Night Vision System for Cars:

Thermal Imaging Camera, Display and Interface.

Sõiduautode öönägemissüsteem:

Termokaamera, ekraan ja kasutajaliides.

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Author's Declaration

I have written the Master’s thesis independently.

All works and major viewpoints of the other authors, data from other sources of literature and elsewhere used for writing this paper have been referenced.

Master's thesis is completed under ..... supervision

/ / 2016 Author ..... signature

Master's thesis is in accordance with terms and requirements

/ / 2016 Supervisor ..... signature

Accepted for defense
..... chairman of defense commission.

/ / 2016 ..... signature

Master’s Thesis Objective & Task

2015 / 2016 academic year, 5th semester
Student: **Taylan ACARSOY**, 130533MADMM
Field of study: **Design & Engineering**
Supervisor: **Martin Pärn**, Chair of Design

Master's Thesis Topic:
Night Vision System for Cars: Thermal Imaging Camera, Display and Interface.

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Tasks and timeframe for their completion:

Nr.	Task Description	Completion Date
1	RESEARCH AND PROBLEM OPPORTUNITY and POTENTIAL ELECTRONICS and ENGINEERING	01/07/15
2	CONCEPT GENERATION REFINEMENT DEVELOPMENT	26/08/15
3	DESIGN PREMLINARY DESIGN DEVELOPMENT PRODUCT-SERVICE RELATIONS ENGINEERING DETAILS BUSINESS-BRAND	15/12/15
4	FURTHER DEVELOPMENT CONLUSION	03/01/16

Design and Engineering problems to be solved:
The objective of this thesis is to investigate night vision systems for the automotive industry, with a focus on working principles of the engineering system, the design of the display, camera and interface. The aim is to develop a product solution in the form of Bluetooth connection between display and thermal imaging camera and smart features, covered the existing user problems.

Defence application submitted to deanery not later than 05.01.2016 Deadline

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Abstract

This research investigates night vision systems for the automotive industry, with a focus on principles of design of the display, camera and interface. The theme of the thesis is to design a solution for highly user friendly night vision system to fit any kind of transportation device. During a preliminary study, the working principles of thermal imaging cameras in the automotive sector and studied how much design aspects are considered on the tangible and intangible pieces like displays, front camera, connections and interface. Thorough research is carried out the usage and needs of thermal imaging cameras in the automotive industry, afterwards a detailed investigation is carried out from an engineering point of view. As a result of this research, some problems are listed;

- Installation, connection and maintenance
- Usage inadequacy on display
- Complex interfaces and indication that makes images confusing for drivers
- Inability to position the device according to the driver's choice
- Over multi-functional usage

After thorough the analyses, a new product design is proposed to offer solutions for defined problems. The proposal focuses on the design of the system: camera, display, connections and interface. In depth is dealt with the use of the device and adaptability for different car models. For instance, new product design proposes a clear interaction with the user, sustains adjustable placement for the display, reduces the number of connections that makes installation and maintenance easier. Additionally, new system sustains a smart usage, with reducing the elements on display and simplifying the interface. Final proposal promises a solution what behaves in a most natural and effortless way for the driver fitting seamlessly into the everyday habits of driving and being there to alert when needed.

KEYWORDS: thermal imaging, night vision, display design, interface design, automotive industry

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1 - Introduction

Recently, increasing population brings the needs of improved and high quality transportation. Global sales of passenger cars are forecast to hit 72.2 million vehicles in 2014. Along with China, the United States are counted among the largest automobile manufacturers in worldwide market, both in terms of production and sales. About 7.24 million passenger cars were sold to U.S. customers in 2012, and around 4.11 million cars were produced here in the same year. (Statistics and Facts about the Global...)

Moreover, just under 74 million automobiles are expected to be sold by 2015. (Number of cars sold worldwide from 19...)
These vast numbers just show the small part of the big picture. Besides, there are several types of vehicles such as trucks, coaches and SUVs, etc. and that makes automotive sector one of the greatest industries in the world.

Therefore, companies are trying to provide better and safer systems for its users even they are drivers or passengers. According to needs and wants, vehicle manufacturers are trying to improve designs, quality and safety issues. Night vision cameras and road tracking systems are one of the most popular new features for transportation devices.

Every year, several amount of accidents happening because of animals, humans and road conditions. Especially at night time, in misty weathers and in harsh environment, it is getting difficult to spot holes and living organisms on the road. Some car manufacturers are trying to improve systems that can help drivers, but there are several problems about these systems.

Road detecting systems and night vision systems are existing technologies. Famous car manufacturers such as, BMW, Mercedes etc, are using that kind of systems in their productions. However, mostly, these new systems are located into new models and prices are really high if we compare with the middle and lower class cars. Therefore, these services cannot reach all the users of the products.

There are two types of night vision systems in the market such as internal and external systems. The new product is aiming to give an opportunity to consumers in order to use night visions systems in any type of vehicles. Therefore, the new product is in the category of external systems. Even there are some attachable products in the market, they have various problems in terms of interface design, installation, maintenance and connections.

Accordingly, in this study, the need of thermal imaging cameras for automotive industry, for drivers are investigated by several methods such as researches, questionnaires by numbers and a market research is made about existing products. Afterwards, the working principle of the night vision system is examined from an engineering point of view with all properties. Moreover, aesthetics of the display are considered and design investigation of the interface is made.

The research is limited to the working principles, electronic sections of the system and overall design applications in displays, interface, camera and contains qualitative and quantitative information about the sector.

2 - Methodology

This part gives information about case study and explains the research, the method of the research, approaches with cause and effects.

The method for this research is a blended technique that incorporates quantitative and subjective substance examination and survey. The information is utilized as a part of a request to make a base learning for readers and these information is upheld with existing products. The research structure is constructed on design and engineering process.

2.1 - Engineering Design Process

Considering design process and the product specialities, the project engineering design process is followed in order to generate a solid and consistent approach according to the topic and product that is chosen.

The engineering design process is a progression of steps that utilization to guide designers and engineers as they take care of issues. The outline procedure is repetitive, implying that designers rehash the progressions the same number of times as required, making upgrades along the way. (Engineering Design Process)

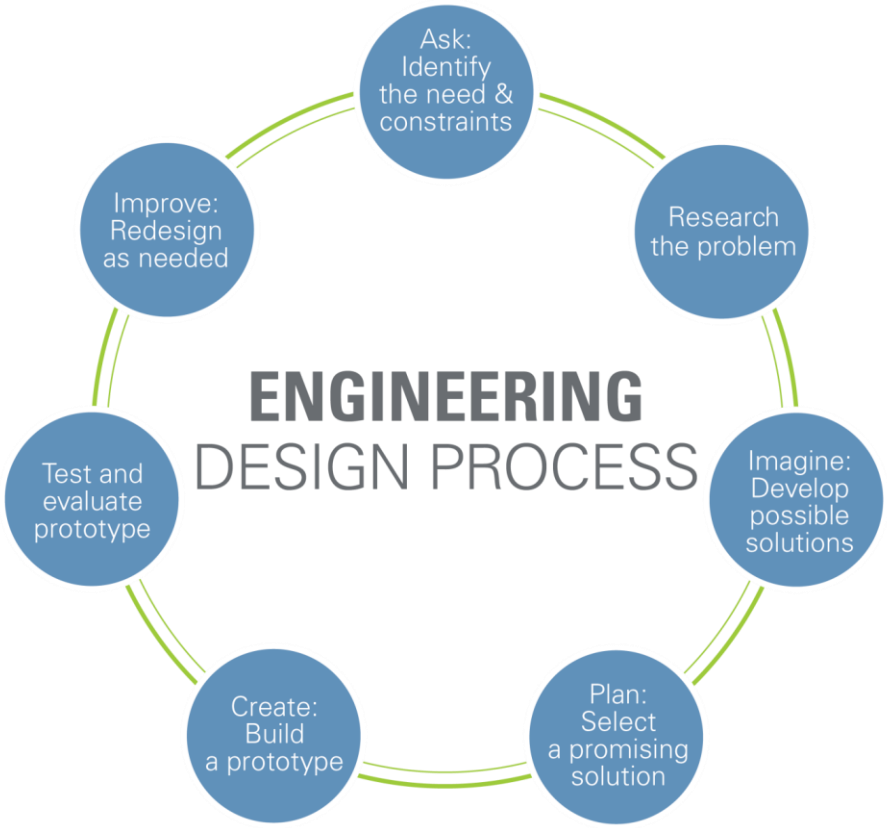

Fig 1. Engineering design process

2.2.1 - Ask: Identify the Need & Constraints

In this step, engineers and designers are asking the series of questions about what they want to create. These questions contain: What is the problem? What do we want to design? Who is it for? What are the project requirements? What are the limitations? What is the goal? The answers of the questions create a database about idea generation.

2.2.2 - Research the Problem

This section incorporates conversing with individuals from a wide range of foundations and fortes to help with scrutinizing what items or arrangements as of now exist, or what advances may be versatile to your needs. Identifying the problems reveal the selections of the new product.

2.2.3 - Imagine: Develop Possible Solutions

In this stage, designers and engineers brainstorm ideas. As many solutions as possible are generated. This is the time to empower extreme ideas and concede judgment. All focus should be concentrated on the theme. Moreover, existing solutions, products and services should be examined.

2.2.4 - Plan Selecting a Promising Solution

In this phase, needs, limitations and exploration of the prior steps should be revisited. The best thoughts and options can be listed. One arrangement can be selected and an arrangement is established to get up and go with it.

2.2.5 - Build a Prototype

This phase helps the designer or engineer in order to make the ideas real. These early forms of the outline arrangement help to check whether the configuration meets the first test targets. If it is not possible to create a working prototype or similar model at this stage, working principles, production methods, materials should be listed and analyzed or virtual parts of the system as an interface can be prototyped in terms of user experience design process which facilitates the task for the user and to make sure that the user is able to make use of the product as intended and with a minimum effort to learn how to use it. (Abras et al. 2004)

2.2.6 - Test and Evaluate Prototype

This stage is highly important to reveal the consistency of the product or service. Does it work? Does it solve the need? Analyzes should be done and feedbacks should be taken about what works, what doesn't and what could be improved parallel with former phase.

2.2.7 - Improve: Redesign as Needed

In this phase discussions are made about further improvements of new design solution. Revisions are made and new designs are drawn. Design should be iterated in order to make a new product or service the best it can be.

2.3 - Main Frame and Sections

Under the guidance of Engineering Design Process Cycle the body and the parts of the research are constructed. The study is divided into five main parts as Introduction, Research, Design, finally, Findings and Final Design Proposal.

In the research phase, the potential of the area is investigated by numbers and examples in order to give an overall information about the sector and potential demand. Later, working principles of the thermal imaging cameras and night vision systems for the automobile industry are given to readers in order to explain what is this system and why people are using. Moreover, the reader gets the superficial knowledge about the working principle of the system. Afterwards, readers are informed about the existing solutions and products in the market. That will help to reader in order to understand the innovation and differences in new product. In the next stage the main problems about the thermal imaging cameras and its all properties are notified and questionnaire is given with the results.

In the next main section, in concept, research is going along with the possible concepts. An overall generation is made and after refinement is done about concepts. Afterwards, in development phase, a shallow information about the design principles of display and interface are given to the reader in order to understand the causes and effects of the new design. Moreover, this phase contains design process, sketches and concepts before the finalization.

In the next category, in design, the reader meets with the preliminary design, and witness of its development with explanations in every design phase. Before the final design, the product and service relations and details are given. At the end, engineering and electronics details are notified briefly. Moreover, the reader is informed about the business and brand design.

In the last section, in findings and proposal, final insights about the design and product are given. After clarifying the vision and new design proposal, the new product is explained with all features. Afterwards, the case is closed with the last section.

The aims of the research in the literature review section are to give clear ideas about thermal imaging technology and night vision system for the automotive industry in general and to make the audience be informed of the point of moving to the intangible idea of monitoring living organisms and being a road assistant to tangible product In this transition period, the audience can find information about design and engineering and factors that affect the design mentality in each section. Moreover, every aspect of the design phenomena is analyzed in terms of device and its properties such as camera, connections, display and interface.

3- Research

3.1 - Introduction to Night Vision Systems

This part explains the thermal imaging systems and night vision briefly, and gives a general idea about the systems to the audience.

Thanks to technological progresses, we see an innovation not only in the computer field, but also in every area of our lives. Companies are providing a whole range new technologies from wearable technology to new vehicle technologies. One of these is night vision systems technology. Assistant in night vision systems is spotting pitch-dark objects which come up on the road like pedestrians, animals with infrared cameras, detect and alert the driver. This technology is running slightly different from the green night vision system that we see in the movies and for military purposes.

The night vision system that detects the pedestrians and animals actually used by Cadillac since 2000. However, since the actual useful model can be seen in the 2005 Mercedes S models. Since 2010 high-end segments used in the Mercedes E-Class. BMW and Volvo have joined this bandwagon. Nowadays, some companies started to use these devices as standard equipment in their vehicles.

When the sun goes down, driving is more dangerous. At night, only 20 percent of the total traffic is on the roads, but forty percent of all fatal accidents occur at night. Short and beam headlight function can provide only limited support. Therefore, companies are seeking another way of trying to get a good view. Night vision assistant via an infrared camera shows things normally invisible. This increases the safety of both drivers and careless pedestrians.

The system displays the street view in the dark on the screen thanks to infrared night vision system. Marks people and animals, optionally send signals to the pedestrians with a flashing spotlight.

Originally developed for the military, night vision technology measures heat signatures and creates an electronic image of everything in view. The system converts these temperature differences into an electronic signal, which it displays like a black-and-white TV image. This image is projected onto the windshield or display on a screen mounted just below your line of sight; or in some cases it can be ported to your navigation system's monitor. The image is available at a glance and won't interfere with regular driving practices. In fact, after a short time, you'll begin using it naturally just like your rearview mirror. (How it works)

Until further notice, companies will keep on assessing present and new innovations in lighting, and headlamp performance on every vehicle that are tested Also, standards will be monitored, bolstering where suitable to permit fresher advancements that offer the possibility to enhance night driving safety. (Stockburger 2014)

3.2 - Working Principle

This part explains the night vision system's main sections as camera and display. In first step human sight is analyzed in terms of night vision. Secondly the bicrobolometer technology is analyzed due to being a lead and basis technology in night vision systems. Enhanced Vision Systems, Near Infared and Far Infared technologies investigated and finally with Head Up Displays which are the last component of a night vision system and have a direct interaction with users, introduced to the audience.

3.2.1 - Human Sight

Human sight is an astonishing blessing. With it, the world shows up in three dimensions and, for the vast majority, our environment shines in over a million hues.

Obviously, for all that human vision gives us, it misses the mark in one critical ability: we are not ready to see extremely all around, unaided, oblivious. We require just to stumble over a family pet or be astonished by somebody in the forested areas during the evening to be helped to remember our constraint.

