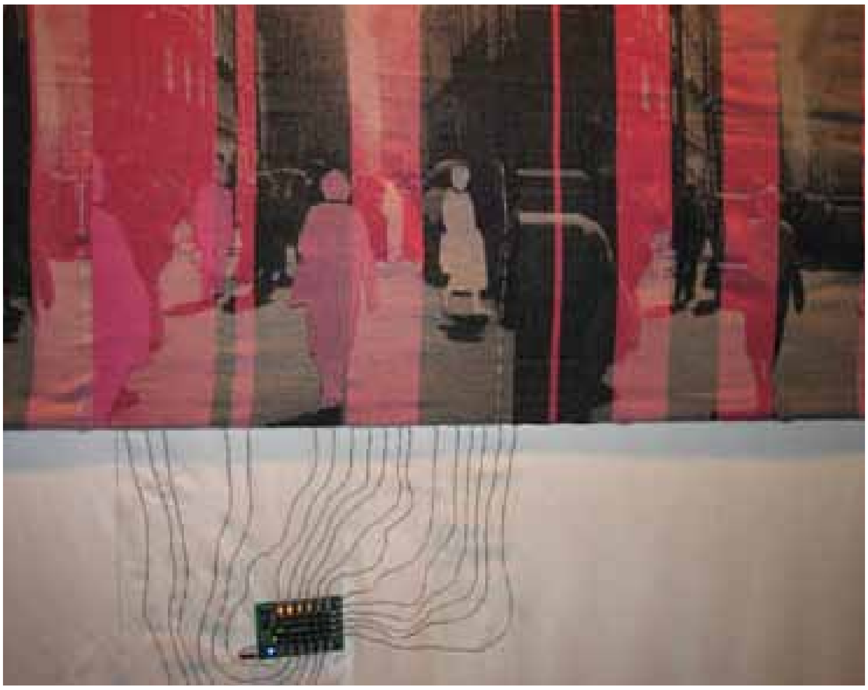


Figure 38. *Berzowska Thermo-Chromic Fabric.*

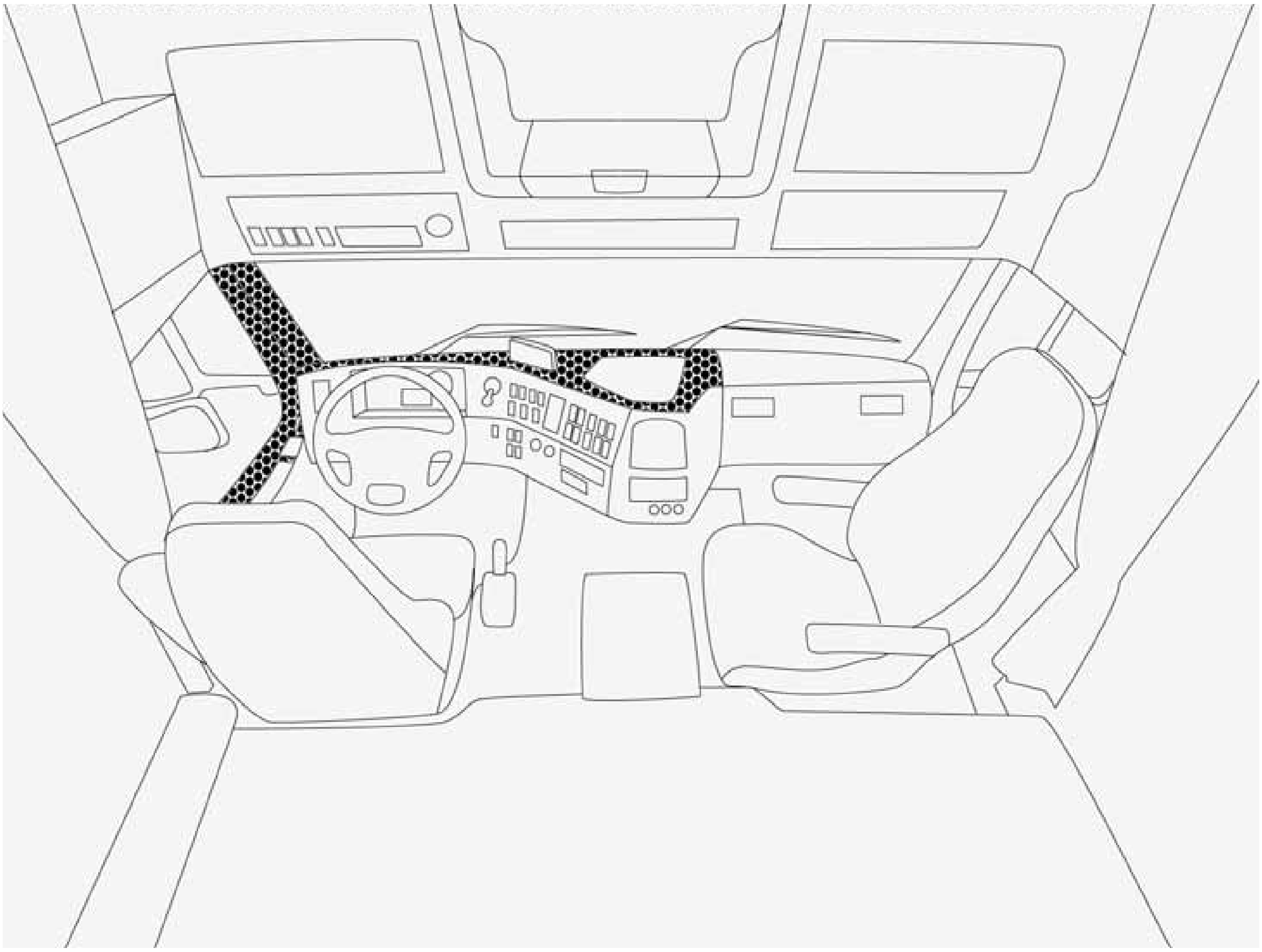


Figure 39. *Fatigue Pattern in Truck Cab.*

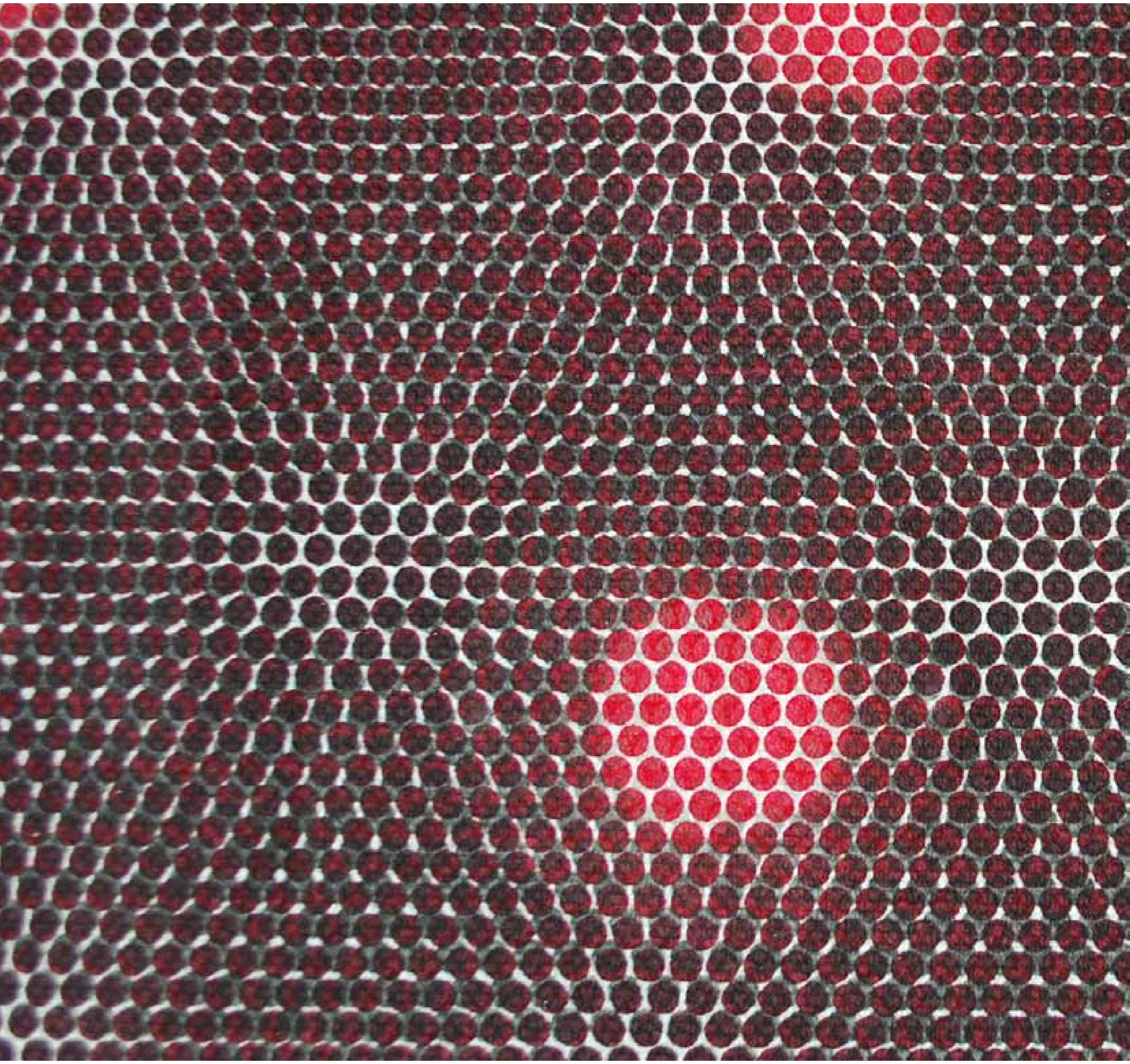
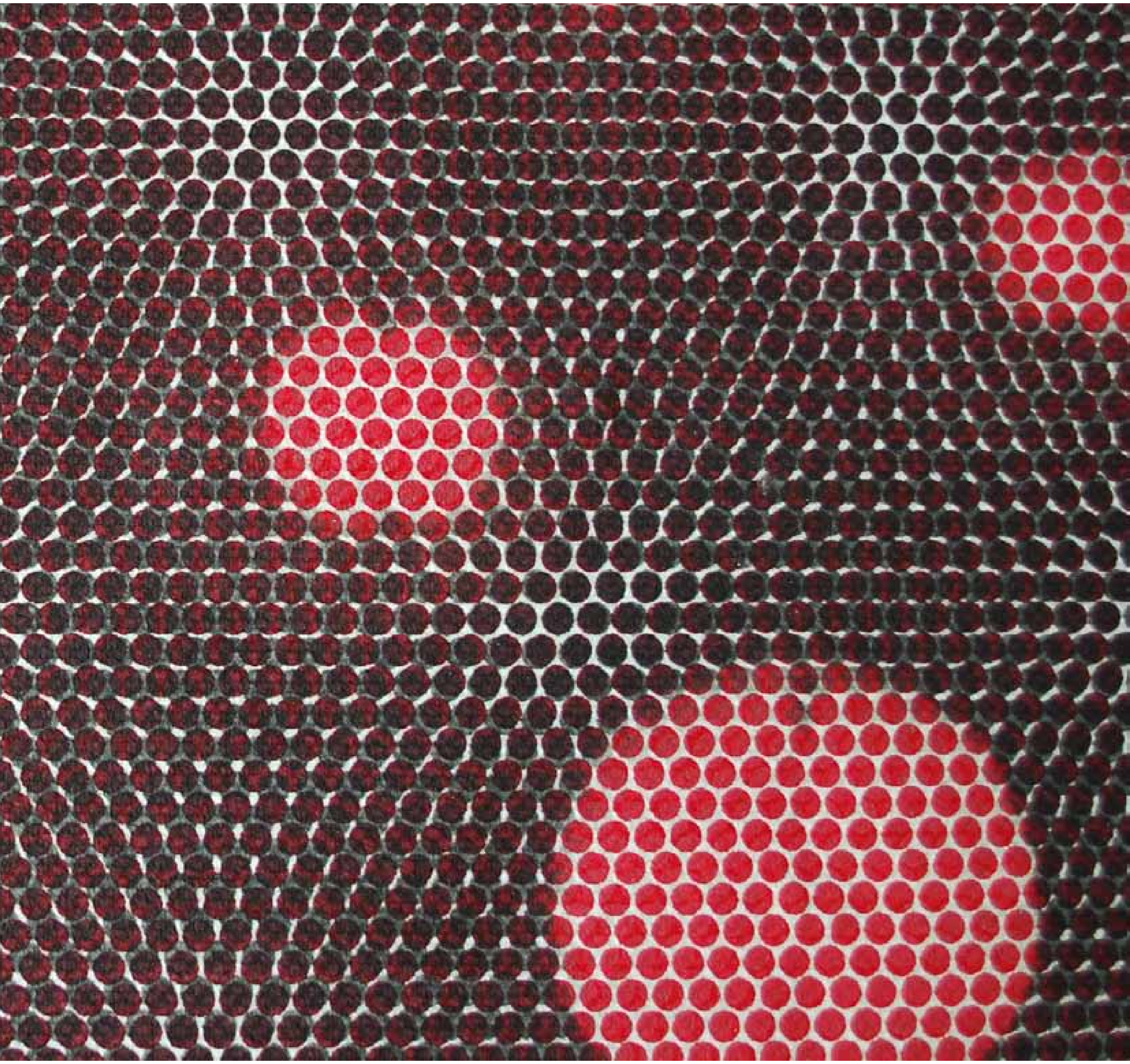


