ISLAMIC UNIVERSITY OF TECHNOLOGY IUT

DHAKA BANGLADESH

BACHELOR OF SCIENCE IN TECHNICAL AND EDUCATION
(AUTOMOTIVE ENGINEERING)

FEASIBILITY ANALYSIS AND ALGORITHM DEVELOPMENT OF A SAFETY DEVICE FOR AUTOMOBILES

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SEPTEMBER, 2013

DEDICATION

I dedicated this thesis to my beloved Father Mr.Nganya Manjang, my caring Mother Mrs.Chakounding Dibba and to my humble and lovely wife Mrs. Isatou Sanneh Manjang for their wonderful and unflinching support in all forms.

Most special dedication goes to all brothers especially Mr.Lamin C.Manjang who has always been so supportive and helpful to me in every way. I could not have done this without your love, patience, care and belief in me. Thank you for taking this journey with me, and thank you for been there for me. You are all the inspiration and courage for me throughout this period of struggle my rock. This is for you.

DECLARATION

This is to certify that the work presented in this thesis is the outcome of the investigations and analysis carried out by **Mustapha N. Manjang** under the supervision of **Prof. Dr. Anayet Ullah Patwari** in the Department of Mechanical and Chemical Engineering (MCE), Islamic University of Technology (IUT), Board bazaar, Gazipur-1704, Dhaka, Bangladesh. It is hereby declared that this thesis work in its entirety has not been submitted elsewhere for the award of any Degree.

I wish to regret and apologize for any error found in this thesis as to err is human and to forgive is divine.

THANK YOU!

……………………………………..

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ACKNOWLEDGEMENT

Thanks to Almighty Allah for giving me the wisdom, strength and health to finish my course work and the thesis of Bachelors degree in Technical and Vocational Education successfully

As my supervisor and teacher, **Prof. Dr. Anayet Ullah Patwari** whose guidance, support, and counsel propelled me through this process. I would be forever grateful for his patience and for guiding me to do what he knew he mastered best. His result orientation, vigor, talent for goal setting and prioritization truly and dearly helped me to make it to the finish line. His constant support helps me to get through the difficulties with time. He was always available and always ready for me.

My most profound acknowledgement goes to the management and staff of the Gambia Technical Training Institute for the provision of my study leave and I thank them for the courage and support they have rendered to me throughout my course of studies here in Bangladesh.

Special thanks to all my classmates and friends for rendering me the friendship and belief in me that I needed. They were the shoulder that I often came to when times got tough. I appreciate their encouragement and their honest and heartfelt joy that they expressed each time another milestone was reached.

My mother, father and my Wife have always believed in me and supported me in all that I have done in my life. Their love and belief in me never hesitated and for that, I am truly grateful. I love them more than they will ever know.

Special and heartfelt thanks to my Automotive engineering lecturer **Associate Prof. Dr. Faisal Kader** of MCE department, **Isah Uman** student No: 113608 **(**M.Sc.T.E (EEE) in editing the thesis for me to my big brothers Lamin C. Manjang, Lamin B.L.Sanyang (Boy C) and Dembo Manjang who never doubted in my ability to succeed.

M.N

ABSTRACT

Use of ROAD SAFETY FEATURES should be a habitual behavior for all drivers and all the road users as well. This should be used as an act of promoting road safety and accident preventive measures whereby innocent and valuable souls and properties that are perished on daily basis will be saved from the menace of automobile road accidents. The invention of the comfortable automobile vehicle devices such as radio/stereo, air conditioning, global positioning system (GPS), and all other related comfort able devices should not be used to distract driver's attention on the wheel while driving. The introduction of modern and general road safety devices such as: air bags, seat belts, speedometers, advanced driver assistance system (ADAS), adaptive cruise control (ACS), advanced emergency braking system (AEBS), brake collision system, lane departure warning system and all other invented devices shouldn`t be seen as an ‘‘amusement devices” but rather as devices that are solely meant for the saving of our dear lives and properties on the road. There must be very strict traffic laws/regulations regarding the automobile road usage and the causes of accidents, the deploying of traffic police officers to be monitoring the swift flow of traffic including: drivers, pedestrians and cyclist, on a daily basis and also traffic talk shows and awareness campaigns on our communication mediums should be thoroughly encouraged.