Our poor night vision can be clarified to a limited extent by the absence of a tapetum lucidum, a layer of tissue that reflects unmistakable light back through the retina to expand what's accessible to the photograph receptors in our eyes. It's what adds to the unrivaled vision of creatures that chase around evening time, for instance, a gecko and some remote ocean animals. (Miller 2014)

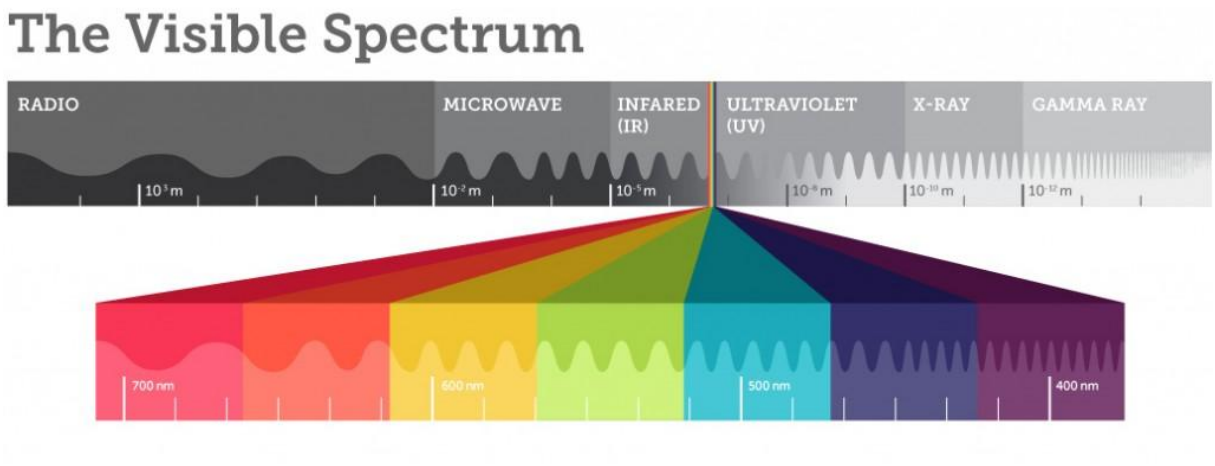

Fig 2. Visible spectrum

3.2.2 - Microbolometer Technology

Uncooled long-wavelength infrared detectors taking into account Vanadium Oxide Microbolometer innovation are opening new conceivable outcomes in an extensive variety of utilizations. The little, wafer-level bundling implies that the IR sensor can be less difficult and more dependable, while expending less vitality and costing tens of dollars rather than hundreds or thousands.

Military staff and common specialists on call may be among the first to profit by new and more reasonable strategies for seeing the already unseeable, however ordinary clients from all kinds of different backgrounds will likewise soon appreciate routinely finding what's hiding from them. (Miller 2014)

Also, the automotive industry is one of the leading industries in that field. The reason: uncooled infrared imaging offers a down to earth approach to enhance driver security through night-vision systems in vehicles.

Moreover, thermal imaging will likewise get to be accessible on a more individual level. The FLIR One, for instance, is an infrared camera connection for the iPhone.

Fig 3. Flir One - Personal infared camera connection

3.2.3 - Enhanced Vision Systems

Night vision system advancement started in World War II and has turned into a basic part of cutting edge fighting. The capacity to find in evening time conditions permits military moves and a potential point of preference to the powers outfitted with this innovation. These night vision systems depend on the low light levels of starlight and night sky brightening (called " atmospheric nightglow") to help picture the focused on the scene and its environment. ((SWIR) Short Wave Infrared Night Visi...)

At the point when military ground transport vehicles (trucks, tanks, personnel carriers, HUMVEE's) need to work altogether dimness, their drivers can utilize Enhanced Vision Systems (EVS) including short wave Infrared (SWIR) enlightenment and Sensors Unlimited short wave infrared night vision camera systems to explore secretly in threatening domain. Dissimilar to Midwave infrared (MWIR) and Long wave Infrared (LWIR), SWIR cameras can picture through the windshield and in this way be mounted in the driver's compartment for a "driver's eye" perspective of the route ahead. SWIR cameras can likewise be coordinated into ruggedized outside lodgings.

Fig 4. Short wave infrared (SWIR) image

The VES is a system utilizing infrared light, which is imperceptible to the human eye. The VES picture on the display could be accomplished by utilizing an ‘active’ or ‘passive’ infrared (IR) camera. The dynamic camera sends IR light on the surroundings which is reflected back to the VES display. It lives up to expectations in the ‘near IR’ scope of the electromagnetic range. A few hindrances with the active system are that the framework system may be ‘blinded’ by conventional headlights from approaching autos and that the extent is to some degree restricted. The passive system does not convey any IR light, but rather utilizes a picture sensor that works in the far IR’ range, which is the same as warmth. The heat of warm objects emanate makes it conceivable to demonstrate the objects as pictures on the VES display.

Through a display in the auto, the driver has the capacity see the environment up to 700 meters before the auto with low beams, contrasted with more or less 70 meters without a VES. With a VES every living objects can be easily identified. The warmer the object is, the brighter it shows up on the VES display. Not just living creatures are warm, along these lines additionally autos, heated houses and traffic signs are obvious. These items are typically not as warm as living objects, however, and subsequently don't show up as splendidly on the display. (Druid 2002)

Fig 5. Vision enhancement system display

Briefly, thermal infrared (IR) imaging sensors react to emitted, more than reflected, radiation. All things emit heat by three methods - conduction, convection and radiation. Conduction exchanges heat through solid items, convection exchanges heat through liquids and radiation exchanges heat through electromagnetic radiation. Objects persistently transmit heat with specific wavelengths, subordinate upon the temperature of the emanating item and its ghastly emissivity. As the object temperature expands the radiation increments. Thermal imaging converts thermal radiation into a digital signal which is then converted into a visible image. (Amin et al. 2008)

3.2.4 - NIR and FIR Systems

There are two sorts of night vision advancements available. Far Infared (FIR) and Near Infared (NIR). FIR identifies the radiation which all items transmit, while NIR distinguishes the reflected brightening in a frequency simply outside the noticeable scope of human being. (Källhammer 2006)

The capacity to distinguish pedestrians and animals utilizing both a NIR and a FIR system was thought about in a study by UMTRI (Tsimhoni et al. 2005) The outcomes demonstrated that the recognition of separation utilizing a FIR system was altogether bigger than utilizing a NIR system, with normal recognition of separation of 119 m for older drivers and 144m for more youthful drivers. Normal identification of separation with a NIR system was 35 and 42 m respectively.

Fig 6. NIR and FIR systems, detection distances for old and young drivers

At the point when the system was supplemented with a programmed cautioning function, the location separation and the precision of location expanded with both systems when the driver was given a notice when the item was 150 meters in front of the vehicle. The FIR system gave the longest location separation at 150 meters, while the identification of separation with the NIR system was 110 meters. The location separation expanded for the NIR system while it diminished to some degree for the FIR system, when the programmed cautioning was given when the object was 75 meters before the vehicle. Normal location separation for the NIR system was 64 meters while the normal recognition of separation for the FIR system was 119 meters. The caution at 75 meters diminished the recognition of separation for the FIR system, in spite of the fact that identification was made before the cautioning was given. The workload was appraised higher by the users of the NIR framework, and the expansion of a programmed cautioning did not diminish the workload fundamentally. (Källhammer 2006)

3.2.5 - Head Up Display

Night Vision displays can either be contact simple, or compatible, with the scene introduced before the driver, or it can be a different display. The different displays are for the most part partitioned into either Head Up Displays (HUD) or Head Down Displays (HDD). The HUD systems accessible in the market that show a picture just underneath the typical viewable pathway either specifically on the windscreen or anticipated on a combiner that can either be transparent, or obscure. A HDD display can utilize either the in-vehicle route showcase or another display in the instrument bunch.

Fig 7. Head Up display

A different display for the Night Vision, whether HUD or HDD, implies that the driver needs to examine both the scenes through the wind shield and the display and always move the look between those two areas. This extra scanningmatches the perspective from the windshield at all times. A contact simple display where the Night Vision picture is totally overlaid on the windscreen perspective would in this manner most likely be favored by drivers.A contact simple display would, however, oblige that the picture from the Night Vision system totally contact simple display needs to have, by definition, a scale element of 1:1. Accomplishing an adequately wide field of perspective would along these lines require exceptionally intricate and costly contact simple displays. Other than execution troubles, the need to cover a more extensive territory before the driver for pedestrian or animal protection purposes would along these lines diminish the potential utilization of contact simple displays. (Källhammer 2006)

According to researches, the outcomes were measured in driving performance and in addition sentiments from the participants. Results demonstrate that there were some critical contrasts and a few propensities of better driving performance when driving with the display in front of the driver. The participants likewise appraised this display as being better situated and effecting the driving in a more positive manner than the display to the right. It was subsequently presumed that that the most favored display position is in front of the driver. (Druid 2002)

Fig 8. Vision enhancement system display position

3.2.6 - Outcome

As mentioned above, the night vision system consists of two main sections as camera and display. Starting from the basis with human sight until head up displays, the main function and overall working principle of the night vision system is trying to supply to the audience in order to give a framework. Positive, negative sides and some standards which are measured by experiments and studies are given to the audience in order to understand the choices and specifications of the new design.

3.3 - Existing Systems and Components

In this section, one internal night vision system which belongs to BMW and two external thermal imaging systems which belong to SATIR company are analyzed with components, details and specifications in order to give the idea what is on the market, the advantages and disadavnatges of the existing systems. The audience will be informed both about parts, prices and requirements of the system.

3.3.1 - BMW Night Vision (Internal Night Vision System)

The community has the chance to encounter the most recent innovation in night vision systems on a BMW 7 Series. In spite of the fact that companies have assessed night vision systems before, this one demonstrated to have far clearer images and was additionally ready to highlight animals and pedestrians. Today's system use propelled infrared cameras to "see" heat, not light, making anything that has a "thermal" picture noticeable even through haziness or mist. (Stockburger 2014)

For a considerable length of time, BMW has created innovative advances which give help to drivers during the night and in this manner in the meantime enhance general road safety. Advancements incorporate Xenon lights, which gives fundamentally expanded brilliance and range, "Adaptive Headlights", whose on a level plane swiveling headlamps guarantee impressively enhanced brightening of the street ahead and "High Beam Assistant" which turns the headlights naturally on and off, are only a couple of developments that can be introduced in BMW models and help drivers during night driving.

Essentially planned to forestall crashes with pedestrians and animals, the most recent systems use infrared cameras and programming intended to perceive the heat marks of people and living creatures. The night vision system that was lately tried by John R. Quain from NY Times introduced in a 2015 BMW X5 as a $2,095 alternative, however it is additionally accessible in a variety of vehicles from Audi, Mercedes-Benz and Rolls-Royce. (Quain 2014)

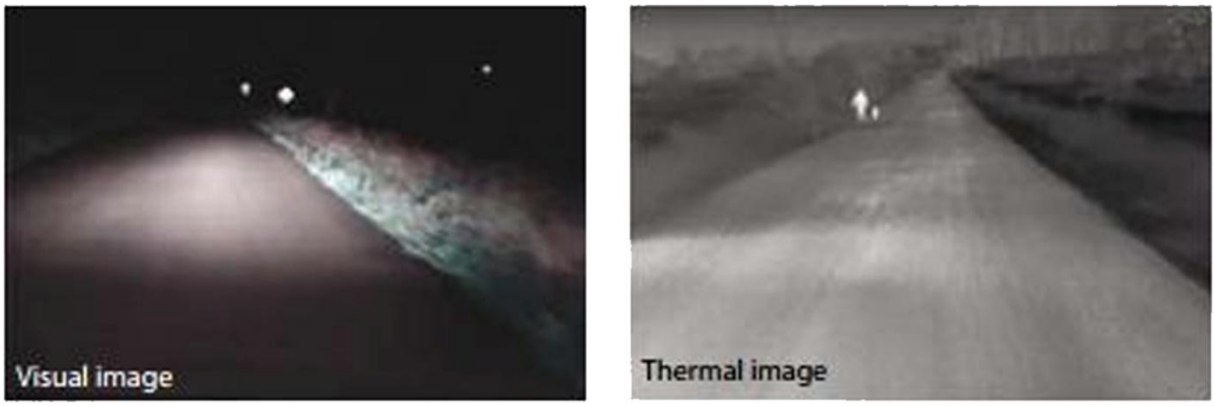

Fig 9. Visual and thermal image in BMW's night vision display

The center of this system is a FLIR Systems thermal imaging camera. BMW is the first European premium auto maker that began to actualize this innovation in its autos. The principal point of the BMW Night Vision systems is to recognize living objects, for example, pedestrians and animals, which are not lit up in the darkness. With a thermal imaging camera, pedestrians can be identified at a scope of around 300m. This is much more remote than with headlights. Early identification of pedestrians means less lethal accidents. Yet, likewise the early recognition of creatures, particularly in North European nations, is sparing the lives of drivers.

Fig 10. FLIR, BMW night vision module

The BMW Night Vision system is turned on and off utilizing a change by the light switch. The 320 x 240 pixels picture is shown on the centrally set on-board screen in the dashboard. It is established in conjunction with the navigation system.

At speeds underneath 80 km/h, the wide horizontal field of perspective (36°) of the thermal imaging camera guarantees that the road can be seen as well as the zones along the edge of the street and environment. (Bicyclists, pedestrians, children, animals, etc...) At a fast pace, the field of perspective is naturally contracted to 24°. In the meantime, the field of perspective takes after the turning of the street up to one side or right. This panning movement is controlled by the parameter "guiding of the wheels". A computerized zoom can be actuated which shows objects at further separation in a 1.5:1 grow.

Moreover, BMW is using FIR technology instead of NIR, because R&D department finds FIR technology more suitable for detection of living creatures, detects pedestrians and animals sooner and appropriate for vehicle usage.

The camera application is made in front of the car because the infrared camera cannot see through glass, so it must be mounted in the auto's grille, yet it can convey warnings about objects 100 to 500 feet ahead. (Quain 2014)

Fig 11. Camera installation inside the grille

BMW Night Vision with Dynamic Light Spot makes pedestrians and animals, oblivious remarkable in thermal imaging – even at a critical distance – and enlightens them specifically. Accordingly, you get an especially clear perspective of everything that you shouldn't miss around night time. Should a basic circumstance emerge, a caution is indicated in the display and in the BMW Head-Up Display. On the occasion of intense risk, a squinting red symbol (animal or pedestrian) is shown. An acoustic cautioning is additionally heard and the brakes are prepared for ideal responsiveness. (Ag)

Fig 12. BMW's Night Vision Display's Visual Caution

Autoliv company states that the night vision system is already available in Europe on the BMW 5, 6 and 7 Series cars as well as the new X5 and X6 crossovers which price ranges are changing between 80.000 up to 200.000 euros.

3.3.2 - FLIR Path FindIR II (External Night Vision System)

PathFindIR II is a capable thermal night vision camera that gives you a chance to see unmistakably in darkness, regardless of the vehicle you're driving or the street you're walking.