Figure 40. *Fatigue Pattern.*



LIGHT CURTAINS

Problem

Light affects everyone's physical and psychological state. Depending on the situation, different light conditions are required. Poor lighting might cause eye fatigue and headaches. Absence of natural daylight triggers depression and poor immune defence. Bright light stimulates us, while low level of illumination calms our senses. Harsh contrasts produce eyestrain. Too much artificial light and too bright rooms hurt our eyes and make us feel jittery. Insufficient lighting is linked to emotional stress.

Light and color affects emotional state of the driver. The truck driver is on the road with various weather conditions, during different seasons and during day and night. Natural light is changing dramatically during driver's working period.

From my personal experience of driving with the truck driver it occurred that there is not enough light in the truck cab. The drivers are missing both reading light and ambience light. Therefore the truck drivers often buy additional lamps to have sufficient light. The long haul drivers who spend several days in the small cab are missing the opportunity to be able to adjust the luminosity of the cab space according to their actions. In the Nordic countries where long time of the year is dark, the light is important to perform actions in the truck but also for the emotional state of the driver.

The truck cab is a very small environment. More light would make it cosier and visually more spacious. Small cab space is divided into working area in the front and living area in the back. Working area usually has enough light to perform work related actions. Living area in the back part of the cabin usually lacks sufficient light.

Design

Light Curtains — electroluminescent wire curtains which create ambience light in the truck interior. Curtains are adjustable for preferred light conditions.

To solve the ambience light problem the idea is to develop curtains which can work as a light source. The aim is to add another function to the existing curtains without adding any extra objects (e.g. lamps) into the small truck interior.

The cab interior has curtains to cover front and door windows. There are curtains between the work and living area in the truck as well. Curtains make up a large amount of textiles in the cab.

The current design uses woven fabric with EL-wire for curtains. The driver should be able to move the curtains as wished, switch the light ON and OFF and dim the light as preferred. Another possibility would be to have an automatic system so that as the driver gets up from his chair, the ambience light on the curtains will turn ON and the cab interior lights up.

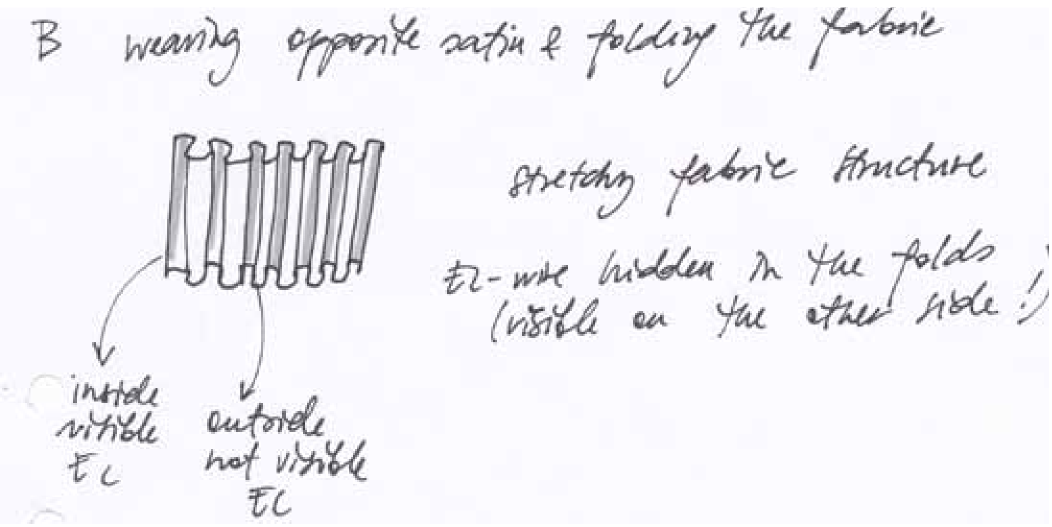


Figure 41. *Light Curtains Sketch.*

Construction

Proposal A – curtains for the front windows.

The curtains are woven as double-weave. The outer layer is woven with plastic sheet. One side of the sheet is black and blocks the light. The other side is silver and reflects sunlight outside. EL-wire is woven into the inner layer which works as an ambient light source.

The curtains are light proof because the drivers prefer privacy in their truck and do not want to be seen from outside. Yet, the curtains distribute light into the cab interior.

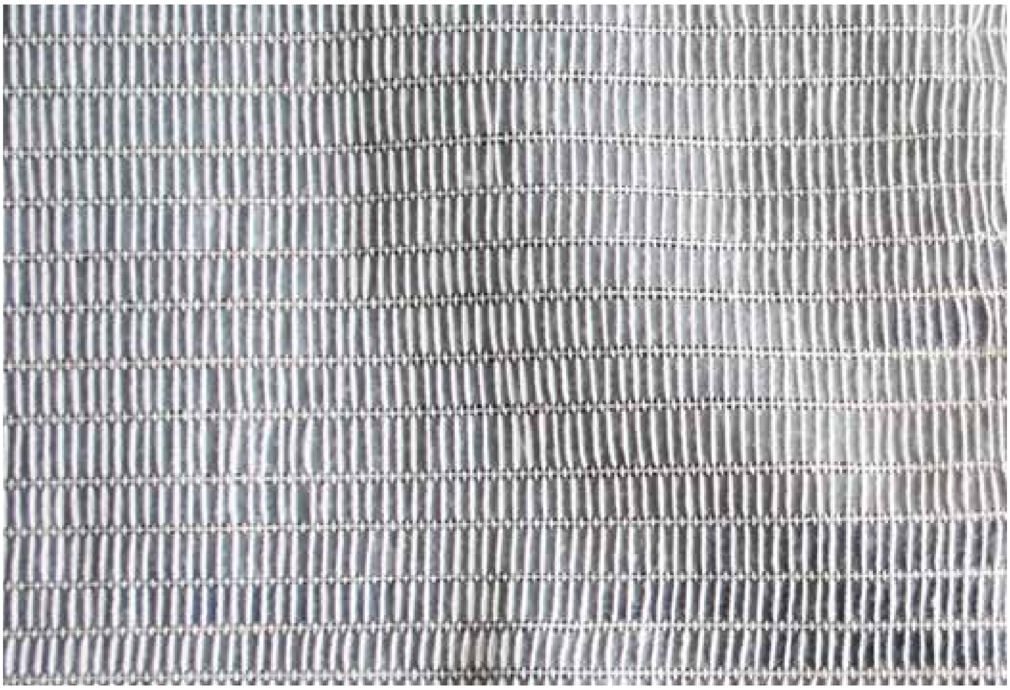


Figure 42. *Light Curtains A. Sunlight Reflecting Side.*

Warm and sunny weather causes problems to the drivers because the cab gets too hot. Therefore they buy extra sun reflecting gadgets for the windows. To solve that problem, sun reflecting materials should be woven into the outer layer of window curtains.

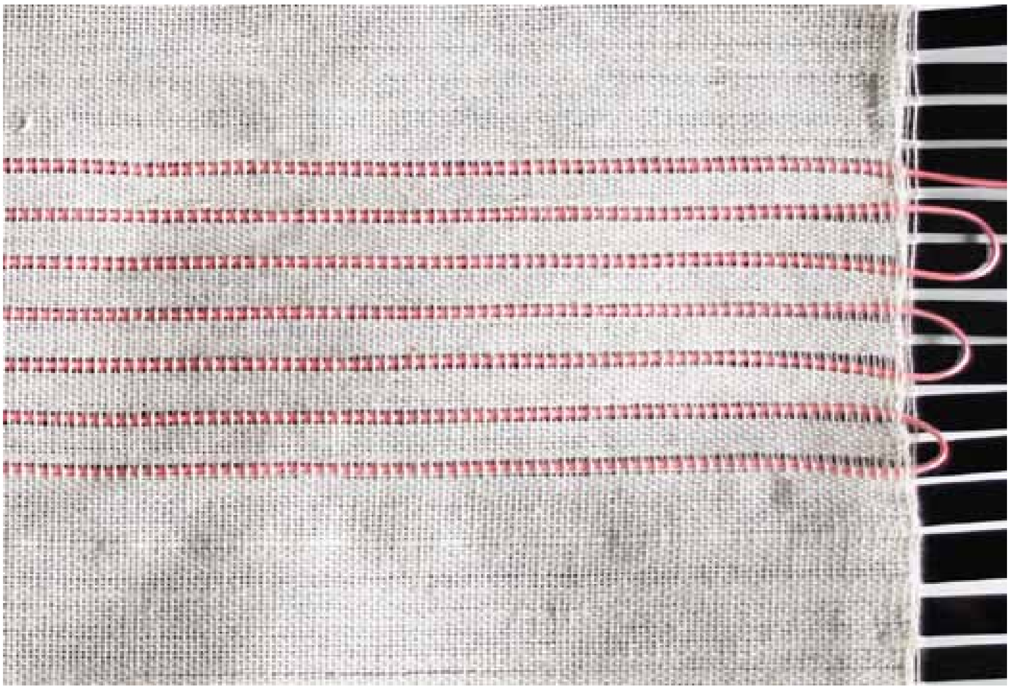


Figure 43. *Light Curtains A. Sunlight Blocking Side with EL-wire.*

The driver can turn the curtain light ON and OFF when desired. The materials used are flexible and therefore it is easy to assemble the curtain.

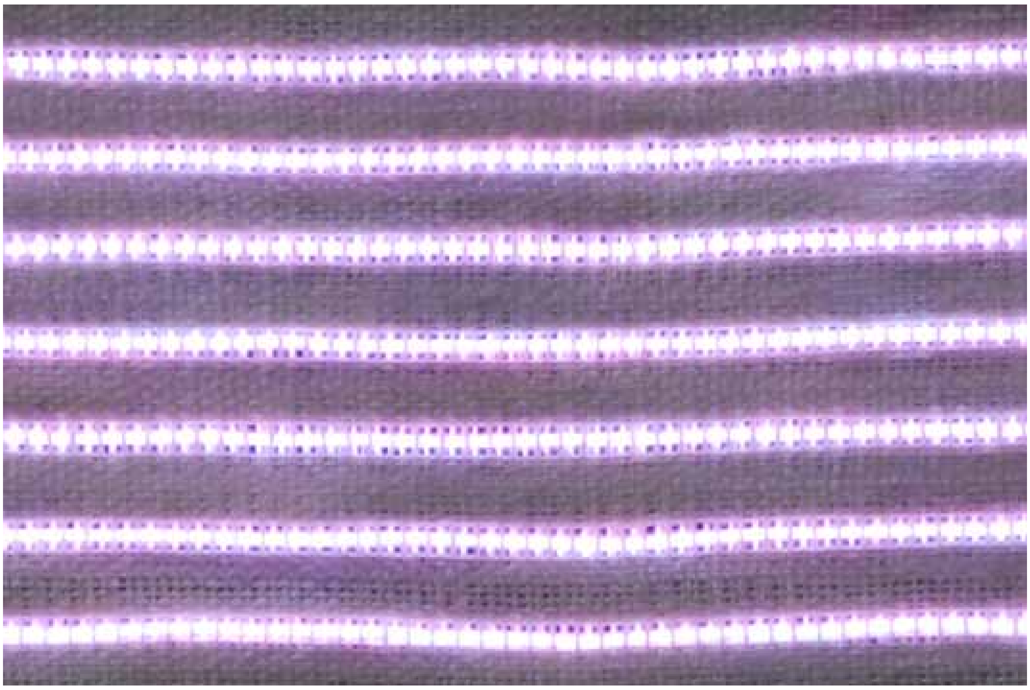


Figure 44. *Light Curtains Sample A with Light.*

Proposal B – curtains which separate work and living area.

The curtains separate work and living environments. At the same time they function as an ambient light source.

Different pleating techniques were explored to find a suitable structure for hiding and revealing EL-wire. The aim was to find a good structure which could be manually asjusted depending on how bright light is needed. Tested were weaving structures which create pleats, also heat pressed origami structures.

Figure 45. *Exploring Pleats.*

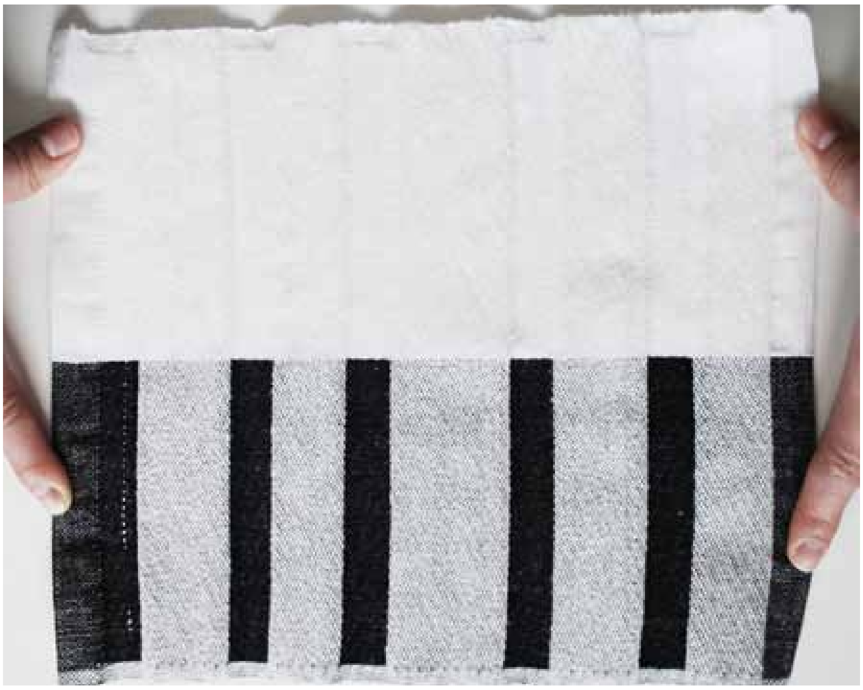


Figure 46. *Light Curtains Sample B Pleats.*

Simple structure with straight pleats was chosen for the final prototype. Straight pleats fold easily according to the straight wire. This lets the user open up the structure for more light by stretching the textile.

Variety of yarns with different transparency leves were tested, also wires in variety of sizes. For the final prototype the thinnest EL-wire was chosen which is nicely hidden in the structure and is not much visible as the curtain is turned OFF. The thinnest EL-wire is very soft and bendable and can be easily folded into the structure.

The curtains are woven as a pleated structure and the light wire is hidden inside the pleats. When the curtains are stretched, the wire appears. By adjusting how much the curtains are stretched, it is possible to adjust the luminosity of the space. The more the curtains are stretched the brighter light appears. That gives the driver the opportunity to adjust the ambience light level of the cab according to his/her actions.

Figure 47. *Light Curtains Sample B with Light.*

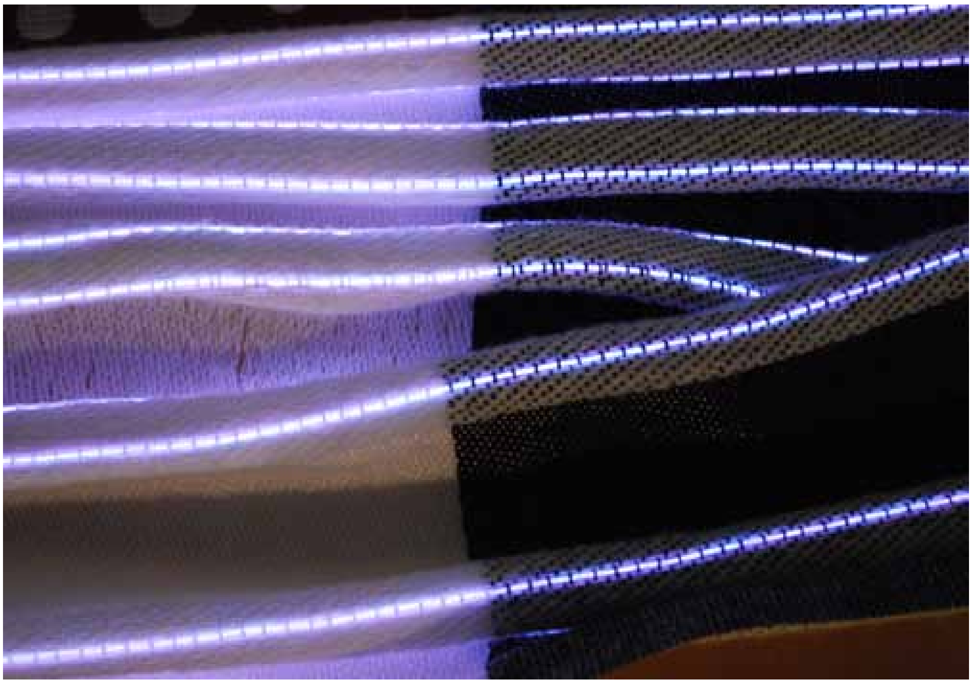


Figure 48. *Woven EL-wire.*

Technology

Proposal A

Double weave construction. Plastic foil is cut in stripes and woven into the outer layer, black side is facing the interior and silver side is facing the exterior. Inner layer is woven with EL-wire. EL-wire is connected to the inverter and can be adjusted ON/OFF.

Proposal B

Satin weave construction is woven in irregular stripes. The striped create pleated effect. EL-wire is woven into the pleats. EL-wire is connected to the inverter and can be adjusted ON/OFF.

Materials

Proposal A:

EL-wire (ThinLight AB)
Inverter (ThinLight AB)
Plastic foil 50 mm stripes (AB Ludvig Svensson)
100% Polyester yarn (Trevira GmbH)

Proposal B:

EL-wire (ThinLight AB)
Inverter (ThinLight AB)
100% Polyester yarn (Trevira GmbH)

Reflection

The prototypes are made on the hand weaving loom. To weave the curtains on industrial machines it is necessary to re-consider the weaving techniques.

EL-wire is rather fragile material and cannot be cut and bent too much. Industrial weaving machines are cutting the edges of produced fabrics and this makes impossible to weave EL-wire on the industrial machines. If the wire is cut then the connection is lost and the wire will not lit up. It is important to find a producer for this specific application.

For proposal B aqua coloured wire was used in the given project. The color of aqua wire varies from deep green to deep blue as the user alters the power frequency from 60 Hz to 6 Hz. Therefore it is possible to develop a system which allows the user to adjust the color of the wire by changing the frequency. That would give the opportunity to change the color of the light depending on the emotional state or actions of the driver. Green light is warm but blue light is cold – this changes the atmosphere of the whole space.

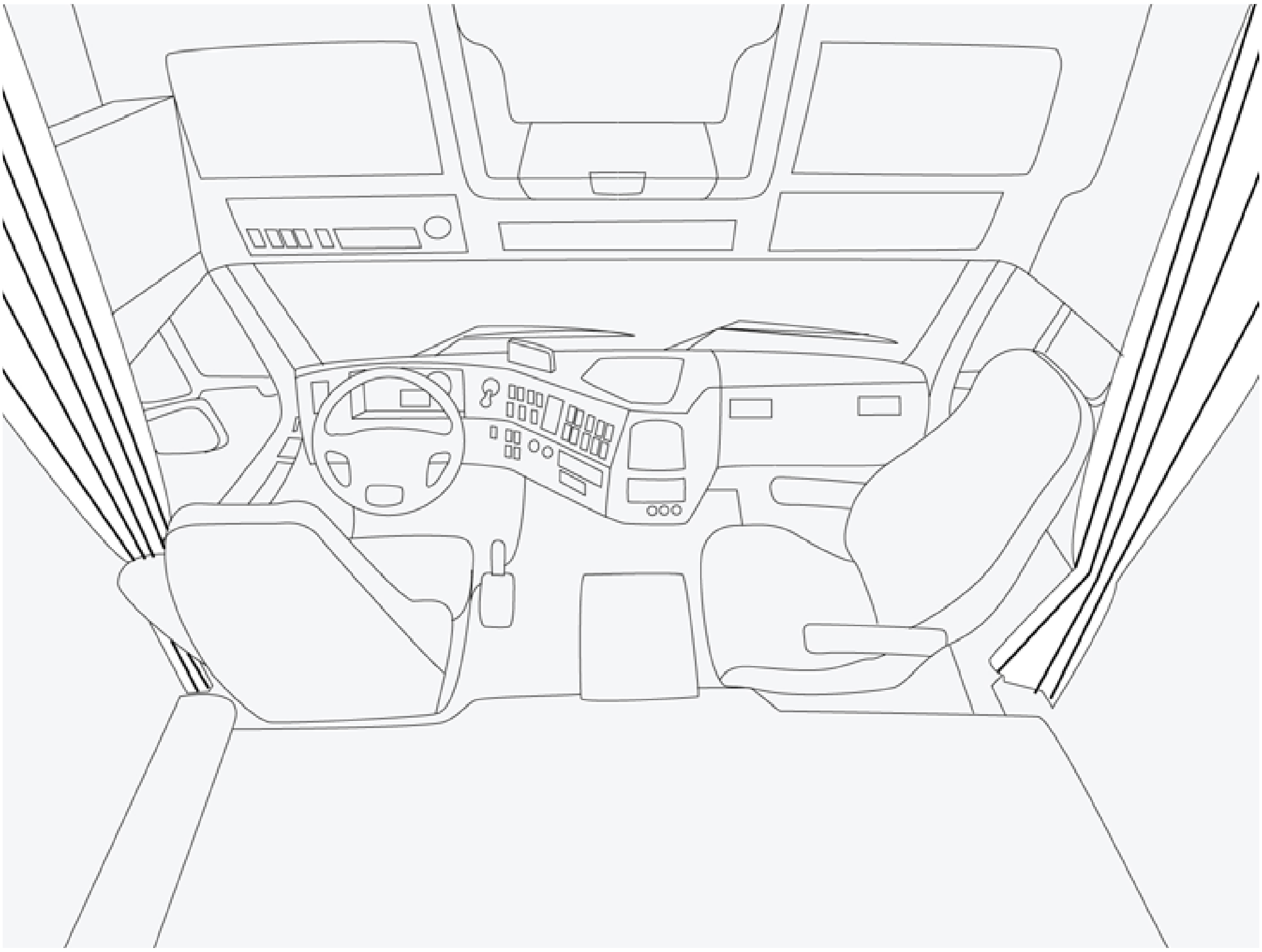


Figure 49. *Light Curtains in Truck Cab.*

Figure 50. *Light Curtains Prototype.*

EVALUATION MEETING AT VOLVO 3P

The aim of the meeting was to introduce smart textiles field, show examples of smart materials, introduce smart textile concepts for truck interior, brainstorm together for more ideas, introduce prototypes and finally to evaluate proposed ideas. Smart textile application possibilities were discussed with people with various competences from different Volvo Group departments.