Headlights generally just give you a chance to see around 450' straight ahead, however PathFindIR II sees heat not light, and this lets people to see everything before you up to four times farther. Presently people, can see unmistakably, night and day, in great climate and terrible, without being blinded by the glare of approaching headlights.

PathFindIR II is an automotive qualified system that is hermetically fixed, appraised to IP-69, with a coordinated, programmed window heater. It utilizes 12 VDC info force, and standard NTSC feature is yield for similarity with most screens or displays. PathFindIR II is based on a 320x240 thermal camera system with a 24° field of perspective. (FLIR Systems)

PathFindIR II system is designed for simple, visceral operation and uses advanced video processing to provide pedestrian and animal detection. The camera has an advanced thermal sensor that converts thermal heat of a scene into an image for display on a video monitor inside the vehicle. Additionally the average market price for the total product is averagely 3600 $. (Car Night Vision Cameras. Car Solutio...)

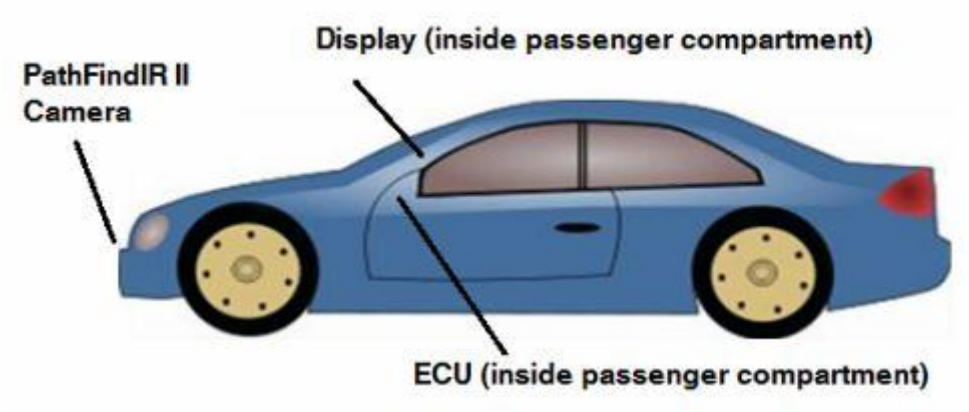

Fig 13. PathFindIR II Lay-out

3.3.2.1 - FLIR Path FindIR II - Components

The thermal imaging camera is designed to give driver vision improvement in bad weather conditions and better occasional awareness than with regular head lights. The system involves two essential segments: the PathFindIR II camera (or imager), and the Electronic Control Unit (ECU). These two coordinated parts are the heart of the system. Most establishments will likewise incorporate a video display (additionally called screen), different cables, mounting sections and mounting equipment. (FLIR Systems)

The standard camera kit contains these components:

• PathFindIR II thermal imager and mounting screws

• ECU

• PathFindIR II to ECU Cable

• Power/Video Cable (Vehicle Power to ECU, ECU video to Display)

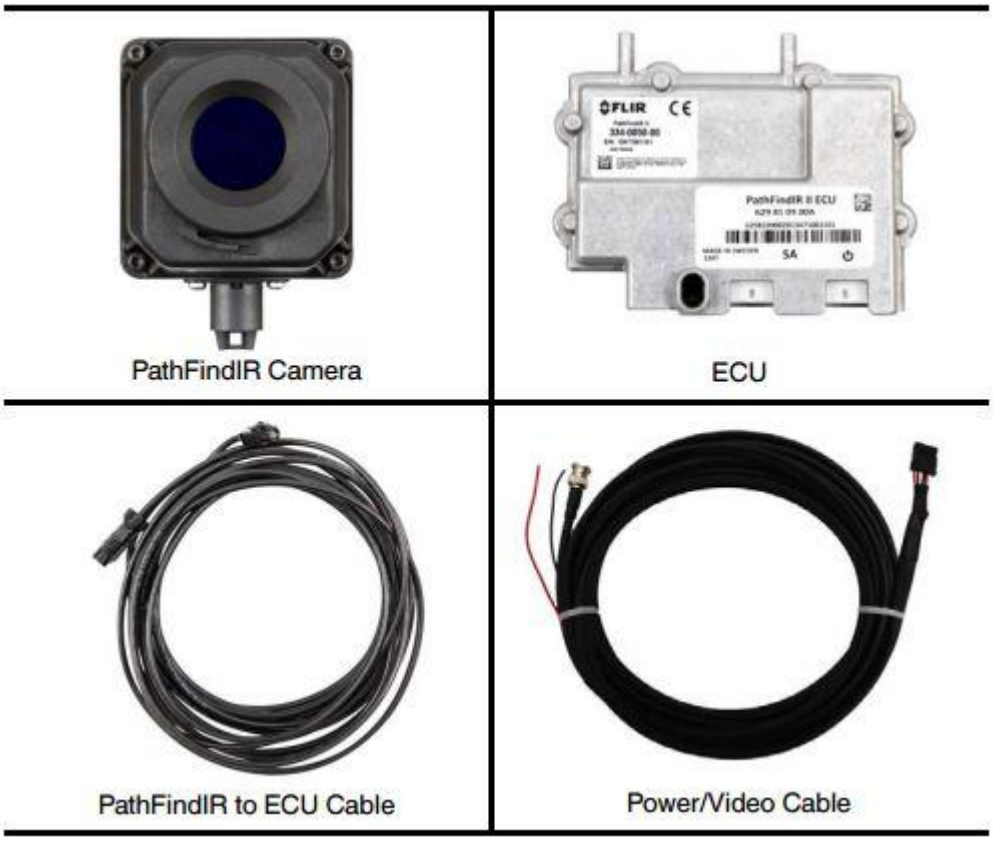

Table 1. Standard camera kit

The ECU associate with the vehicle power and interconnects the PathFindIR II to a video display. The ECU gives energy to the camera, controls the camera operation and performs the picture preparing for pedestrian and animal identification capacities. The ECU outputs the handled picture as analog video so it can be seen on a display.

The Installation Kit includes these components:

• Safety Vision Video Monitor, cables, adapters and mounting hardware

• ECU mounting bracket and mounting screws

• Camera mounting bracket and mounting screws

Table 2. Installation kit

The Power/Video Cable is 20' (6m) long and gives a flying prompts power and video. It might be important to expand the video cable with an extra cable to join with the video display. It may likewise be important to give extra power cable to reach out to the power source.

3.3.2.2 - FLIR Path FindIR II - Specifications

Thermal Imager	
Sensor Type	320 x 240 Uncooled Microbolometer
Field-of-View	24° (h) x 18° (v)
Spectral Band	8-14 microns (LWIR)
Sealed Design	IP69 rated, hermetically sealed providing extra insurance in all weather conditions
Outputs	NTSC
Power	
Power Requirements	12 VDC
Power Consumption	2 W (6 W w/heater on) 1.8 A max. system current
Spectral Band	8-14 microns (LWIR)
Environmental	
Operating Temperature	-40°C to 80°C
Weather Resistance (Camera)	Hermetically Sealed, Automotive Qualified
Weather Resistance (ECU)	Non-Hermetic; Passenger Compartment mount required
Window	High-Impact Resistant Optic w/ Built-in Automatic Heating Element
	Replaceable Window
Physical	
Camera Dimensions	2.6" × 3.4" × 3.2" (60 × 86 × 82 mm)
Camera Weight	0.6 lb (300 g)
ECU Dimensions	5.8" × 4.3" × 0.9" (148 × 110 × 24 mm)
ECU Weight	0.7 lb (350 g)

Table 3. PathFindIR II specifications

3.3.3 - SATIR - La Moon (External Night Vision System)

La Moon is providing a wide edge perspective of the road, and at a further distance than typical headlights. High resolution picture gives clear indication of the road condition and risks which are approaching or standing for the vehicle. Enhancing mindfulness so the driver can respond to the conditions and hazards. (NV618W (La Moon) - SATIR)

Although in the other products, La Moon uses an outside wireless camera on the top of the vehicle. Additionally the average market price for the total product is averagely 5800 $. (Car Night Vision Cameras. Car Solutio...)

La Moon features can be listed briefly as below,

- Ability to see clearly at night

- Wirelessly connect between the camera and the tablet

- Driver assistance during poor weather conditions

- Unaffected by oncoming headlight glare

- Pedestrian detection

- Convenient Installation

- Great System Integration

Fig 14. La Moon, outside camera and inside display lay-out

3.3.3.1 - SATIR - La Moon Specifications

Camera	320 x 240 Uncooled Microbolometer
FOV	28×21
Detector Resolution	384×288
Packaging Standard	IP65
Tablet	
Screen Size	7 inches
Screen Resolution	1024×600
System	Android 4.0
Power	
Battery Type	Rechargeable lithium-ion battery
External Power Supply	DC10-30V
Car Charger	Standard configuration

Table 4. La Moon specifications

Fig 15. La Moon wireless camera and display

3.4 - Outcome

All external and internal systems have advantages and disadvantages in terms of usability and safety. In terms of usability, internal systems have an advantage, they come with the total production of the vehicle and designed according to production specifications. The systems provide a safe drive according to experiments that made by Department of Computer and Information Science University of Linköping. In the experiment one simulator was used in three different experiments. The simulator used in these experiments was fixed-base, but had excellent visual and auditory qualities for drivers. (Hollnagel and Källhammer 2003)

As it is mentioned and discussed in the other sections, the main problem related with night vision systems in the market is about their high prices. If we look at La Moon and PathFindIR II, we will face with over 3000$ price ranges. When we analyze internal night vision systems, car prices are starting from averagely 80.000 euros. In this case, it is impossible to see that kind of systems in middle and low class cars. Although these systems started to be used in the beginnings of 2000s, night vision systems that are giving healthy results, took place in the automotive industry after 2010. Therefore, only the range of 1-8 years old cars provide those systems for users.

Indeed, it is difficult to find a huge amount of people that can afford high class cars, also external night vision systems are creating difficulties for its consumers with averagely 3000$ prices. Moreover, external night vision systems have problems that do not exist in internal night vision systems.

If we look at PathFindIR II, the installation should be done by the user. In this condition the user should go to an expert or automotive service. The connection between thermal camera and display is provided with cables. The connection with cables is making the maintenance harder. The 12 Volt power which is needed for system running, is provided from car accumulator.

On the contrary, to the PathFindIR II, La Moon system lets the user make product's installation and thermal camera is located outside of the vehicle. However the outside location of the camera creates dangers such as vandalism and thievery. The connection between thermal camera and display is provided by wireless system and it is eliminating the cable connection. La Moon's power source is rechargeable batteries and both PathFindIR II and La Moon night vision systems are using Android operating systems.

Fig 16. PathFindIR II installation

Both external night vision systems have good screen resolutions, but the problems are starting to occur in the interface phase. If we analyze BMW night vision systems, we will face with the simple display interface and successfully marking in terms of pedestrian and animal detection. Moreover, the vision enhancement system provides a simple and noticeable image on the car front window and mark the living objects in the display, follow their movements. The driver takes vocal and image warning at the same time. However, the display is serving to the other systems of the vehicle such as video calling, tv, rear camera, etc... In this case, this multi-functional feature creates problems for the user.

When we analyzed PathFindIR II, the simple interface attract the attention again. However, in terms of data processing, marking the living creatures and following the movements of the pedestrians and animals, BMW night is vision system is in one step further. On the other hand, La Moon comes up with a complex and over multi-functional interface. The battery indicator which is one of the most important things about La Moon, is not obvious on the interface. At that point, the system which is using rechargeable batteries as a power source, needs to be improved in terms of interface.

Fig 17. La Moon interface

When display location inside the car is analyzed, it is obvious that BMW internal and other external systems are prefering different locations inside the car. BMW is using fixed internal display in front of the driver or in the middle of the car. Other night vision systems are using external displays in the middle of the car, under the rear view mirror.

In terms of external night vision systems, there are only two companies in the market and it proves that there is a market gap and lack of rivalry.

The main problems that were indicated before can be listed as;

- High car prices for internal systems and high product prices for external systems

- Installation, connection and maintenance problems

- Complex interfaces and indication that makes images confusing for drivers

- Positioning of the device according to the driver's choice

- Over multi-functional usage

3.5 - Opportunity

According to the problems that are identified in the previous section, high prices create an opportunity in the competition. Installation, connection and maintenance problems can be solved in existing products. Indications and complex interfaces can be designed simply and in a clever way with extra functions. There are some opportunities in additional functions that can be added for users' needs and at the same time over multi-functional usage should be reduced.

Moreover, as it is mentioned in the introduction phase, Worldwide sales of passenger cars are estimated to hit 72.2 million vehicles in 2014. Around 7.24 million passenger cars were sold to U.S. clients in 2012, and around 4.11 million autos were delivered here around the same time. In addition, around 74 million cars are relied upon to be sold by 2015. In addition to these companies are in a race in terms of the developments of safety and electronics features of the vehicles.

The expense of electronics and software in the automotive industry was under 20 percent of the aggregate cost 10 years back. Studies show that today it is as much as 35 percent. All the more critically, electronics systems keep on contributing more than 90 percent of advancements and new features. All major OEMs are focusing on regular product fields, for example, quality and safety; infotainment gives an approach to OEMs and suppliers to separate their products. (Akshay Singh, Arjun Kakkar, Evan Hirs...)

As this paper focus on, one of the developments of safe driving is night vision systems. San Diego personal injury law offices states that, night driving, fog and animal crossing are in the list of top the 25 causes of traffic accidents. (Top 25 Causes of Car Accidents)

Every year, more than 4,000 people are killed, and several thousands more are harmed, when struck by a vehicle. About 70 percent of those occasions happen around night time, when drivers have constrained perceivability. (Stockburger 2014)

Statistics demonstrate that driving at night time speaks to a critical potential threat. In Germany, exactly 50 percent of deadly accidents occur at night, despite the fact that an average of 75 percent of all driving is done under the daylight. This implies that the danger of driving around night time is twice as high as during daylight. A comparative circumstance is to be found in the US. With a 28 percent of all driving, 55 percent all deadly crashes and accidents happen during the night time.

Statistics about traffic accidents through Europe in general likewise legitimize concentrated thought of the issue of nighttime driving. As indicated by assessments, approx. 560,000 individuals are harmed in the in the dark in Europe and average of 23,000 are dead. (Statistics – accidents data - Europea...)

The reasons are clear: poor or fundamentally restricted sight conditions on the highways and country roads, obstacles or restricted bends which are perceived as well late with the low beam, wrong judgment of speed or distance because of an absence of introduction for the eye, crashing into the "dark hole" of the headlights of approaching traffic movement, potentially exacerbated by wet, reflecting roaad surfaces etc...

Our eyes are the first line of warnings against these dangers. Unfortunately, eyes are not the best identifiers and they can utilize some help when driving during the night time to keep away from accidents and hazards.

In order to support the existing data a consumer research is made. The aim is investigating the consumer tendencies, needs and wants.

3.5.1 - Consumer Research

In this section, by comparing the data, which was acquired from literature research, with survey results, all of the results are evaluated. An online consumer research which contains 100 participants from different countries and participants answered 10 questions.

First of all, in order to see the customer's demographic map, gender and age question was asked.