Three design proposals, Eco Driving, Fatigue and Light Curtains were shown as prototypes.

Discussed were new application possibilities using new textile techniques, value adding possibilities, integration of interface into textiles. Considered were financial and competitive advantages of the field of smart textiles for the vehicle industry, opportunities of new collaborations.

The participants could reflect on previous design proposals. Comments, developments and new ideas were added. Finally participants ranked the ideas.

The ideas were ranked as following:

17 points – Eco Driving
14 points – Fatigue
10 points – Floor lights up as the road is icy
Living area lights up
9 points – "Slow down" appears on the steering- wheel when speeding
8 points – Integrated buttons in the gloves
5 points – Light Curtains
4 points – Steering- wheel changes color when seatbelt not used
Blind Spot detection
Seat adjusted to driver's body temperature
Door lights up when door is open
Intruders' notification

Reflection

Participants agreed that it is time for textiles to become more functional, instead of being just nice in color and pleasant in material. Participants could see a wide range of useful and functional possibilities for smart textile applications for trucks. Yet, a lot of work is still to be done before new materials become ready for production.

Some designs were discussed and argued in detail, eco driving for example. The Eco-Driving prototype provoked several contradictory opinions. On the one hand a lit up pattern could disturb the driver, on the other hand people are nowadays more used to visual noise, especially in developed Asian countries where they are used with dynamic and colourful environments. Those aspects should be discussed and analyzed further. Eco driving applications for truck exteriors should also be considered.

Some of the presented ideas were developed further. The ambience light problem and light curtains prototype were discussed as possible solutions for other functions. One idea was an alert system where the whole cab lights up when the driver gets drowsy (fatigue detection).

The meeting was valuable due to the received feedback from people with design, production, product planning and engineering background. Existing ideas were discussed, developed and new ideas proposed.

Organizers:
Fredäng Helene (Textile Engineer Volvo 3P)
Heyden Anna (HMI Specialist, Volvo Technology)
Kisand Marta (The Swedish School of Textiles)
Sagesjö Marjukka (Product Development/Feature expert Driver Interface, Volvo Technology)
Walenius Henriksson Maria (Environmental Engineer Volvo Technology)

Figure 51. *Evaluation at Volvo 3P.*

Participants:
Andersson Karin (Groupmanager for Interior Trim & Cab Equipment, Volvo 3P)
Andreasson Ulf (Product Manager, Cab, Volvo Trucks)
Byström Carina (Chief Designer Interior Volvo Trucks, Volvo 3P)
Hellstedt David (Section Manager Cab Interior, Volvo 3P)
Hjulström Ohlin Ulrika (Colour, Materials & Finishes Designer, Volvo 3P)
Nurmi Hannele (Feature Leader for Material and Environmental Impact, Fire Safety, Volvo 3P)
Svenske Erik (Product Requirement Manager, Volvo Trucks)
Theodorsson Nina (Feature leader Driver interface, Volvo 3P)
Uma Preetha (Engineer, Volvo 3P)

CONCLUSION

RESULT

The result of the project “Smart Textiles as Innovative Interface for Commercial Vehicles” is a set of prototypes of smart textiles interfaces for truck interior.

In-depth research about truck driver’s job was the foundation for the current project. Personal experience of following a driver at his job for a day verified the knowledge gained from theoretical research. Analysis of driver’s visual perception motivated to work with visual light and color materials. Technological knowledge about light and color-change smart materials was extended by learning electrical circuits and programming. Brainstorming was done as sketching and the results were discussed and ranked by truck industry related people. Finally, three concepts were chosen to be designed and developed as prototypes.

The outcome of the current project is a set of three prototypes for the themes of Eco Driving, Fatigue and Light Curtains.

Eco Driving prototype is an electroluminescent light pattern on the steering-wheel which informs the driver about his/her ecological driving performance.

Fatigue prototype is a color-changing pattern to notify the driver about his/her physical condition. Thermo-chromic pattern on the dashboard changes color and graphics, when the driver gets tired or sleepy.

Light Curtains are woven electroluminescent wire curtains which create ambience light in the truck interior. Curtains are adjustable for preferred light conditions.

Those concepts propose to improve safety, information distribution and comfort of trucks. The prototypes are interactive interfaces which react (light up, change color) to stimuli and communicate information to the driver.

REFLECTION

Truck cab is almost fully covered with textile surfaces: seats, bed, walls, ceiling, carpet, door panels, walls etc. Therefore smart textiles can be applied on large variety of interior surfaces in the truck. The biggest challenge of the current project was to identify problematic functions which could be solved with smart materials.

The result of the project “Smart Textiles as Innovative Interface for Commercial Vehicles” is a set of three prototypes which communicate information to the driver. The three concepts Eco Driving, Fatigue and Light Curtains cover safety, work and living related functions of truck driving and illustrate the variety of possibilities of using smart textiles in truck interiors. Smart textiles can improve diverse comfort and work related functions in the truck.

I have worked in automotive field previously and designed colours and textiles for car interiors. Therefore I assumed that working with trucks would be similar and familiar working environment for me. It emerged, that truck design differs from car design. Trucks are used for business, that is, to earn profit. Cars are consumer products which follow trends and users’ taste and needs. There is a fundamental difference between the production and use of cars and trucks, even though those products may appear similar at a first glance.

WORKING METHODS

To start the current project, it was important to make an in-depth research about truck driving, to learn about truck driver’s work and leisure related activities, and about truck aesthetics worldwide. This helped to get an overview of truck driving as a phenomenon and provided a good foundation for the design process.

After theoretical research I explored truck driver’s job by following a driver at his work for a day. That was an important method which confirmed the theoretical knowledge and added practical approach to it. Spending a day with a driver gave a possibility to see the driver’s work in action, ask truck driving related questions and perceive truck interior space personally. Those were very important guides for the following design process. The practical aspect of research helped to formulate a starting point for brainstorming.

The analysis of the research about truck driver’s visual perception resulted in a decision to continue working with visual sense. Therefore light and color materials were chosen to work with.

Knowledge about smart textiles was extended by further research and learning of light and color-change materials, learning textile circuits and programming. Technological knowledge was the basis for interface communication methods’ development of the given project. Explored were how technology should interact with the driver and how the driver should perceive the communicated information.

Brainstorming method resulted in a set of wide range ideas for security, safety, work and living related aspects. The ideas were analysed and ranked at a meeting with people from different departments at Volvo. Since the brainstorming ideas were based on theoretical research and experience of following a driver at his work, it was also important to receive the opinions from truck industry related people. This ranking method helped to sort out the most favourable ideas that could be developed further. Analysing the ranking outcome helped to choose concepts to develop in the prototyping phase.

In the prototyping phase three concepts of Eco Driving, Fatigue and Light Curtains were developed. During prototyping different aspects of design (concept, expression, technology) were re-defined and analysed. Testing and trying variety of materials and technologies helped to choose the best ones for the current project. The result is an example of potential production samples. Yet, for mass production the chosen materials and technologies should be re-considered.

SMART TEXTILES AND AUTOMOTIVE FIELD

Smart textiles have been a field of interest for automotive industry for years. Several car companies have made concept cars using varieties of smart materials. Unfortunately until today no smart solutions have reached mass production.

The current design project aims to get closer to the production of smart textiles in automotive industry. The prototypes illustrate possibilities of smart solutions for truck interiors. The smart materials chosen for the current project, electroluminescent wire, electroluminescent panel and thermo-chromic ink, are widely used in other application areas and can be mass produced. For example electroluminescence panels are used in advertising banners and thermo-chromic print for color changing coffee cups.

Electroluminescence and thermo-chromic materials have to be explored and tested further for specific truck interface applications. Combination of smart materials and textiles needs to be investigated, because the properties of smart materials vary depending on specific textile material and application. Usability and durability needs to be tested and proofed for mass production.

PERSONAL DEVELOPMENT

I had little knowledge about smart textiles and brief experience working with color and light materials in previous projects. Until the current project I was applying smart materials on textiles without altering the characteristics nor electronically controlling those materials. In the current project I expanded my knowledge with studies about electronics, textile circuits and programming. The challenge in this project has been to learn how to create automated and digitally controlled interfaces that react on certain stimuli and respond accordingly.

I am a textile designer not an engineer; therefore my project was largely about learning the basics of electronics. That was a very educative and interesting process because of gaining new knowledge and combining it with my previous knowledge about textiles. My previous experience working with different textile techniques supported new combinations with high-tech materials. The most enjoyable part of the process was testing and experimenting with textiles and technology together.

The current project gave me a good foundation to continue working with light and color-change materials. In the future work, research on textile electronics and experiments of embedding smart materials with fabrics, should be deepened. There are endless possibilities for implementing electronics into textiles. New materials and technologies emerge rapidly and that makes the field of smart textiles more exciting to work with.

ACKNOWLEDGEMENTS

I would like to thank my supervisors, colleagues and fellow students who contributed to this project.

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Figure 7. Kisand, M., 2011. *Sketching Movement.* [Photograph] (Private collection).

Figure 8. Kisand, M., 2010. Thermo Chromic Samples. [Photograph] (Private collection).

Figure 9. Kisand, M., 2011. Electroluminescent wire. [Photograph] (Private collection).

Figure 10. Kisand, M., 2011. Intelligent Materials. [Schematic] (Private collection).

Figure 11. Kisand, M., 2011. EL-wire. [Schematic] (Private collection).

Figure 12. Kisand, M., 2011. EL-panel. [Schematic] (Private collection).

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Figure 20. Kisand, M., 2011. Circular Pattern. [Drawing] (Private collection).

Figure 21. Kisand, M., 2011. Spread Pattern. [Drawing] (Private collection).

Figure 22. Kisand, M., 2011. Linnaea Borealis Pattern. [Photograph] (Private collection).

Figure 23. Kisand, M., 2011. Plain background dotted pattern. [Photograph] (Private collection).

Figure 24. Kisand, M., 2011. Eco Driving Technology. [Photograph] (Private collection).

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Figure 29. Kisand, M., 2011. Eco Driving pattern on steering-wheel. [Drawing] (Private collection).

Figure 30. Kisand, M., 2011. Fatigue Sketch. [Drawing] (Private collection).

Figure 31. Kisand, M., 2011. Dotted Pattern. [Photograph] (Private collection).

Figure 32. Kisand, M., 2011. Sketching Optic Pattern. [Drawing] (Private collection).

Figure 33. Kisand, M., 2011. Two Screens and Variety of Patterns. [Drawing] (Private collection).

Figure 34. Kisand, M., 2011. 3D and 2D pattern. [Photograph] (Private collection).

Figure 35. Kisand, M., 2011. Copper Sticker. [Photograph] (Private collection).

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Figure 37. Kisand, M., 2011. Fatigue Dotted Pattern. [Photograph] (Private collection).

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Figure 39. Kisand, M., 2011. Fatigue Pattern in Truck Cab. [Drawing] (Private collection).