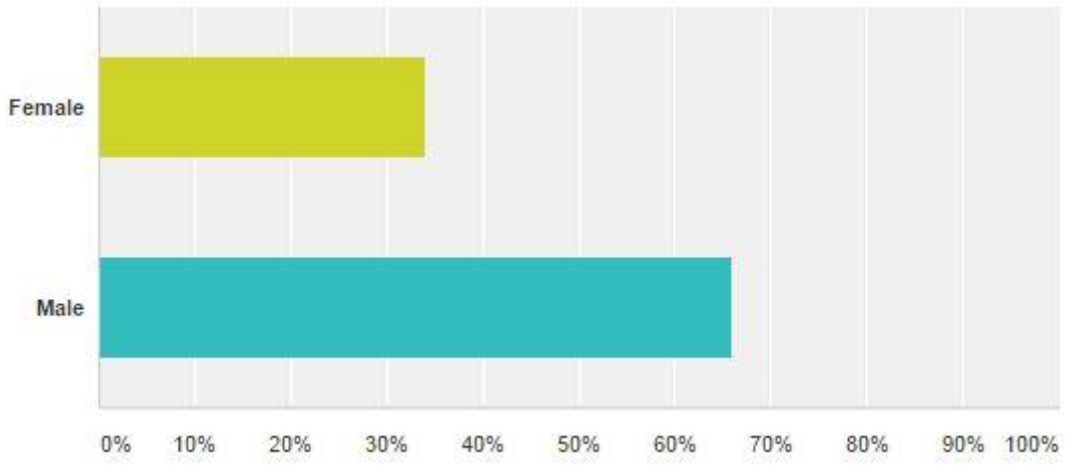

Fig 18. (What is your gender?)

As it is shown in the figure 18, %65 of the participants are male and %35 female drivers. Secondly, the age issue is an important factor, because the human sight quality decreases when people are getting older. Therefore the audience can understand and evaluate the consumer research according to those criteria.

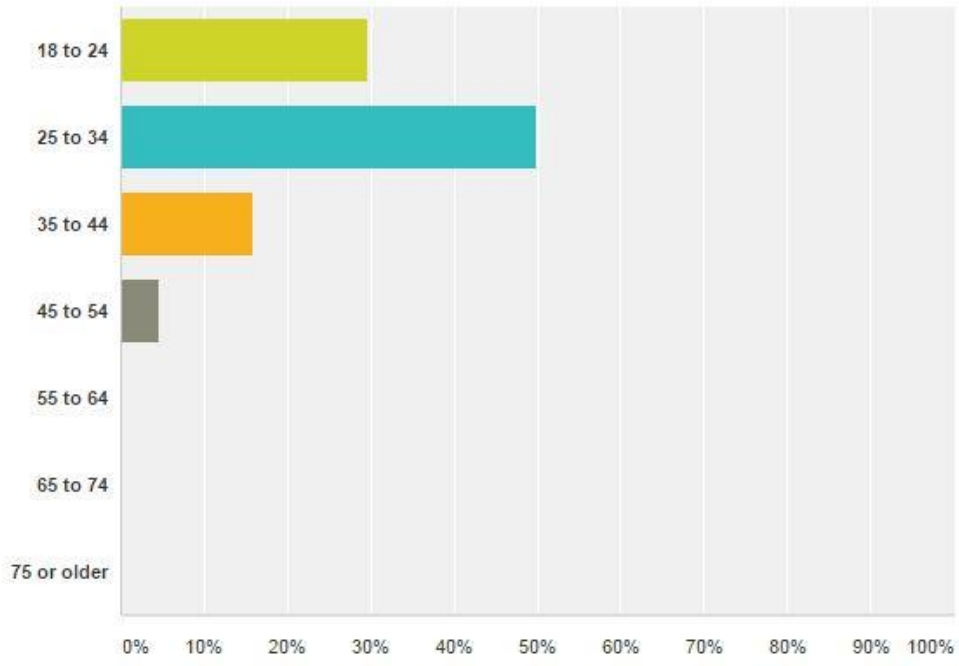

Fig 19. (What is your age?)

As it is shown in the figure 19, %30 of the participants are in the age of between 18-24, %50 of the participants are in the age of between 25-34 which group is named as young drivers. The older drivers which belongs to age range of 35-44 and 45-54 constitute the rest of the participants with a number of %20 total participation.

In the next question, people are marked what kind of vehicle they drive. It is also vital to understand the density of the vehicle type and availability of the night vision system for that vehicle.

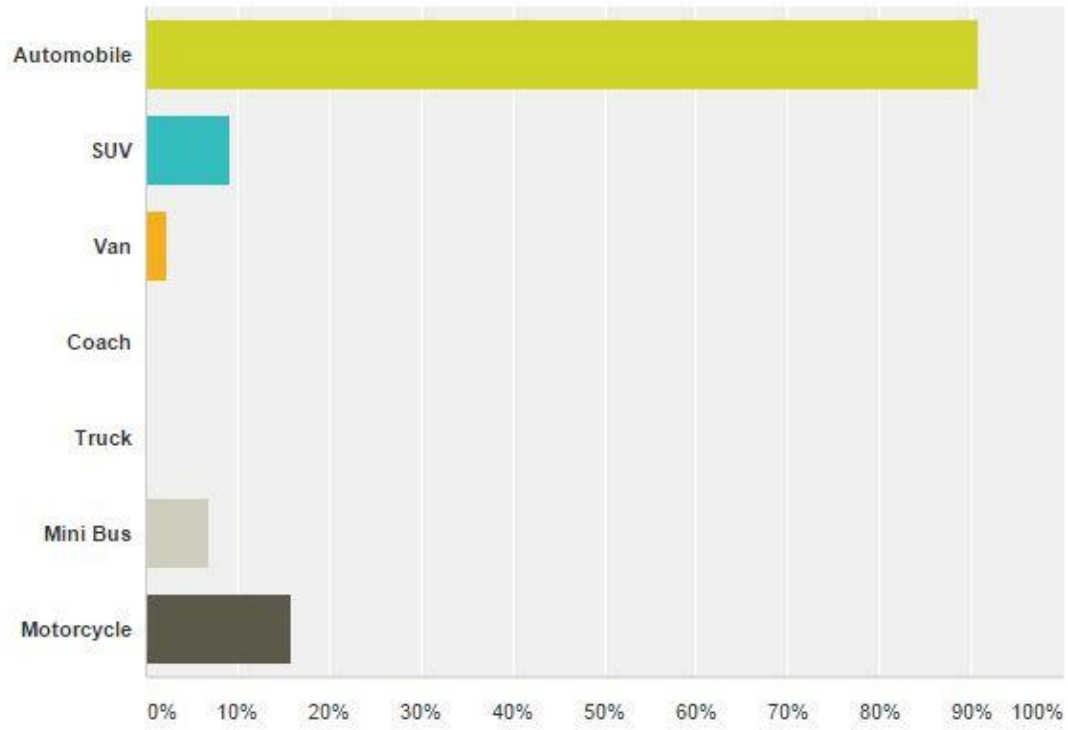

Fig 20. (What kind of vehicle do you drive?)

As it is shown in the figure 20. %90 of the participants are driving a passenger car, and most of them are driving motorcycle as a second vehicle. SUV, Van and other type of vehicles from the rest of the participants. According to the findings of the research and numbers in the previous section it is logical to create a target on passenger cars.

The following question is testing that the participants ever had a traffic accident or not in order to evaluate the following questions logically.

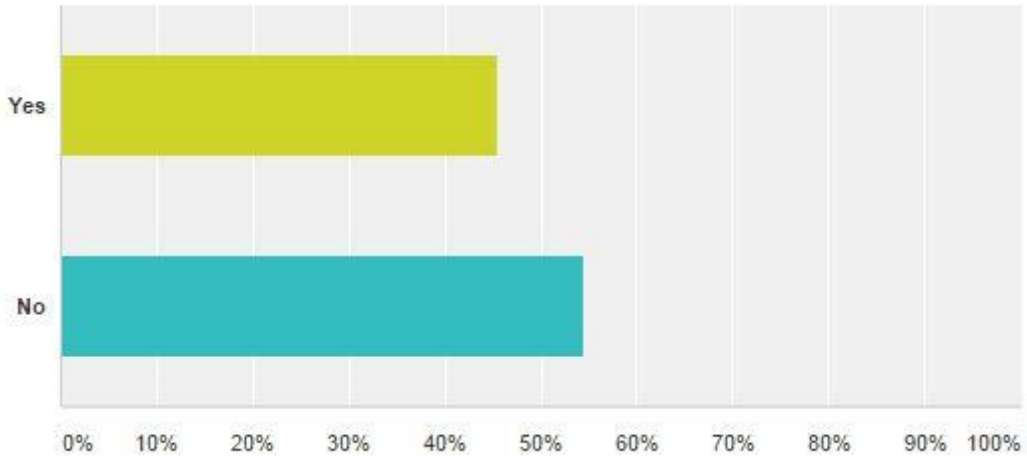

Fig 21. (Have you ever had a traffic accident?)

The figure 21 shows that %55 of the participants never had a traffic accident, other %45 of people had a small or big scale of different accidents. The following question is pointing the causes of that accidents.

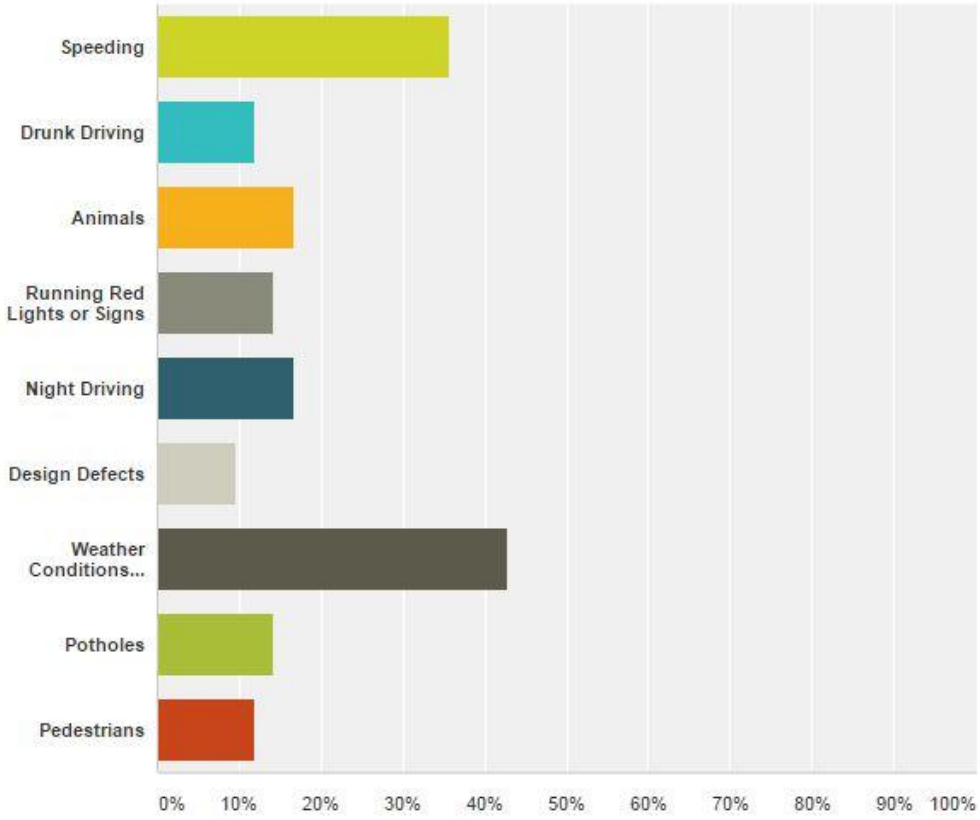

Fig 22. (If "YES" what was the cause of the accident? or What are the conditions that make your driving difficult?)

%45 of the participants marked their accident causes and what makes their driving difficult. Nearly %45 of the people marked weather conditions such as rain, fog and snow, etc... Also that weather conditions make driving more difficult at night time. Averagely %20 percent of them finds night driving difficult and had an accident at night. Moreover, other %20 percent had an occasion about animal crossing. The rest of the participants marked potholes and pedestrians, which are difficult to detect in night driving, crossing red lights and traffic signs, design defects, drunk driving and speeding as the causes of accidents.

In the following question, participants answer whether they have difficulties in night driving and in a harsh environment or not. It is clearly obvious that there is a difficulty with night time driving in harsh environment. Nearly %75 of the participants finds night driving difficult as it is shown in the figure 23.

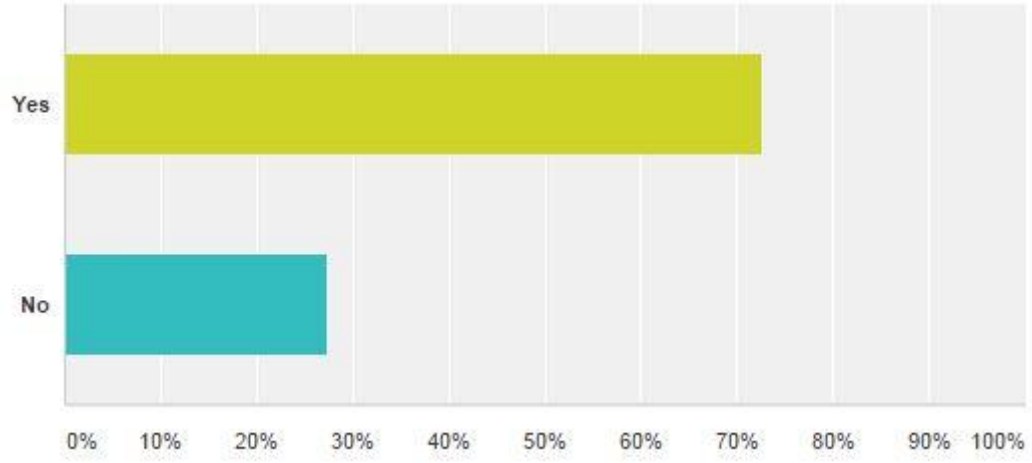

Fig 23. (If Do you have difficulties when you are driving at night or in harsh environments?)

In the next step we can easily identify the market gap about night vision systems. %90 of the participants do not have a night vision system in their vehicles as it is seen in the figure 24.

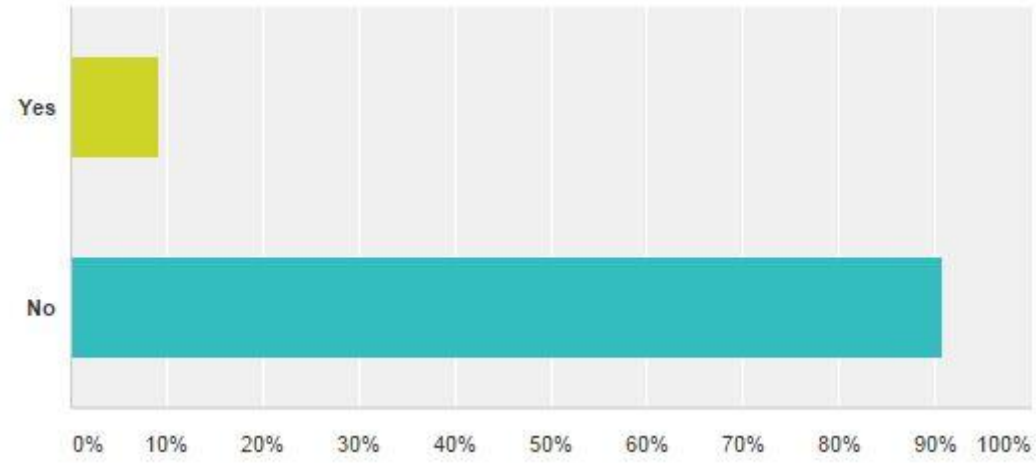

Fig 24. (Does your car contain a night vision system?)

Moreover, it is vital to get feedback from consumers about night vision systems. Nearly %80 percent of the participants marked "YES" when they are asked Do you think that night vision cameras and displays provide a safer drive? This huge number proves that consumers need that kind of systems for a safer drive.

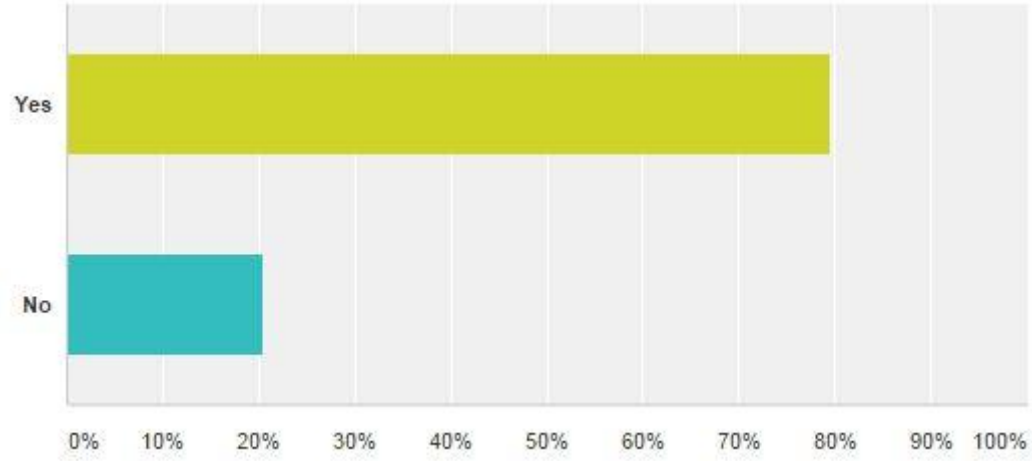

Fig 25. (Do you think that night vision cameras and displays provide a safer drive?)

Even %80 percent of the participants find night vision systems and displays safer for drive, nearly %45 of them marked "NOT SURE" when they are asked Do you consider to use an attachable and cheap night vision camera system for your vehicle? %35 percent of the participants have an intention to have the night vision system in their car. Therefore, although %45 of the participants find it safer, they are not totally willing to buy those systems because of the reasons, which mentioned about in the Problem section, such as cost, installation etc...

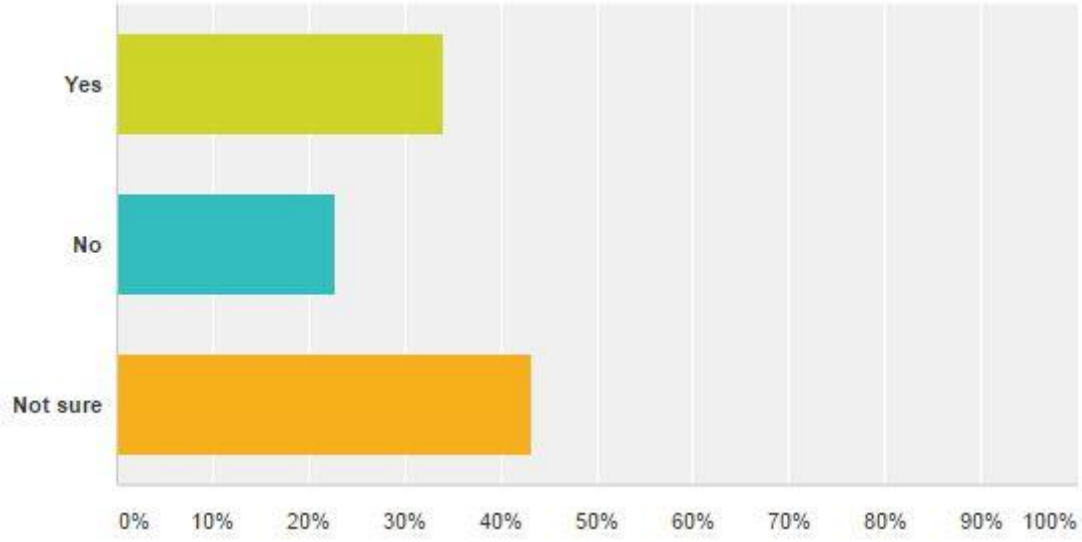

Fig 26. (Do you consider to use an attachable and cheap night vision camera system for your vehicle?)

Lastly, participants asked to marked a price between the range of 50 and 500 euros, according to their budget for night vision systems. Indeed, these data do not reflect the clear idea about prices, because any consumer wants to get the service or product with a minimum price. However, it is clear as it is shown in the figure 27, consumers have an intention to pay different range of prices for night vision product service system.

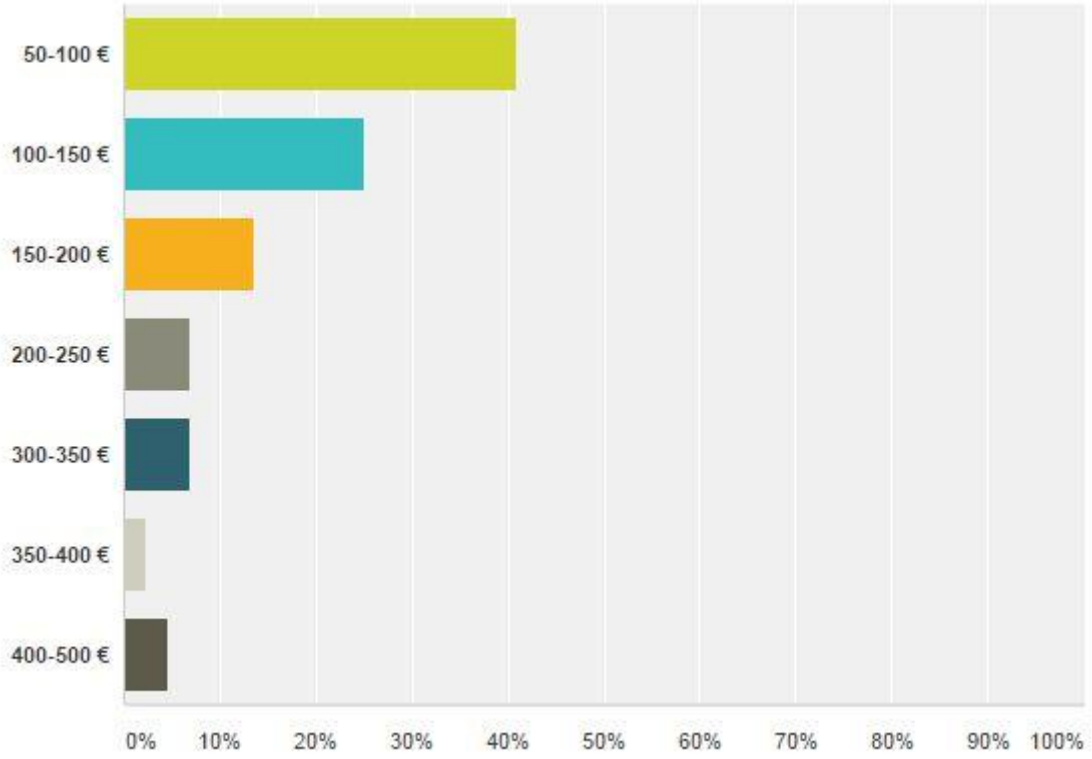

Fig 27. (How much can you afford for that kind of system?)

3.5.2 - Conclusion

Considering the massiveness of the automotive industry, with nearly 74 million passenger cars of expected sales until the end of 2015, innovations and R&D budgets, it is easy to decide investing money, spend energy and design products and services for this sector. Moreover, driving safely issues are popular topics in the sector. Considering the high numbers in accidents that are about night driving and lack of competition in the area, make night vision technology a trendy field. The high prices of both external and internal night vision systems in the automotive industry and problems, that are mentioned in the previous sections, constitute a new product gap. Moreover the consumer research's data is supporting this hypothesis.

3.6 - Target Market - Market Positioning

When the existing products, prices, features and customer research is analyzed, the target market and market positioning of the new device begin to comprise. According to customer research and market research, the massive amount of vehicles is in the passenger car category.

The products that are examined in the market research shows that BMW and equivalent brands such as Mercedes, AUDI etc... have vehicles with night vision systems. Although they are quality, these full package passenger cars are named high class cars with the price range of between 80.000 and over 250.000 euros. Even there are external systems in the market like La Moon and PathFindIR II, there are several problems that are mentioned before, in these products. Additionally, the prices are high, according to middle and low class consumers.

Therefore the new product targeting middle and low class passenger car owners without considering age because the consumer research reveals that there is an %80 percent potential in the market.

The market positioning of the new product is lower price from any other night vision system and more qualified features than external systems, in addition to this, it is aiming somewhere between AUDI and BMW - Mercedes in terms of quality.

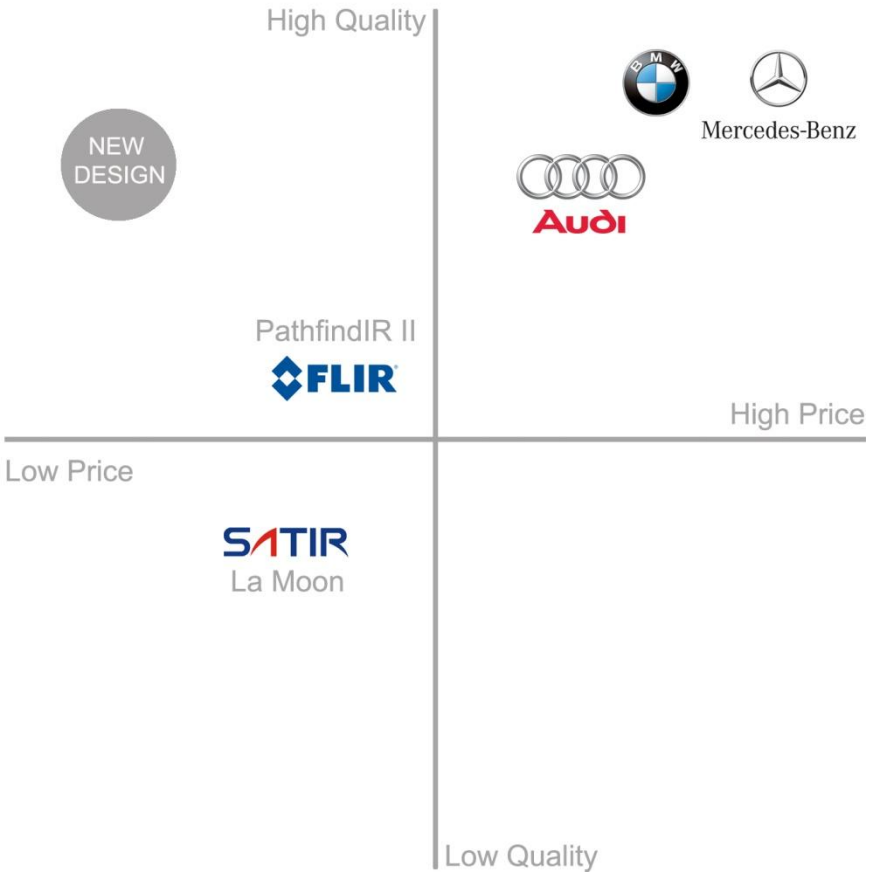

Fig 28. Market positioning of the new product

4- Brief

In this section, a clear design brief is given to the audience in order to understand main frame, overall design phase and upcoming steps of the new design. Later a 5W1H (What, Who, When, Where, Why, How) is made for giving tips about new product. Later a SWOT (Strength, Weakness, Opportunity, Threat) analysis is done in order to evaluate the new concept. Finally, after mindmap which includes tips from brainstorm is given to the audience.

Project name and description

A new product for automotive night vision systems. Product system contains external thermal imaging camera and a display for monitoring objects, pedestrians and other living creatures.

Background / Overview

A new product which eliminates some of the existing problems and offering additional features for users.

Objective: what is the goal of the ad or campaign?

The primary objective is to persuade the audience to believe that the new product has new features and different from similar ones, buy and use the new product, as well as to create and characterize this new brand.

Target audience: who are we talking to?

The primary target audience is people who are driving or owning middle or low class passenger cars.

Focus: what's the most important thing to say or show?

The new product is aiming to create an option for customers, providing an easy installation and maintenance. Additionally, it is planned to be one step further in terms of usage, aesthetics and features from similar products.

Reasons why: what are the most compelling reasons to believe, to try, to buy?

It is aiming to sustain the latest technology with adaptable options for any kind of users. It will provide a good service and maintenance. Additional features and usability issues are considered.

How the new product will bridge the gap?

Without giving up from the latest technology and advancements, the new product will be a new option in the market with its additional features in terms of usability, safety and aesthetics. Moreover, considering the lack of options in the market in terms of external night vision systems, it will bridge the gap between consumers and safe drive.

References

Accidents, Technology, Consumers, Drivers, Passengers, Automotive Industry, Standarts

Ideas Platform

The main ideas platform is traffic accidents and safe driving. The night driving is chosen because of specific boundaries, market gap and lack of options in the market.

4.1 - 5W 1H

WHAT is the problem?

The main problem is the difficulties and dangers in night driving.

WHERE it is happening?

It is happening while driving inside the vehicle.

WHEN it is happening?

It is happening while driving during night time, in darkness and in harsh environment.

WHY people need this system?

Night driving assistances provide a vision that can not be provided by human sight. It helps to driver in order to see the objects, animals and pedestrians clearly in darkness, foggy, rainy, snowy and harsh environment. It decreases the number of fatal accidents.

WHO can use this system?

Anyone who has a passenger car can use this system. The system is available for other kind of vehicles such as trucks, vans and SUVs. However main target audience is passenger car owners.

HOW can this system meet with customers?

It is possible to introduce this system to customers with existing technologies. The product will be sold in techno markets, hypermarkets and related locations which are selling automotive parts.

4.2 - SWOT Analysis

Fig 29. SWOT analysis

Strengths

The product will draw the attention of customers with additional features, inside the market, which is lack of options already. Aesthetics and convenience of the product will create a demand for it.

Weaknesses

A new product in the market always have some problems such as reliability and quality etc... Although astronomic prices of high class passenger cars, the existence of the internal systems creates a treat. Installation and maintenance are critical issues for that kind of systems.