Figure 40. Kisand, M., 2011. Fatigue Pattern. [Photograph] (Private collection).

Figure 41. Kisand, M., 2011. Light Curtains Sketch. [Drawing] (Private collection).

Figure 42. Kisand, M., 2011. Light Curtains A. Sunlight Reflecting Side. [Photograph] (Private collection).

Figure 43. Kisand, M., 2011. Light Curtains A. Sunlight Blocking Side with EL-wire. [Photograph] (Private collection).

Figure 44. Kisand, M., 2011. Light Curtains Sample A with Light. [Photograph] (Private collection).

Figure 45. Kisand, M., 2011. *Exploring Pleats.* [Photograph] (Private collection).

Figure 46. Kisand, M., 2011. Light Curtains Sample B Pleats. [Photograph] (Private collection).

Figure 47. Kisand, M., 2011. Light Curtains Sample B with Light. [Photograph] (Private collection).

Figure 48. Kisand, M., 2011. Woven EL-wire. [Photograph] (Private collection).

Figure 49. Kisand, M., 2011. Light Curtains in Truck Cab. [Drawing] (Private collection).

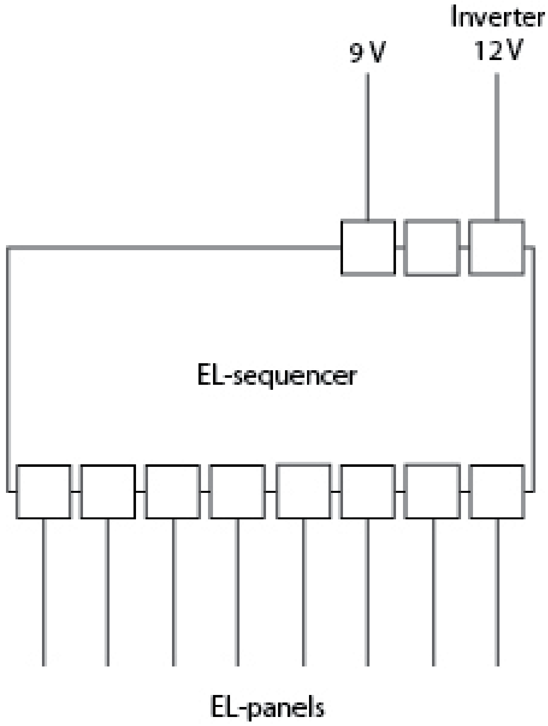
Figure 50. Kisand, M., 2011. Light Curtains Prototype. [Photograph] (Private collection).

Figure 51. Kisand, M., 2011. Evaluation at Volvo 3P. [Photograph] (Private collection).

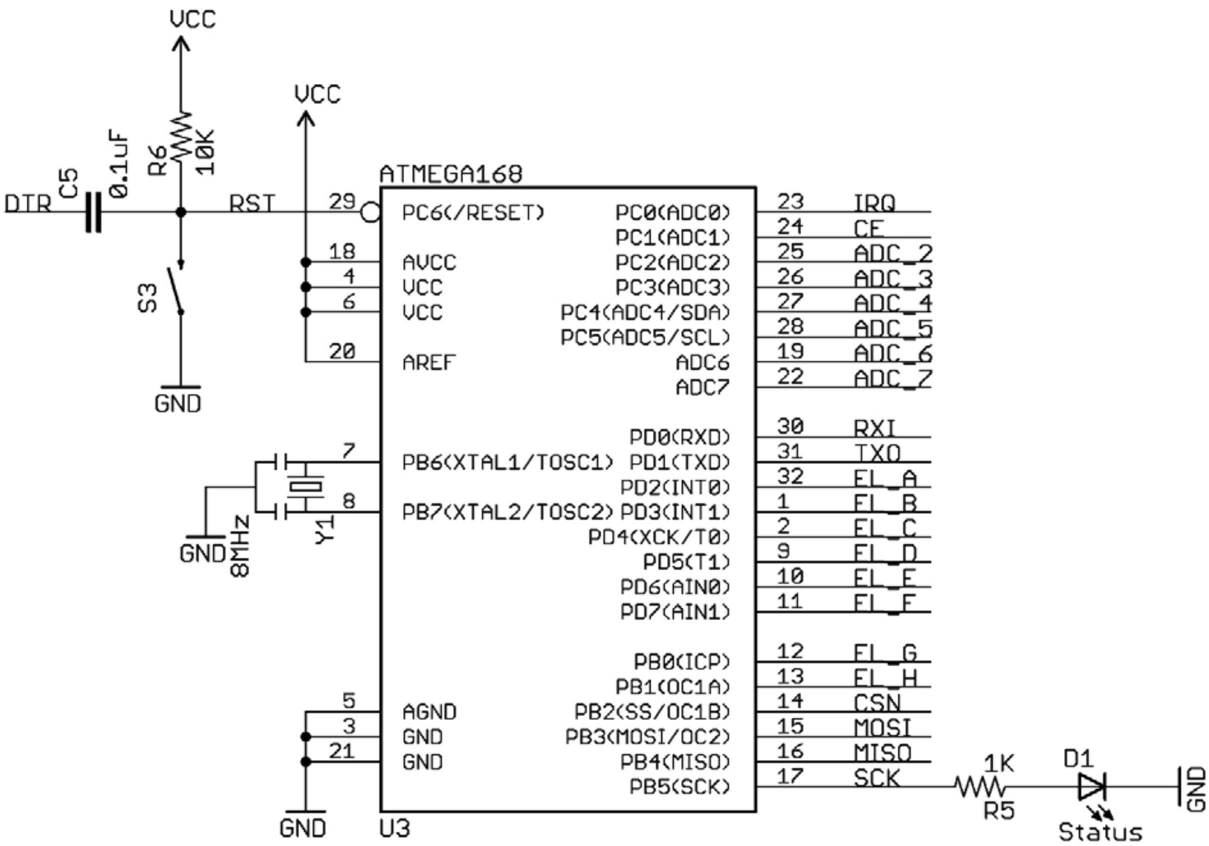
Arduino Programming Code Eco Driving Prototype

```
/*
EL-panel circuit, looped.
 */

void setup() {

  pinMode(2, OUTPUT);
  pinMode(3, OUTPUT);
  pinMode(4, OUTPUT);
  pinMode(5, OUTPUT);
  pinMode(6, OUTPUT);
  pinMode(7, OUTPUT);
  pinMode(8, OUTPUT);
}

void loop() {
  digitalWrite(2, HIGH);
  delay(1000);
  digitalWrite(3, HIGH);
  delay(1000);
  digitalWrite(4, HIGH);
  delay(1000);
  digitalWrite(5, HIGH);
  delay(1000);
  digitalWrite(6, HIGH);
  delay(1000);
  digitalWrite(7, HIGH);
  delay(1000);
  digitalWrite(8, HIGH);
  delay(1000);

  digitalWrite(8, LOW);
  delay(1000);
  digitalWrite(7, LOW);
  delay(1000);
  digitalWrite(6, LOW);
  delay(1000);
  digitalWrite(5, LOW);
  delay(1000);
  digitalWrite(4, LOW);
  delay(1000);
  digitalWrite(3, LOW);
  delay(1000);
  digitalWrite(2, LOW);
  delay(1000);
}
```

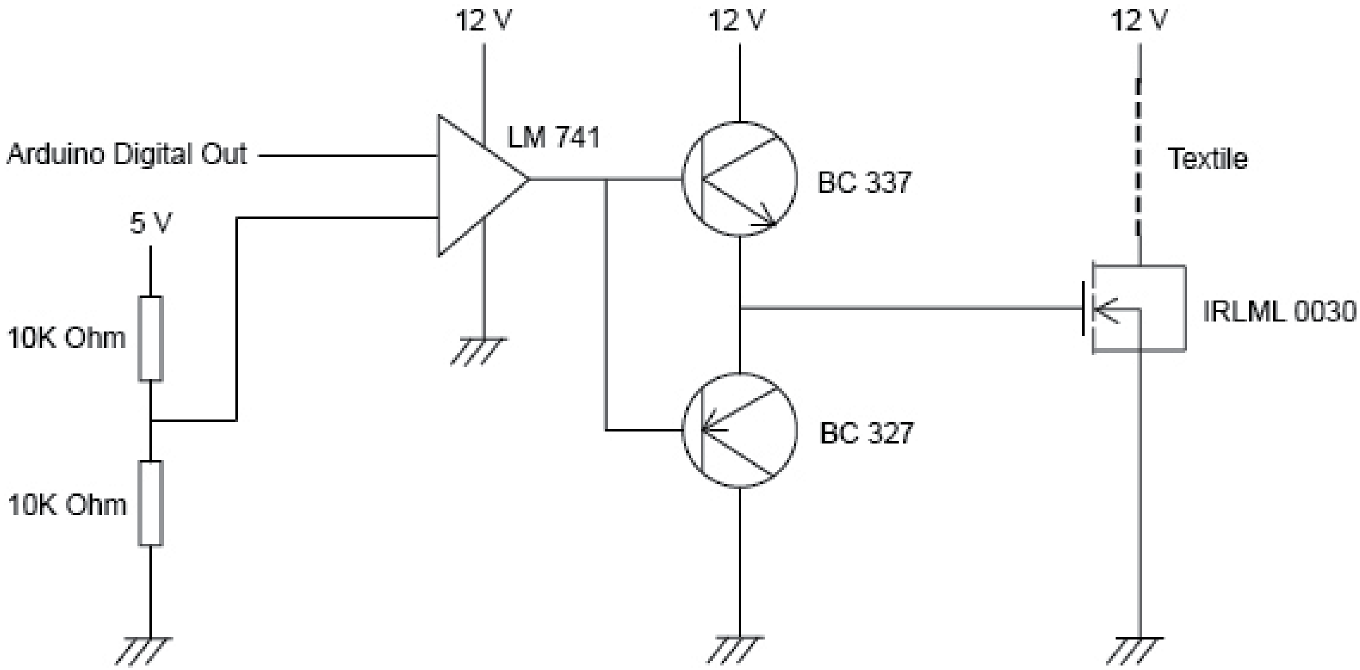
Schematic Eco Driving Prototype



Schematic EL-sequencer (Sparkfun, 2010)



```
/*
Heat circuit with button.
 */
int sensorValue=0;

void setup() {
  pinMode(2, OUTPUT);
  pinMode(3, OUTPUT);
  pinMode(4, OUTPUT);
  pinMode(5, OUTPUT);
  pinMode(6, OUTPUT);
  pinMode(7, OUTPUT);
  pinMode(8, OUTPUT);
  pinMode(9, OUTPUT);
  pinMode(10, OUTPUT);
  pinMode(11, OUTPUT);
  pinMode(12, OUTPUT);
  pinMode(13, OUTPUT);
  Serial.begin(9600);
}

void loop() {
   int sensorValue = analogRead(0);
  Serial.println(sensorValue);
  if (sensorValue > 800)
  {
  digitalWrite(2, HIGH);   // set the pin on
  delay(40500);              // waiting time
  digitalWrite(2, LOW);    // set the pin off

  digitalWrite(3, HIGH);
  delay(30500);
  digitalWrite(3, LOW);

  digitalWrite(4, HIGH);
  delay(40500);
  digitalWrite(4, LOW);

  digitalWrite(5, HIGH);
  delay(30500);
  digitalWrite(5, LOW);

  digitalWrite(6, HIGH);
  delay(40500);
  digitalWrite(6, LOW);

  digitalWrite(7, HIGH);
  delay(40500);
  digitalWrite(7, LOW);

  digitalWrite(8, HIGH);
  delay(30500);
  digitalWrite(8, LOW);

  digitalWrite(9, HIGH);
  delay(40500);
  digitalWrite(9, LOW);

  digitalWrite(10, HIGH);
  delay(30500);
  digitalWrite(10, LOW);

  digitalWrite(11, HIGH);
  delay(30500);
  digitalWrite(11, LOW);

  digitalWrite(12, HIGH);
  delay(40500);
  digitalWrite(12, LOW);

  digitalWrite(13, HIGH);
  delay(40500);
  digitalWrite(13, LOW);
  }
}
```