Opportunities

As it is mentioned several times, there is a high customer demand and a huge market gap in the market. Statistics about automotive production and accidents point out an opportunity in that sector. Existing technologies help for further development and problems in other systems provide opportunities for newer versions.

Threats

Even there are existing technologies, human safety is a critical issue and the new product should use impeccable system. There is already a bias about using these kind of systems, even consumer reports show a demand.

4.3 - Mindmapping

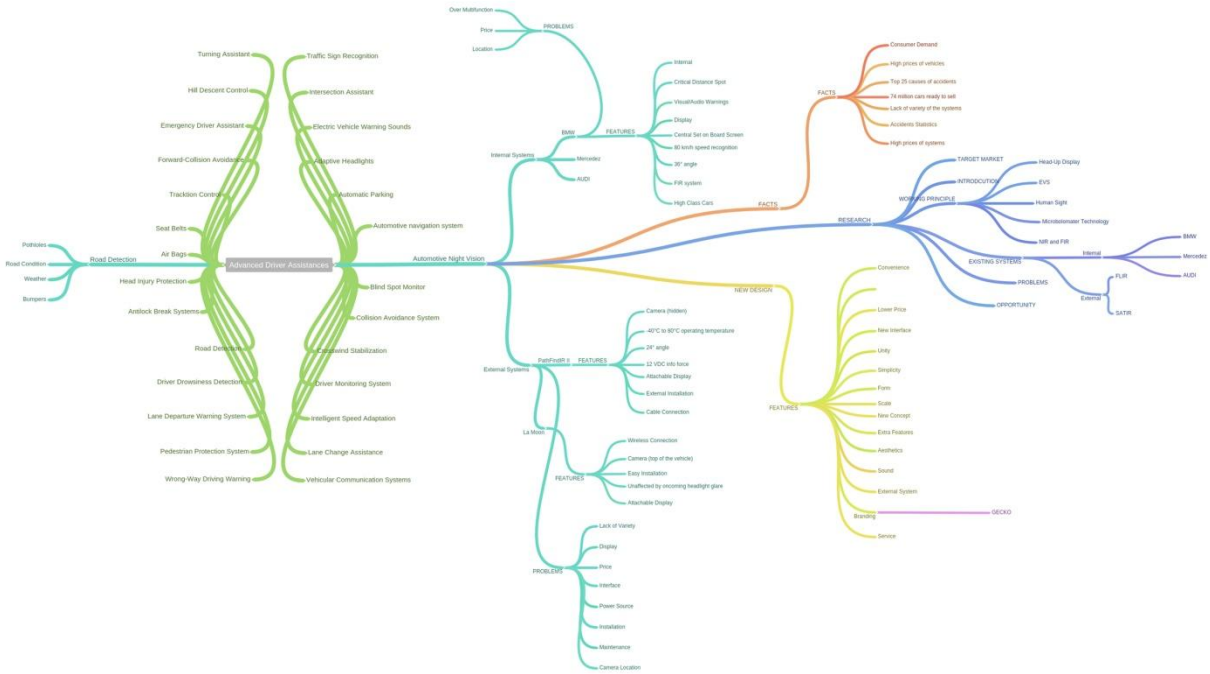

Fig 30. Mindmap of the new night vision system

Mind mapping is an effective method for getting data all through your brain. Mind mapping is an innovative and sensible method of note-taking and note-production that truly "maps out" the thoughts. (Mindmapping)

In order to create a route for the project and create concepts a mindmap is done. Mindmapping started with advanced driver assistance for automotive sector. Latest systems were listed and two main topics selected as Road Detection and Night Vision. Later, the main focus is decided as night vision and integration of these systems is ignored. For the research phase, internal and external systems analyzed with features and problems. The facts about the automotive sector and crash data bases are analyzed. According to accumulated data, the principles and ideas started to occur for new design. Mind map helped in order to create research body, ideas and features for the new product.

4.4 - Conclusion

As a result of the analysis and data that is accumulated so far, new design features are decided as an external night vision assistance system which is using long wave infared camera system. Installation will be done by professionals and service system will be designed according to that. The connection between display and camera will sustain thanks to wireless technology. It eliminates the extra cables and sustains easier maintenance. The display design will be coherent with vehicles, inside location will be adaptable according to the driver's needs and wants. Moreover, it will have a simple interface and function in order to use the device in a most natural and effortless way for the driver fitting seamlessly into the everyday habits of driving and being there to alert when needed.

5- New Design

In this section, the new product - service system is presented to the audience with all features and technical details. Comparing the data that is given in the other sections, readers will understand how the decisions are made about the new design. Moreover, the detailed informations about camera, display and interface are given. Finally, the audience will understand how all product - service system works.

5.1 - Inspiration

For the name of the new product "GECKO" is chosen. The reason is obvious, gecko lizard is one of the greatest animals about night vision. Geckos' eyes are about 350 times more sensitive than human eyes, they see colors in the darkness and they can sharply focus on at least two different depth fields at the same time. (Gecko Eyes Make Great Night Vision Ca...)

According to capability and features of the animal, the gecko is chosen as an inspirational point for both brand logo and the design of the product. Moreover, considering the technological point of view of the product and usage, these features are reflected to the design. In order to form an identity for the product, blue gecko is chosen. The logo and the product take its identity, colors and form from the uniqueness of blue gecko.

However, the animal is just a starting point in terms of inspiration. The main design decisions about the product is coming from the existing solutions' shortcomings and their problems that are listed before. The new design's structure and decisions are decided according to create a new solution that sustains a clear interaction with the user, sustains adjustable placement for the display, reduces the number of connections that makes installation and maintenance easier. Additionally, the new system should have a smart usage, with reducing the elements on display and simplifying the interface. Finally, the new concept is planned to create as much as natural and effortless usage.

Fig 31. Blue Gecko

5.2 - New Concept

The new product is consisted of three main parts as thermal imaging camera, display and an adaptable unit for different locational usages. In addition full package of product contains cables and mounting pieces.

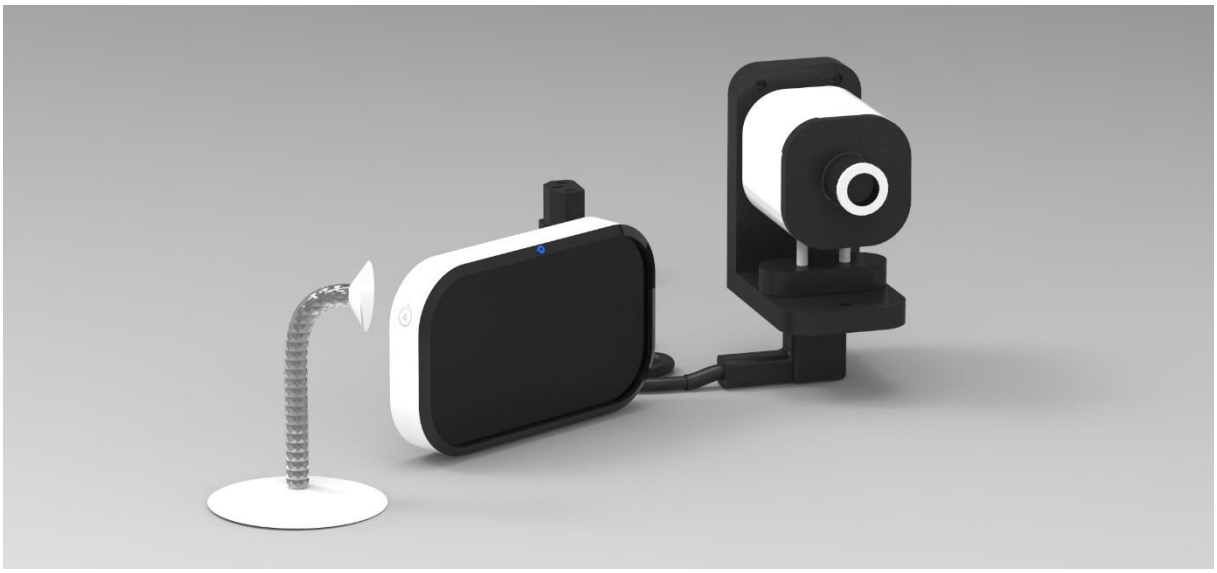

Fig 32. New product's main parts

As in the brand inspiration, new product design and components are based on Gecko Lizzard's features. An Identity depicts the visual gadgets used to speak to the organization. Identity systems are visual segment bundles that are combined with style rules and utilized as a system to guarantee the corporate images cohesive and consistent. (Lamson 2013)

Therefore, the main aim is creating a design language and construct a product identity for new brand and for products. In addition, high tech capabilities, driver's safety issues and ease of usability issues are considered both design of the components and interface. Additionally, in some of the visualizations of the new product, a Ford passenger car's 3D model is used as a symbolization of the middle class passenger car.

5.2.1 - Camera

The thermal imaging camera uses a wireless connection in order to connect and process images to driver's display. The power source of the device is accumulator of the car. The form of the camera is designed in an accordance with display and other parts. Additionally the measurements of the device and design of the installation parts are made according to easy installation and adaptability for different kinds of vehicles. The design of the camera is robust because it is not seen and has an inner usage.

Fig 33. Thermal imaging camera

As to be seen in the figure 34. below, the installation of the thermal imaging camera is progressed in front of the car. The installation shows discrepancy, according to the vehicle. However, generally the car grille should be cut from the center and the device is mounted. Thanks to device measurements, the gap in front of the car is not noticeable, and after mounting the cut piece of the grill can be applied again. The important point is that the lens of the camera should see the outside clearly without restrictions of the grille's plastic pieces.

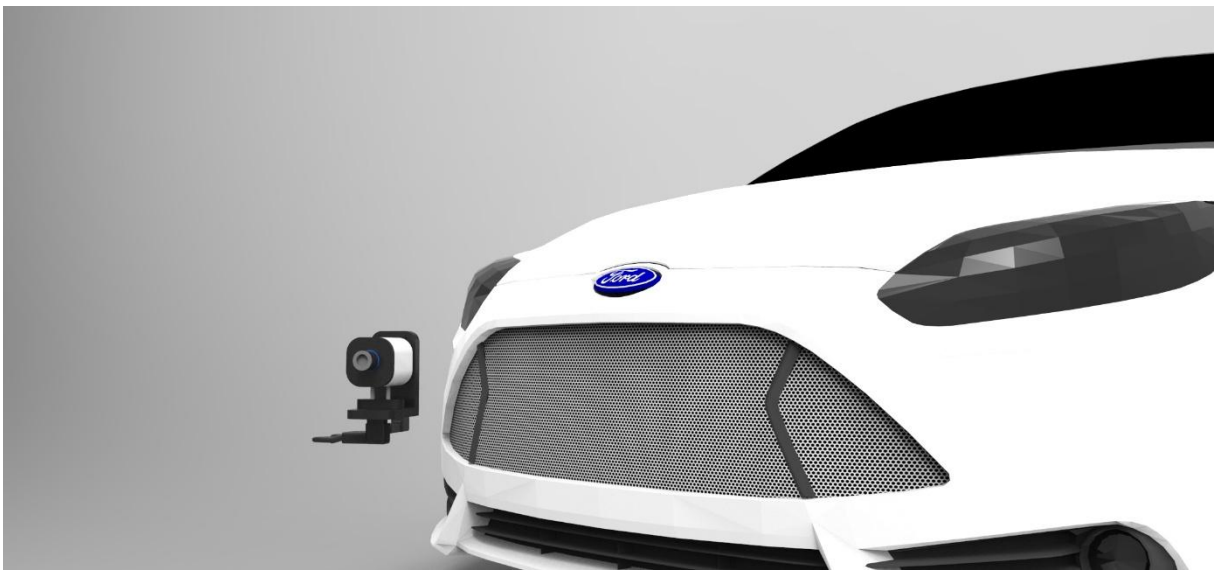

Fig 34. The grille of the car and thermal imaging camera

The installation is made with special screws which product package contains. User or mechanics can read user manual in order to make the installation. Moreover the adjustable parts help to install the device in right angles.

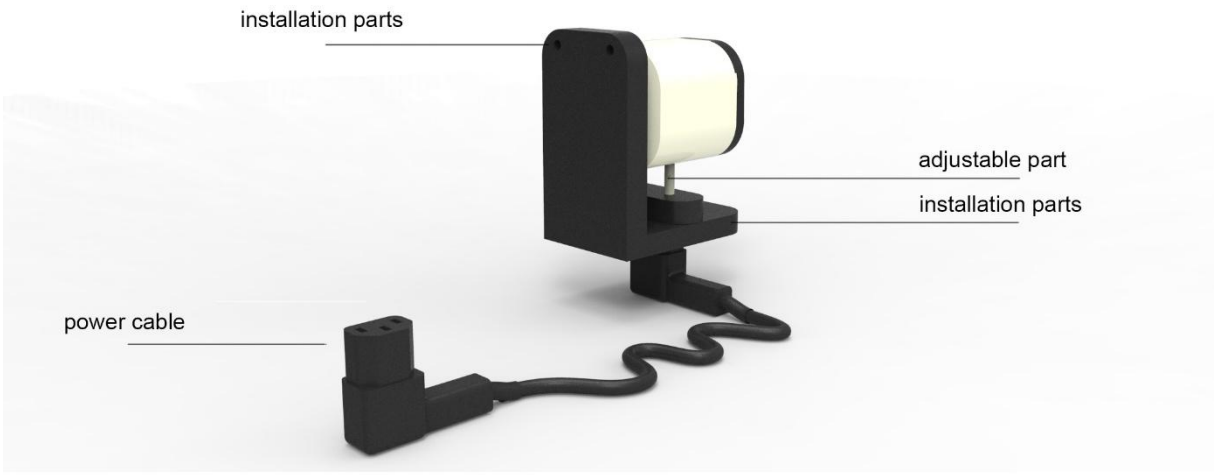

Fig 35. Thermal imaging camera II

The recommended dimensions for the installation are optimally 25.5'' from the touch point of the front tires to the ground to the center of the lens of the camera and somewhere between headlights and fog lights with a maximum distance of 31'' and minimum 19''. The mounting the camera in the maximum range is more adequate, because it reduces the risk of damaging by rocks and other road condition effetcs and it should be as far as possible from the engine to prevent high temperature changes.

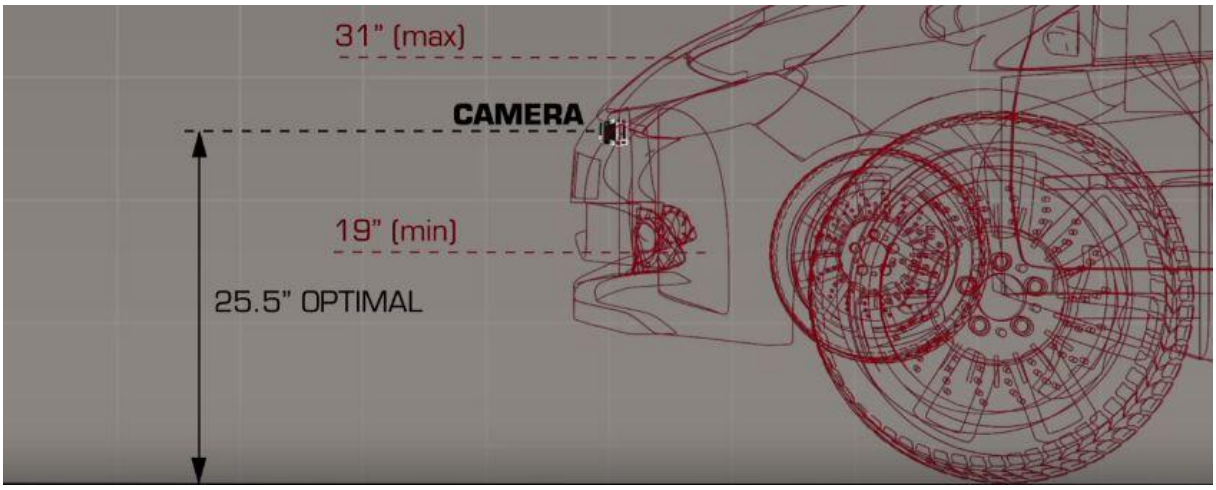

Fig 36. Camera placement I

In the middle, the camera should be precisely aligned under the horizon level. The angle of the device could be changed plus or minus 2° through the horizon level. It is also possible to mount the camera in other places, but the maximum level of efficiency is sustained by mounting the device in the center.

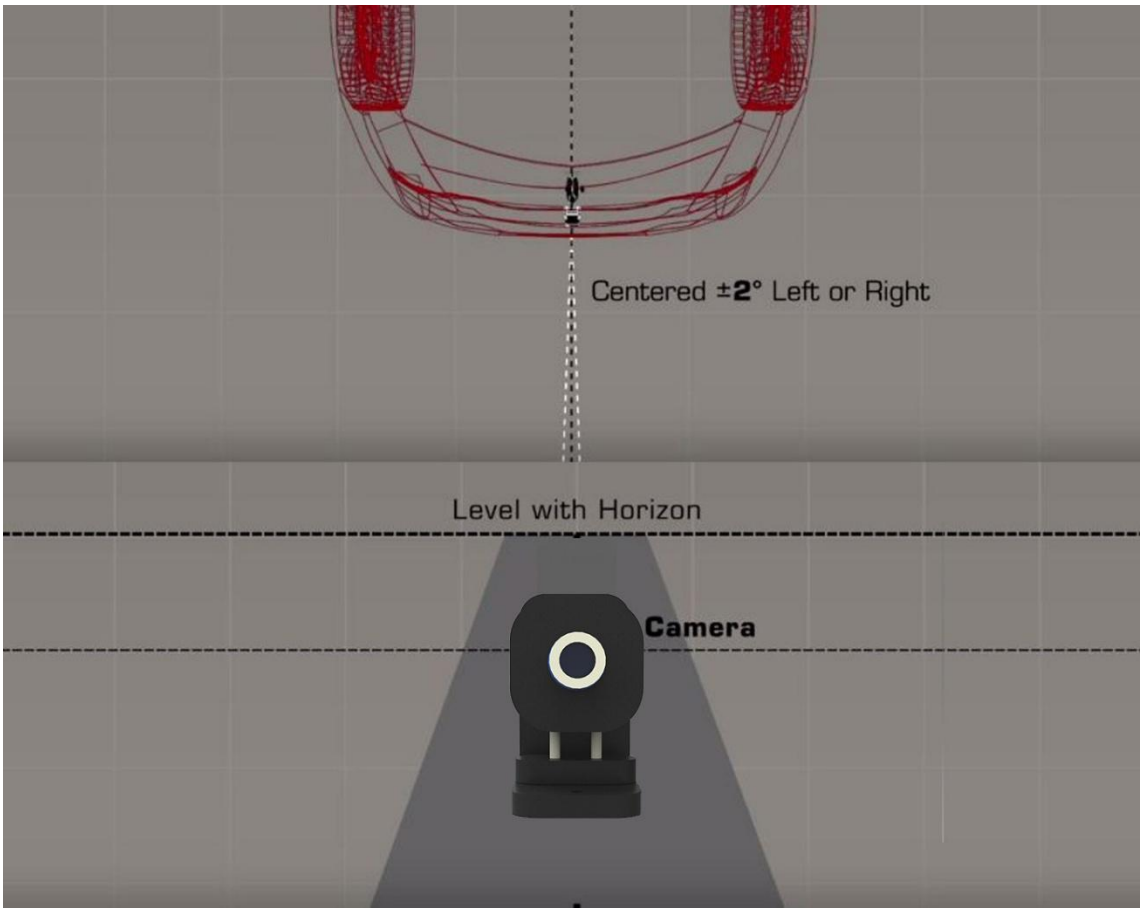

Fig 37. Camera placement II

In order to test the camera working conditions, after installing in front of the vehicle, the power cable should be connected with the accumulator. Later, the wireless system is started automatically and recognize the display. When the blue light on the camera shines, it means that the camera is connected to the power supply successfully.

Fig 38. Power cable and blue sign light

Thermal cameras can't utilize common glass lenses, as the glass will reflect thermal radiation as opposed to permitting the radiation to go through the lenses. Ordinarily utilized materials for thermal lenses are Germanium (Ge), Chalcogenide glass, Zinc Selenide (ZnSe) and Zinc Sulfide (ZnS). (Lenses for thermal cameras | Axis Com...)

Therefore, these materials are suitable for a LWIR (long wave infared) camera with 8-14 microns spectral band. Moreover system uses 320x240 uncooled microbolometer sensor and it has 24° x 18° field of view. The camera needs 12V power source and accumulator is effective for this need. The camera can operate between -40°C and 80°C and has a weather resistance. Camera dimensions without extra parts are 120x80x40 mm. and the power cable is 150 cm.

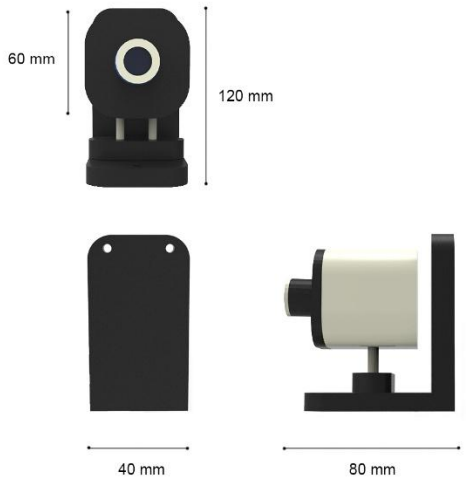

Fig 39. Dimensions of the camera

5.2.2 - Display and Adaptable Mounting Device

Display design started with trying the regular electronics devices' shapes and functions. While designing the device, smart phones, tablets and computers are based. Before reaching the final design different concepts and possibilities are tried as in the figure 40. below.

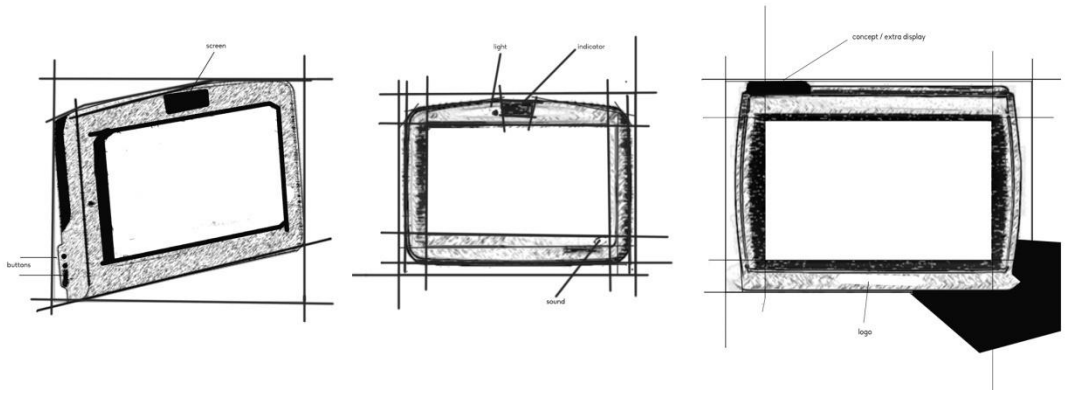

Fig 40. Design sketches of the display

After deciding the shape and functions, the vital places such as buttons, inputs and outputs and mounting places for the user are spotted and tried to apply to the design. Later a new innovation and function named as an adaptable mounting device, added to the design. Firstly,

the mounting device is designed according to fulfill the drivers' needs and sustain a better display view. Therefore the pieces of the mounting device and the connection points of the display and mounting device are decided later and applied to the final design.

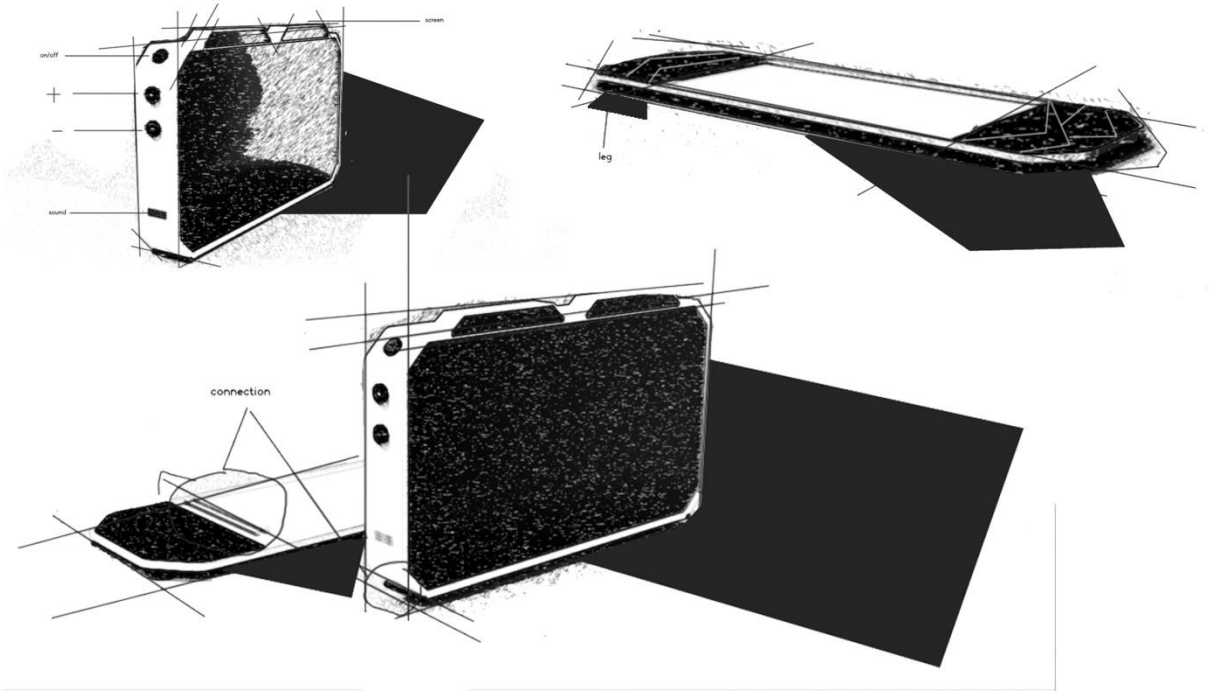

Fig 41. Design sketches of the display and adaptable mounting device

Fig 42. Display I

There is no button on the display in order to sustain a clear usage. The aim is to design a clever product with its functions and features for users. The features of the display arrange itselves according to the environment without interrupting the user. The display gives both sound and image based warning. The driver can arrange the volume according to herself or himself easily and in both sides speakers are located in order to give a clear sound warning.

Fig 43. Display II

Display is working with rechargeable lithium-ion batteries. The device can take two batteries at the same time and it lasts many days and weeks. Moreover the device and batteries can be charged while using with the help of micro USB car charging device. There are three inputs behind the device which are rear mirror usage mounting part, USB, and regular electronics' end point. Moreover, display and camera has a function together, which is saving the videos. Therefore, USB part can be used for connecting the display with tablets, smart phones, computers and flash disks in order to transfer the saved documents inside the display.

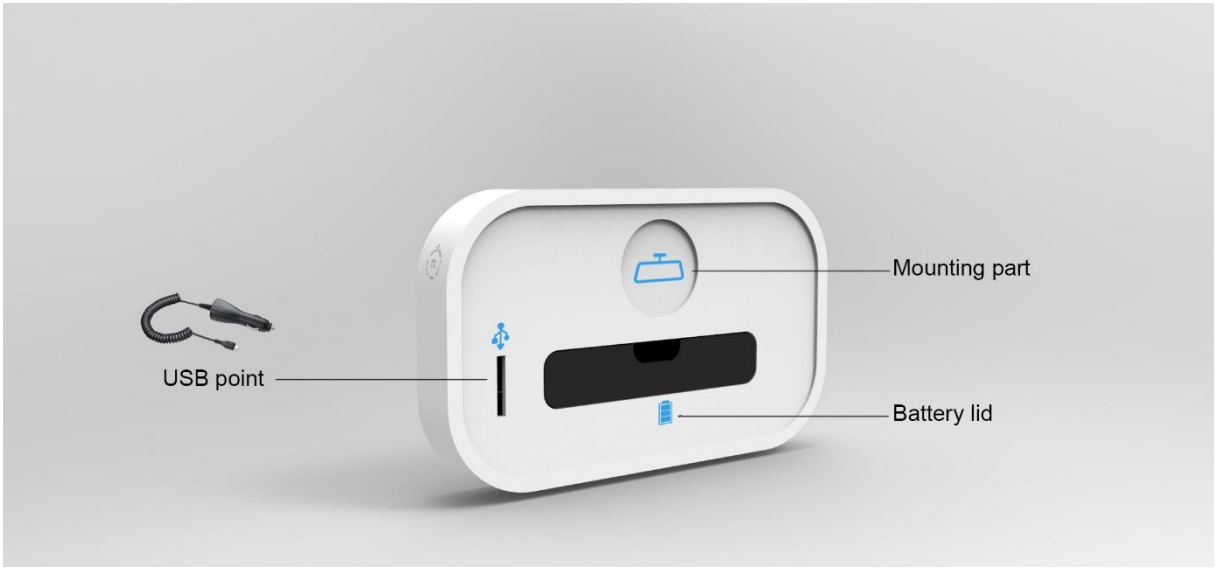

Fig 44. Behind the display

As it is mentioned in the research phase, using the display in front of the driver, gives the best results of a safe drive. However, it is depending on the user. Gecko provides an opportunity to its users to locate, display wherever they want. The mounting part on the back side of the display gives an opportunity to central usage.

Fig 45. Central usage of the display

Moreover the new addition, which is named as adaptable mounting device, creates an opportunity for flexible usage. Its features provide to adjust the angle and location. In addition to this vacuum flask of the mounting device gives a strength to display and display together in order to stand steadily on different kinds of surfaces.