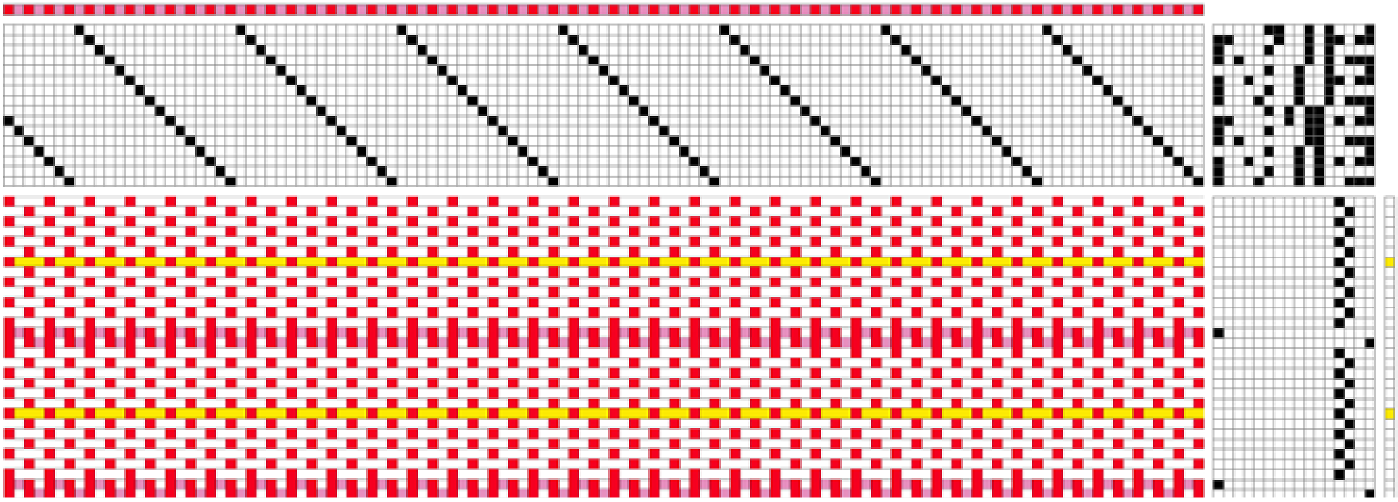

12 V
12 V
12 V
Arduino Digital Out
LM 741
BC 337
Textile
5 V
10K Ohm
IRLML 0030
BC 327
10K Ohm

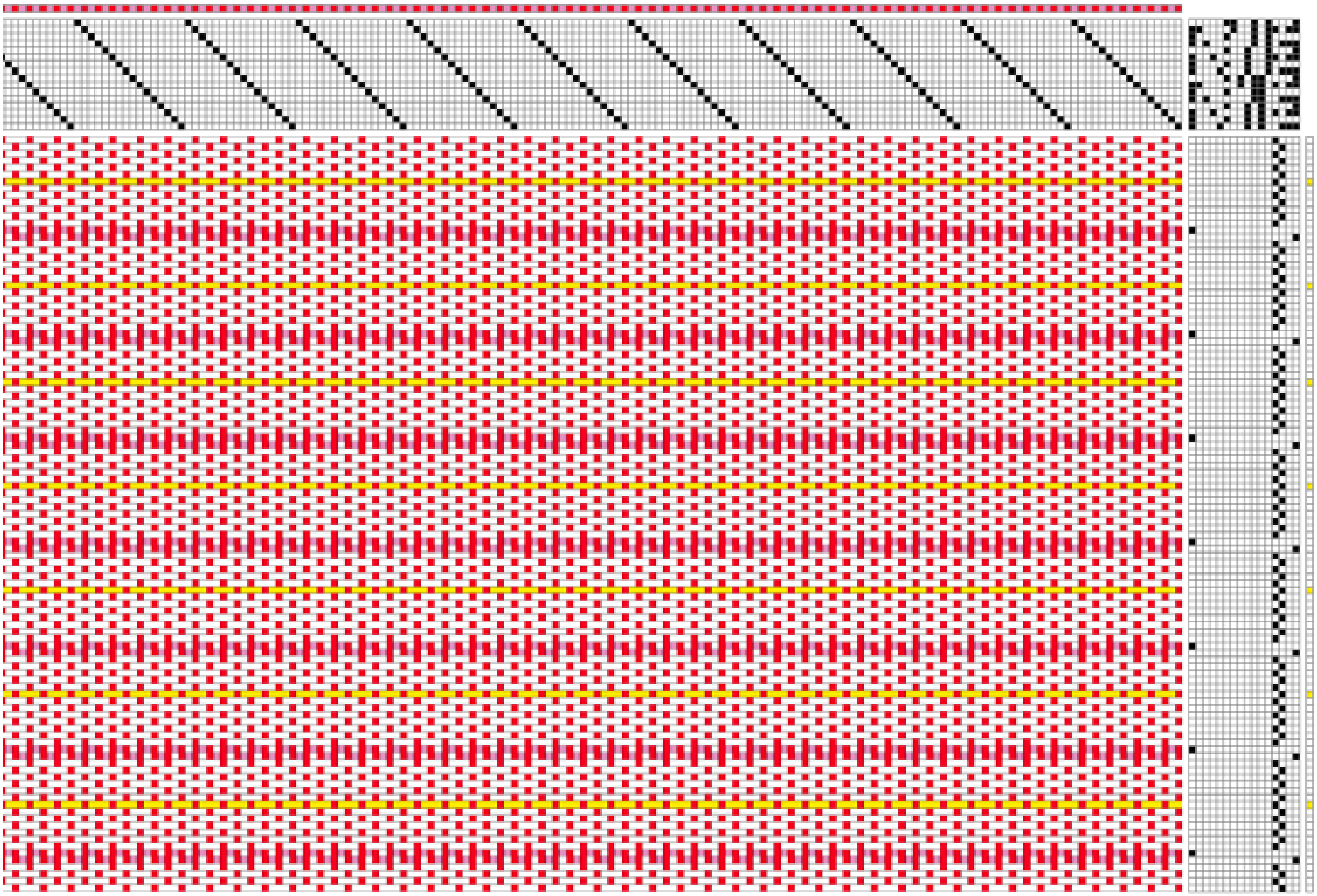
Light Curtains Pattern A Binding

Warp 1: cotton 30/2 (white)
20 threads/cm

Warp 2: cotton 30/2 (white)
10 threads/ cm

Weft: cotton 60/2 (white)
EL-wire Ø 1,2mm (aqua green/blue)
Plastic foil 50 mm stripes (silver/black)



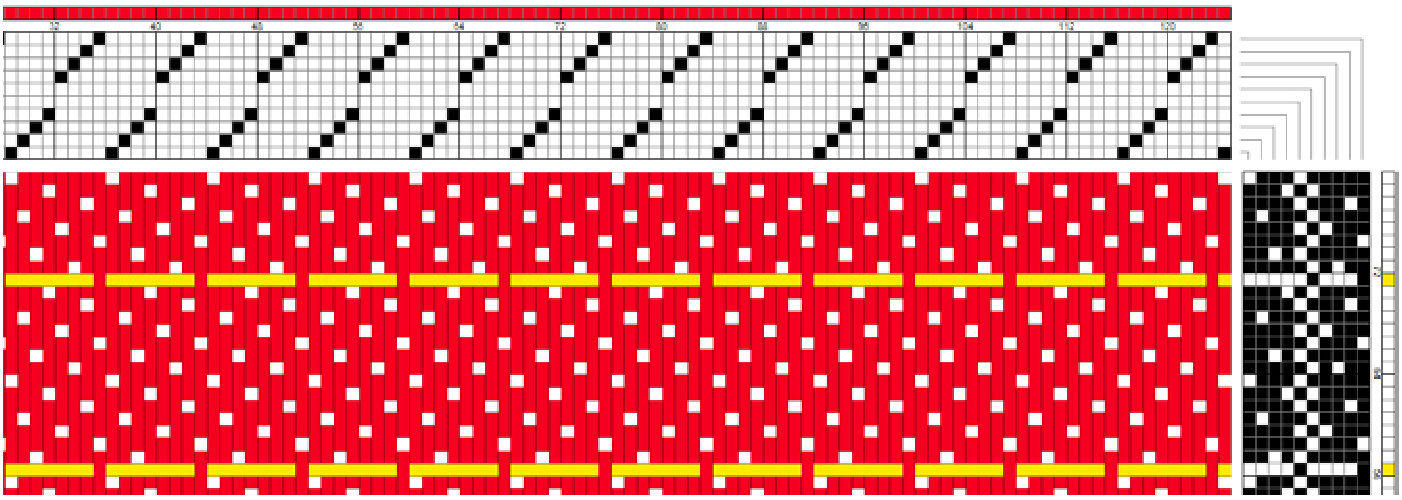


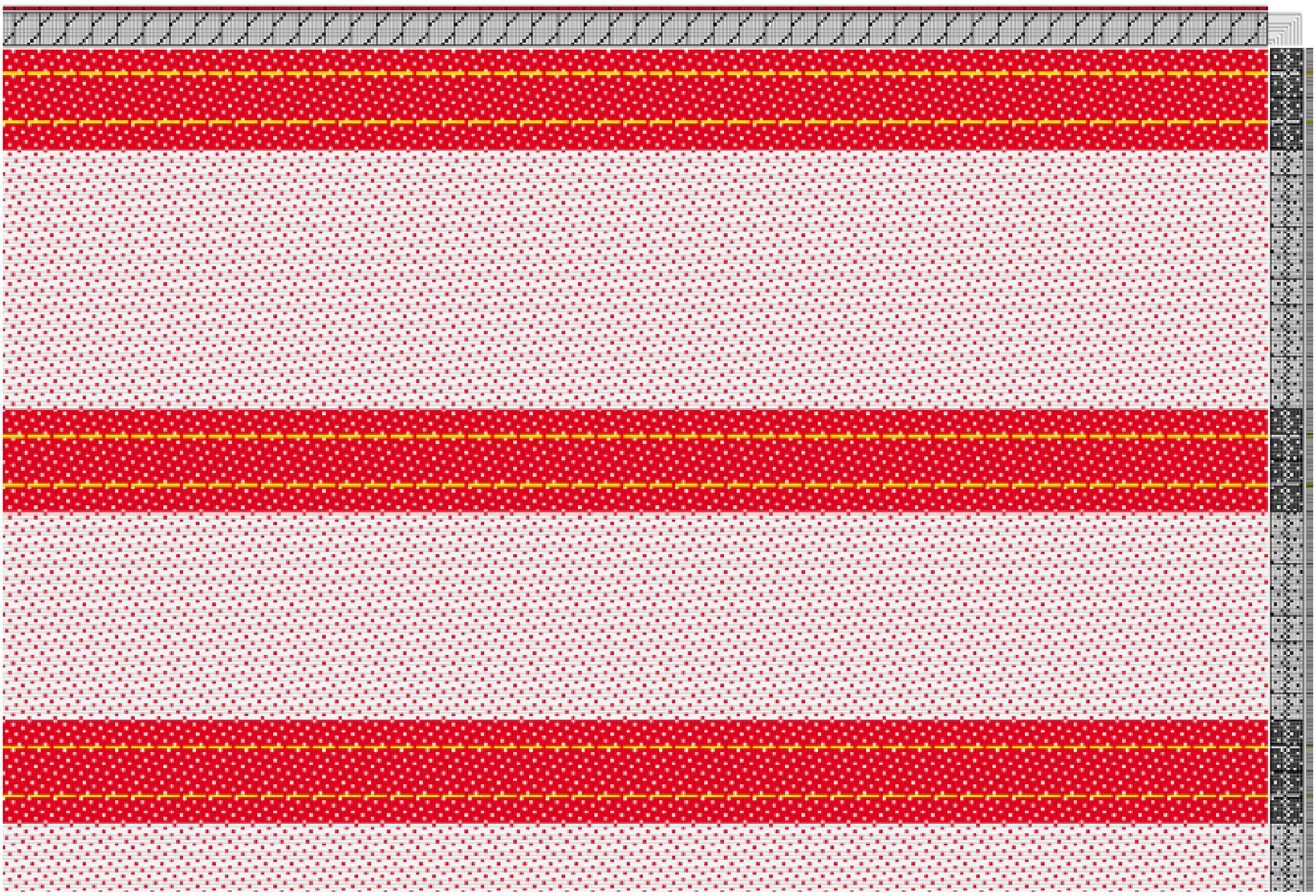
Light Curtains Pattern B Binding

Warp: polyester 40/2 (black and white)