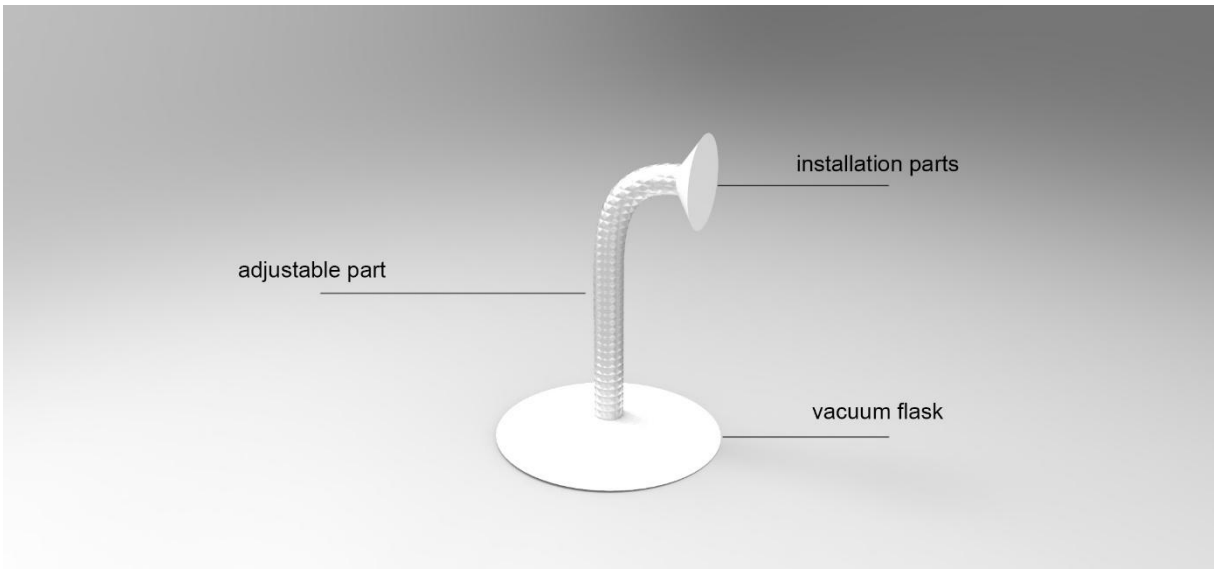

Fig 46. Adjustable mounting device

The display has one circular gap on behind, that gap and the installation part of the mounting device fits perfectly and flexible part of the mounting device creates adjustability. The driver can change the angle, location and the mounting device according to his or her comfort.

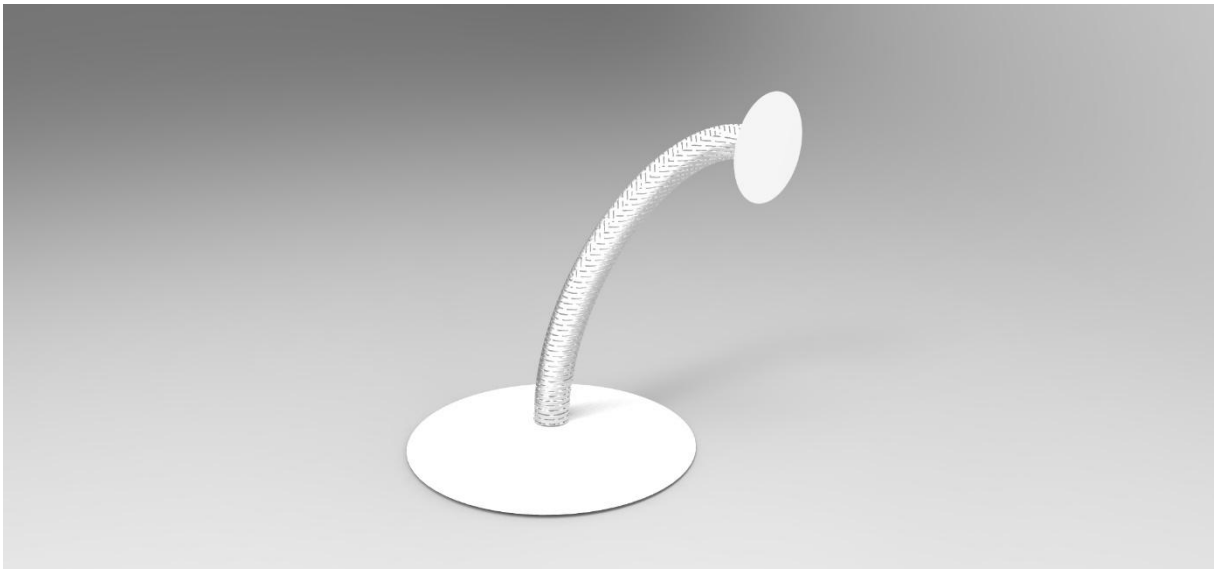

Fig 47. Adjustability of the mounting device

Every car has different kind of console design. Therefore the mounting device and display are designed according to that. The elastic parts are durable and swivel thanks to elasto plastic material inside the stainless steel hose and appropriate any kind of surface with vacuum flask base. The elastic vacuum insulated bottom part of the mounting device trapped small amount of air and creates a vacuum lock. It prevents the tilt overs of the device. The mounting device provides central usage like the rear mirror mounting device.

Fig 48. Central usage with adjustable mounting device

In addition to this, it gives the opportunity to use the device in front of the driver or between the driver and center.

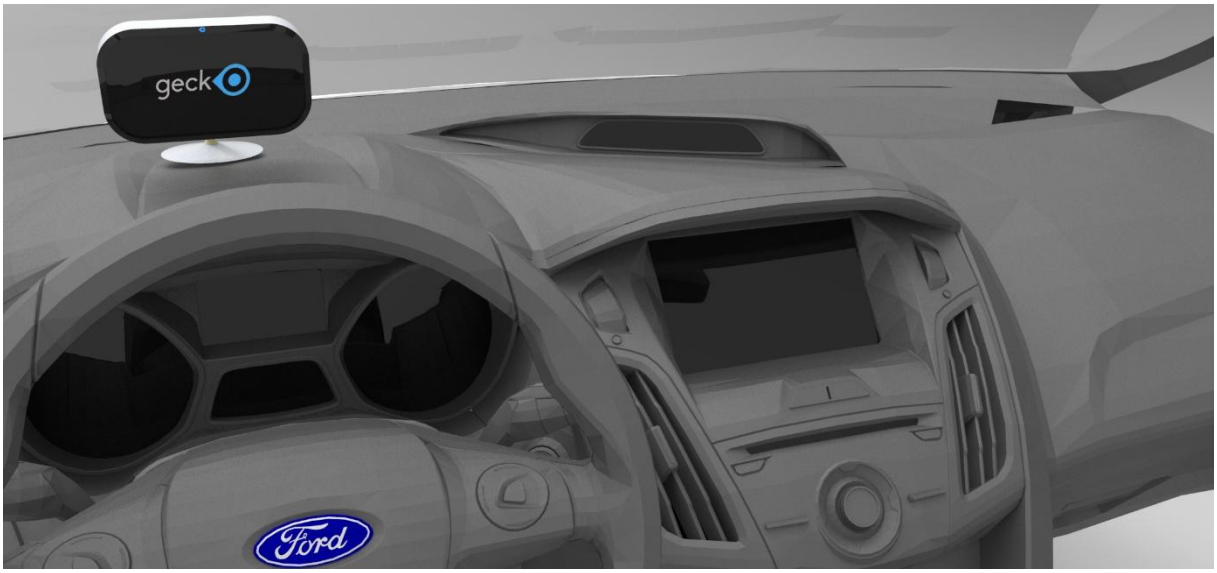

Fig 49. Front usage with adjustable mounting device

The display uses 1024x600 touch LED screen in order to give perfect view and consume less energy. Also, there is a car USB charging device for charging while using or without taking out the batteries. The display contains 5,8 inch screen and uses Android 5.0 Lolilop as operating system. ABS outside shell is durable against impacts and easy to clean. Dimensions of the display are 160x95x20 mm.

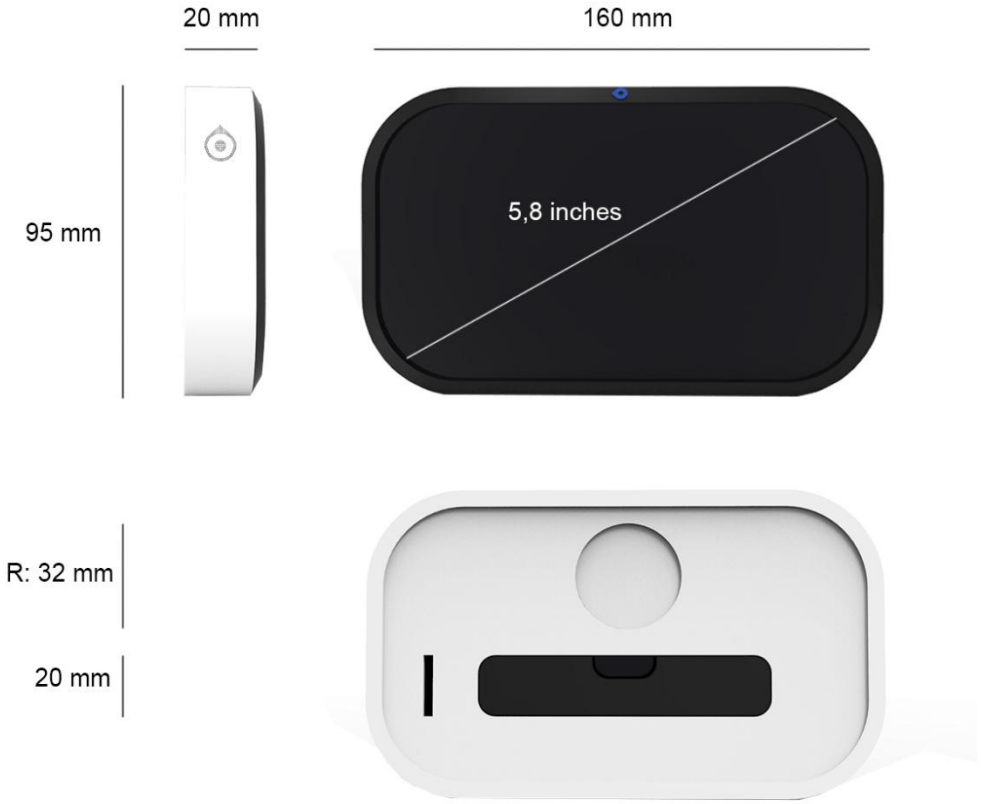

Fig 50. Dimensions of the display

5.2.3 - Interface

A successful interface should be clear, concise, familiar, responsive, consistent, attractive, efficient and forgiving. (8 Characteristics Of Successful User ...)

Therefore the design of the interface is kept as simple as possible and short as possible. Symbols that are used in the interface are familiar. It is fast and when you make mistakes it is easy to take it back. Colors are designed in an accordance with overall design and create an attraction for the user.

When the engine starts to work the camera and display connects automatically and a waking up screen appears with the logo. Also on the top middle of the display eye part of the logo starts to shine in order to indicate progress of the device. At that moment, the device is processing and making itself ready to be used.

Fig 51. Waking up screen

After the device is ready, the user can check the battery with the help of signal light which is on the top of the device. If the light is blinking, it means that the battery of the device is low.

When the logo disappears on the screen two symbols appear on the screen with scripts. The main page is really simple and it contains two symbols. One of them ''Menu'' and the other one is ''Start''. If the driver does not want to use the device, device will automatically turn itself off. If the driver wants to use it, he or she should touch the start symbol.

Fig 52. Main page

In the menu and sub-categories, user can connect the display with another device and can make video transfer. The videos are saved in MP4, abbreviation of the MPEG, a format which is a format for working with video files and refers to the Motion Pictures Expert Group.

The device is not saving all videos that are recorded by the camera. User can choose the time and go back to the estimated time zone and device will show that selected times. The device is keeping a video memory for 24 hours and remove them automatically after 24 hours. Moreover, under the menu button user can make necessary arrangements.

Fig 53. Night vision view I

In the home page near the settings symbol, there is "Start" script with the product symbol. The user can initiate the system by touching it. The home symbol becomes smaller and goes to the bottom right in order to sustain a clear view for the driver.

Thermal imaging camera process the images and when display detects a living creature a "Warning" symbol appears in the bottom center of the screen. Living creatures are marked and movements are followed on the screen.

Fig 54. Night vision view II

The reaction of the device is different in rural and urban areas. Therefore, device arranges itself and its features like sound warning, according to the area. The process is shaped according to the density of the traffic lights and surroundings. The camera recognizes that surrounding and send signals to the display according to driver's comfort. For instance, less sound and image warnings in urban areas.

Fig 55. Night vision view III

5.2.4 - Brand

Logo design work started with illustration of the head shape of gecko lizard. The color tone of blue gecko is the main inspiration. Later, instead of abstraction of the head, the important point of the project is chosen as eye because it is all about vision. The improvements and trials are made with different typefaces.

Fig 56. Logo trials

Finally a dynamic and technological gray tone typeface is chosen in order to point out high-tech features of the product and an abstraction of the blue gecko eye is completing the "GECKO" brand name.

Fig 57. Corporate identity mock-up with new product logo

6- Further Development

As it is mentioned in the beginning, the aim of the research is to investigate thermal imaging cameras for automotive night vision, with a focus on working principles of the engineering system, the design of the display and interface. The aim is to develop a product solution in the form of Bluetooth connection between display and thermal imaging camera and smart features, covered the existing user problems.

As a result of accumulated data a concept is created with simplifying and improving the features of the existing solutions. However, a detailed technological and user centered research is needed in order to finish the final product.

As the research is following the design and engineering process, building a prototype, testing and evaluating it and redesigning it according to the outcome of technological and user centered research, are needed.

Besides, a system scheme, business plan and brand design are should be applied to a new concept in order to create a successful producable product for the market.

Moreover, the new technologies can be added to the concept and some features can be improved and excluded in the future development.

7- Conclusion

Through the research, several aspects of thermal imaging systems for automotive night vision, are outlined in terms of design, engineering and usability.

After introducing the working principles and existing solutions, the research uncovered some main problems such as;

- Installation, connection and maintenance problems

- Usage inadequacy on display

- Complex interfaces and indication that makes images confusing for drivers

- Inability to position the device according to the driver's choice

- Over multi-functional usage

As a result of accumulated data and problems that are identified, a new product design took place after the research and brief. New product concept’s aim is bringing solutions to the existing problems that are listed above. For instance, the features of the new design contain; clear interaction with the user, sustains adjustable placement for the display, reduces the number of connections that makes installation and maintenance easier. In addition to that, the new system is trying to propose a smart usage, with reducing the elements on display and simplifying the interface. Therefore, under different conditions, the device behaves in a natural and effortless way for the driver without intervention of the user. These features provide a clean, safe and easy usage of a complex system.

Moreover, lack of variety and prices create a market gap for this sector. The opportunity in the market is proved by numbers and consumer research.

As a result of these informations and insights, research is focused to create an alternative product concept that is trying to solve those problems as much as possible and filling the market gap.

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