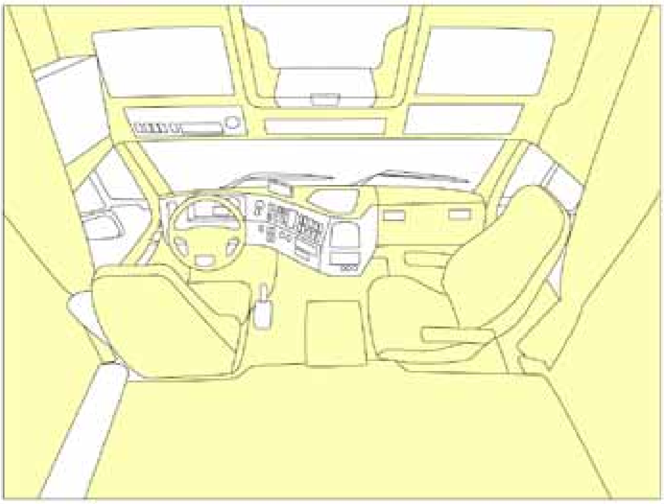
22,5 threads/cm

Weft: polyester (white)
EL-wire Ø 1,2mm (white)

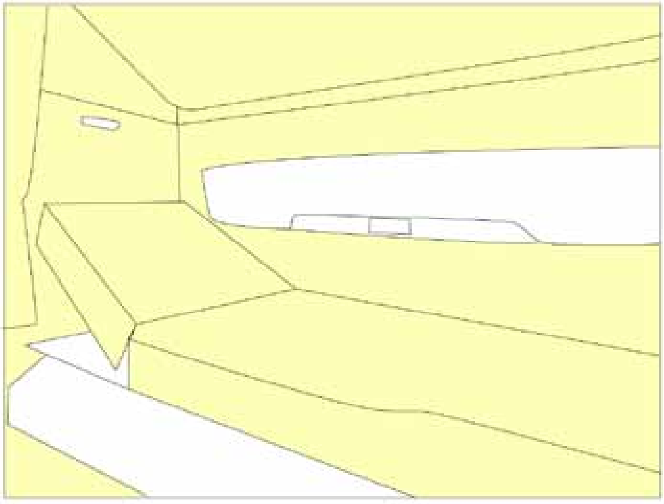




TEXTILES IN THE TRUCK INTERIOR



Seats
Armrests
Floor carpets
Ceiling
Walls
Door panels
Steering wheel
Curtains
Sunshades
Front panel
Table



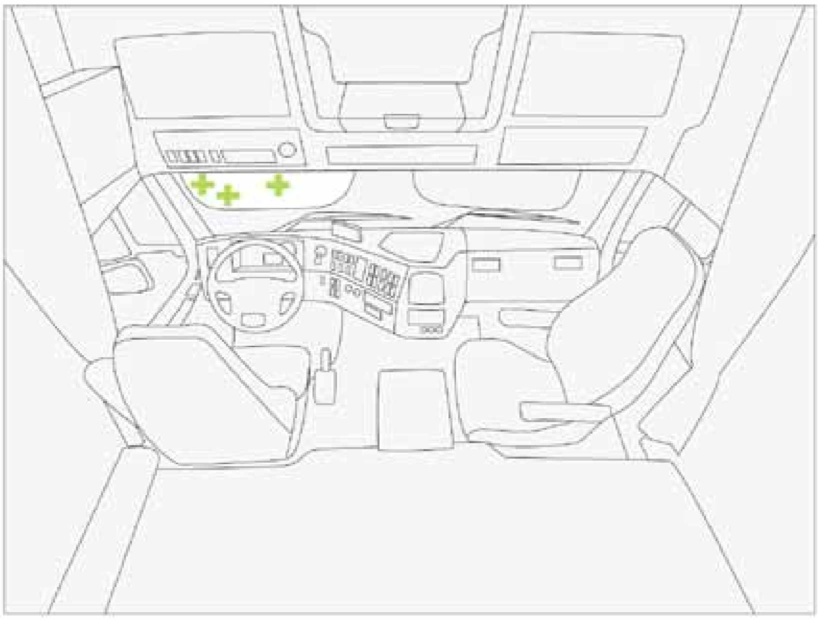
Bed
Curtains
Walls

COMMUNICATION

Textile pattern which indicates how many friends are around.

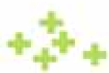
Dynamic pattern on the sunshade. Symbols light up as fellow drivers are around. The more friends are near the more pattern will appear.

Material: EL- film or LED



Pattern:

One truck around



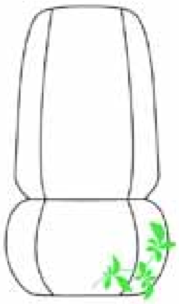
Several trucks around

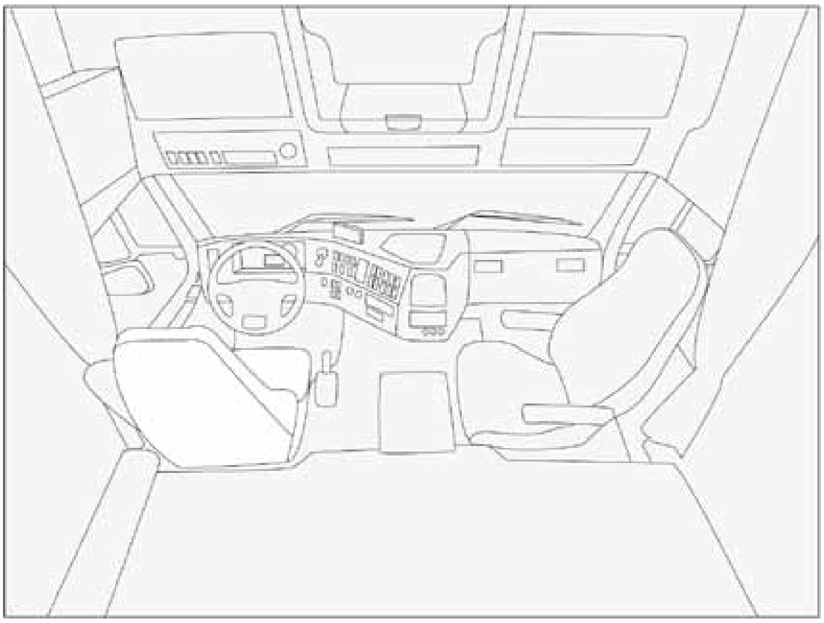
DOOR OPEN

Driver seat that notifies if the door is left open.

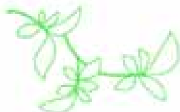
Pattern on the left side of the seat corner lights up as the door is left open.

Material: Thermo- Chromic ink





Pattern:



Door closed
(pattern off)

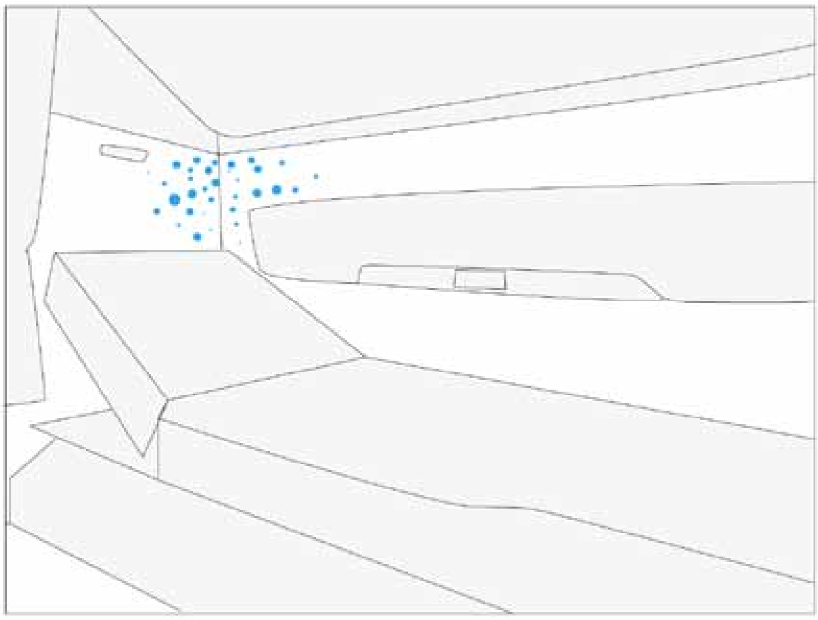
Door open
(pattern on)

INTRUDERS

Textile pattern which notifies the driver about the intrusion in the truck.

Pattern on the walls lights up in the case of intrusion. The location of the lighted pattern shows the direction of the intrusion.

Material: LED



Pattern:

No intrusion
(LED off)

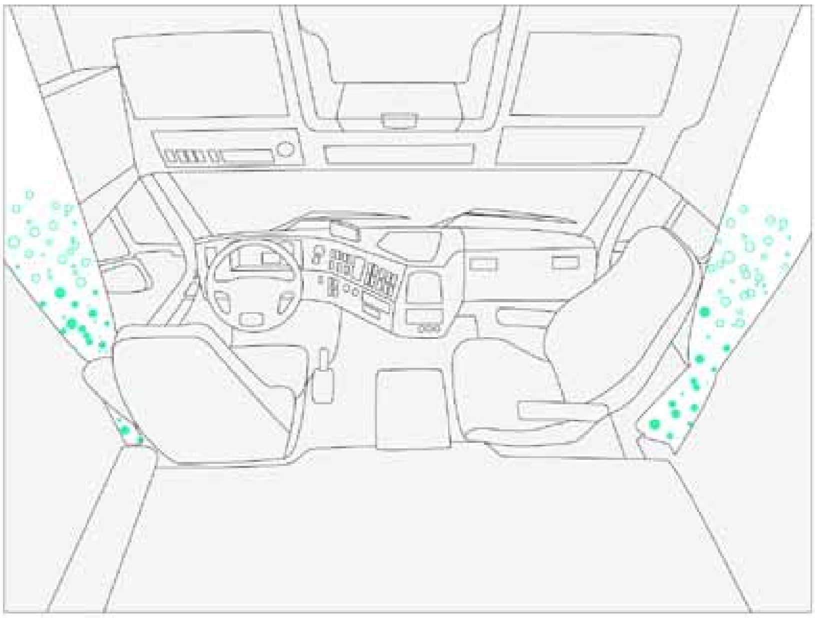
Intrusion
(LED on)

INTRUDERS

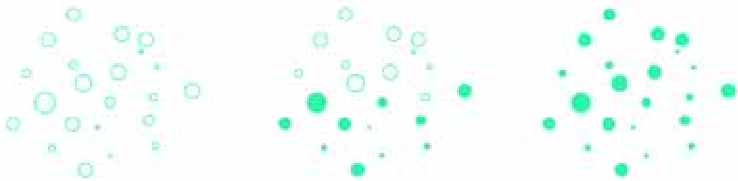
Textile pattern which notifies the driver about the intrusion in the truck.

Pattern on the curtains lights up in the case of intrusion. The brightness of the pattern shows the intensity of the intrusion. Blinking pattern warns of invasion.

Material: EL- film, EL- wire or LED



Pattern:



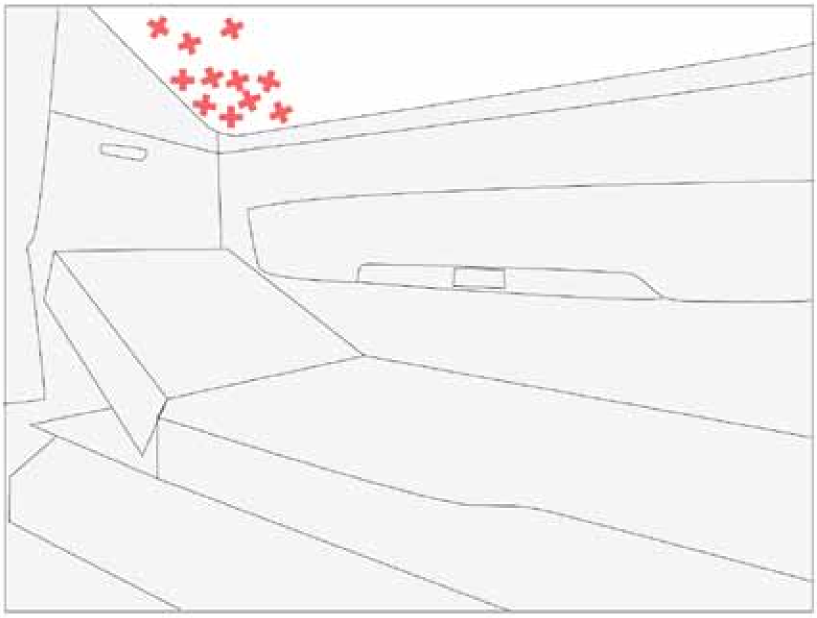
No intrusion (LED off)	*Intrusion (some LED on)*	*Invasion (LED blinking)*

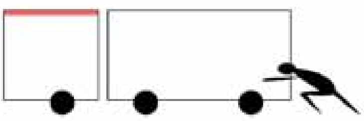
INTRUDERS

Textile pattern which notifies the driver about the intrusion in the truck.

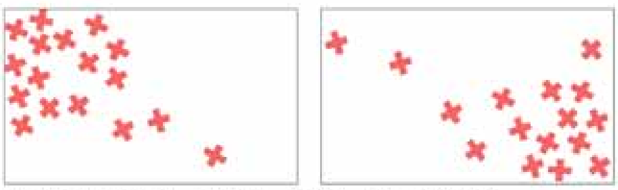
Pattern on the ceiling lights up in the case of intrusion. The position of the lighted pattern shows the direction of the location of the intrusion. Blinking pattern warns of invasion.

Material: EL- film





Pattern:



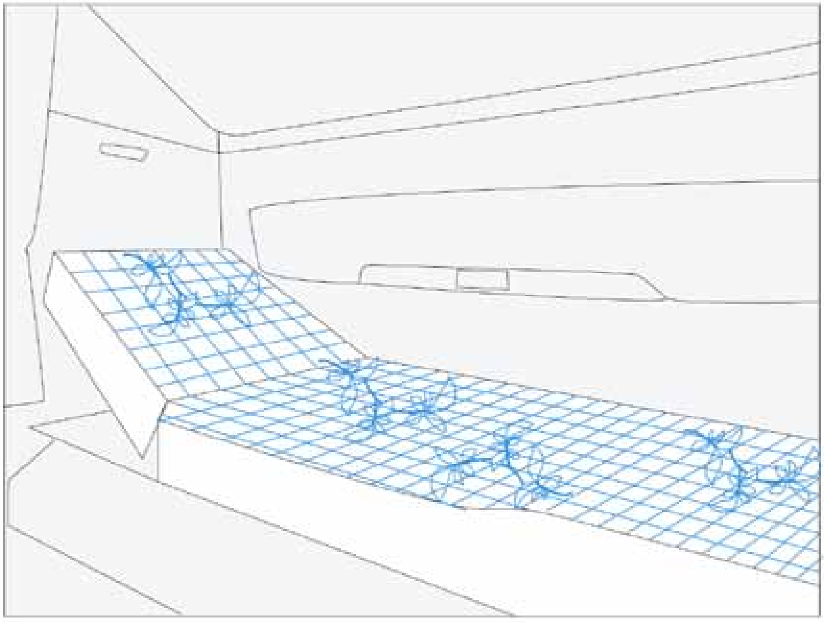
Intrusion moves from left to right (Pattern developes in the same direction)

SLEEPING

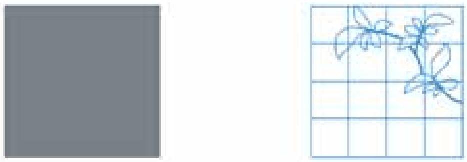
Textile pattern on the bed clothes that changes the color when someone sleeps in the sheets.

Pattern on the bed changes the color when itgets into contact with human body heat (at least 27 C). Playful pattern change reduces boredom. Grey single color sheets become blue patterned.

Material: Thermo- Chromic ink



Pattern:



Grey
(less than 27 C)

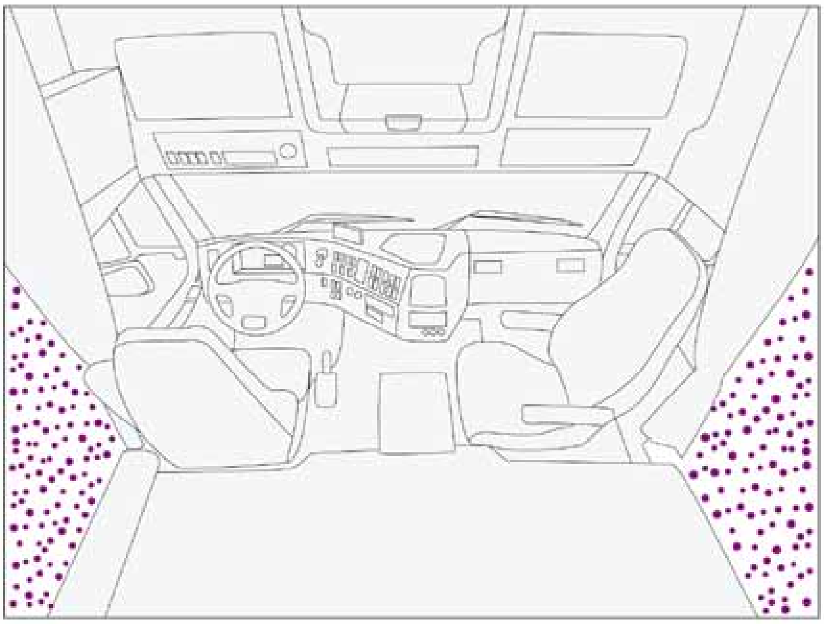
Blue pattern
(more than 27 C)

TEMPERATURE

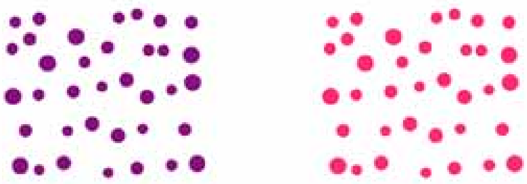
Walls notify about reached room temperature.

Pattern on the walls changes color as the room achieves a certain temperature.

Material: Thermo- Chromic ink



Pattern:



Purple
(less than 27 C)

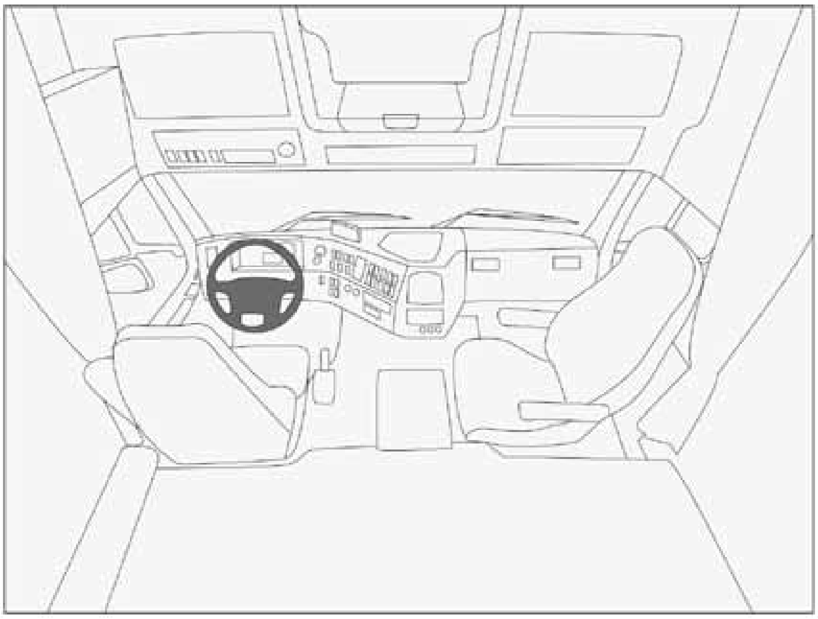
Red
(more than 27 C)

WEATHER

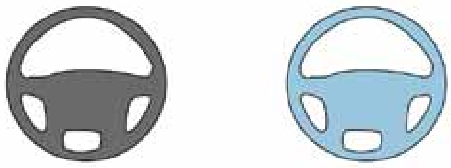
Steering wheel that informs about the weather and conditions outside.

Color on the steering wheel indicates the weather conditions outside. Grey colored steering wheel turns into blue when the road turns wet.

Material: Thermo- Chromic ink



Pattern:



Grey color (dry weather)

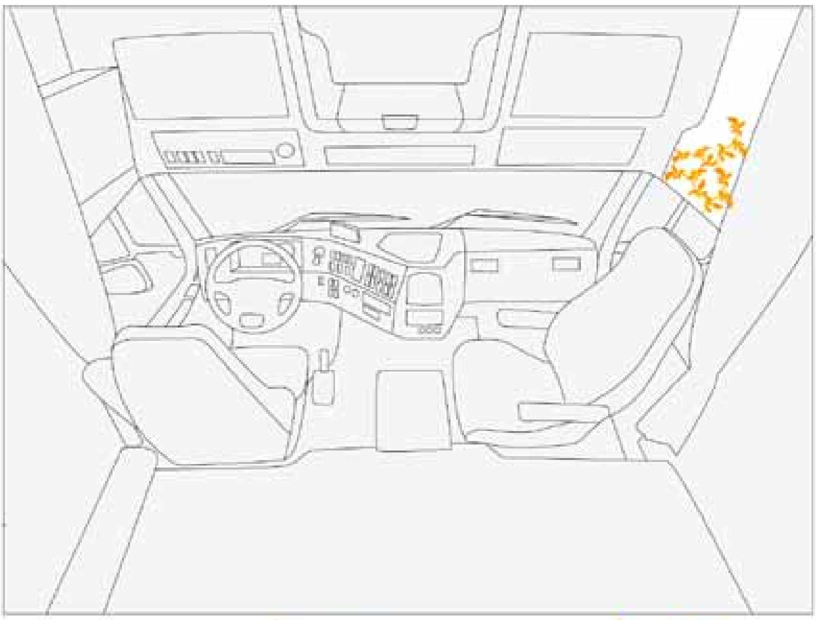
Blue color (wet road)

BLIND SPOT

Wall that lights up when an obstacle enters the blind spot.

Pattern starts to light up when a vehicle or a pedestrian enters the blind spot.

Material: EL- film



Pattern:

Blind spot empty (pattern off)

Obstacle in the blind spot (pattern on)

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