The vast number or majority of vehicle road accidents are caused by human errors. It has been proven by many research institutes and individual researches that about or more than 57% of our daily accidents or crashes are all due to human errors. There are prevalence's where accidents are also caused as a result of mechanical and environmental factors but that should not be taken as an excuse(s)s and cause more human errors to commit dangerous accidents. The human behavior is seen as a devastating factor of lost of many lives and properties on our roads. Those human related factors such as: use of mobile phones, drink and driving, undertaking, road raging, tailgating, over speeding, driver fatigue, human information processing behaviours and other factors are seen as major causes of accidents and results to the vast number of loses in both uncountable economic values and lives annually. If both our governments and her people have come up with traffic regulations where all would be bound and forced to respect, obey and implement to fight against these above dilemmas, will be a stepping stone to simply reduced road accidents if not totally eliminated as a way of minimizing the lost of valuable lives and properties .Bad driving behavior can be totally discouraged and put to a stop by placing hefty fines, seizure of drivers licenses or on serious cases imposing prison charges on drivers who are found wanting or guilty of committing bad and serious traffic accidents.In most sincere cases, over speeding, drink and driving and use of mobile phones while driving is seen as a bad behavior which is related to mostly teenagers who are amused by the comfort ability of our road conditions, the comfortable inner vehicle devices/entertainment facilities that leads to their improper usage of our roads and the committing of fatal accidents. Proper attention must be paid to strictly observe and regulate such ill behaviours which always claim hundreds of thousands of lives and resources annually. Excessive speeding is responsible for the high proportion of

mortality and morbidity rate that results from automobile road accidents. Controlling the use of mobile phones and over speeding while driving can be a great deal but it will immensely reduce the impact of crashes, lessening the severity of injuries sustained by the victims, loss of lives and save many resources that are lost due to road accidents. Finally, until when we are determined to change our bad behaviours on the roads for good, the world would have been a better and safer place to be .But our failures to adopt to the changes in traffic regulations that are geared to save our lives and properties will not only result to mayhem, but surely send us to our early graves and left our families and loved ones in tears and agony. On a more and final note, I would like to suggest thus: ‘’A well behaved driver is always a step away from committing road accidents and also has a better tendency of living a very prosperous long life and building a driving career and as well as having a longer vehicle life span as well”.

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CHAPTER ONE

1.1 INTRODUCTION

The word automobile comes, via the French *automobile* from the Ancient Greek word αὐτός (*autós*, "self") and the Latin*mobilis* ("movable"); meaning a vehicle that moves itself. The loanword was first adopted in English by *The New York Times* in 1899. The alternative name *car* is believed to originate from the Latin word **carrus or carrum** ("wheeled vehicle"), or the Middle English word *carre* ("cart") (from Old North French), in turn these are said to have originated from the Gaulish word *Karros* (a GallicChariot).

An automobile, auto car, is a wheeled motor vehicle used for transporting passengers, which also carries its own engine or motor. Most definitions of the term specify that automobiles are designed to run primarily on roads, to have seating for one to eight people, to typically have four wheels, and to be constructed principally for the transport of people rather than goods. The term *motorcar* has also been used in the context of electrified rail systems to denote a car which functions as a small locomotive but also provides space for passengers and baggage. These locomotive cars were often used on suburban routes by both interurban and intercity railroad systems. It was estimated in 2010 that the number of automobiles had risen to over 1 billion vehicles, with 500 million reached in 1986. The numbers are increasing rapidly, especially in China and India.

However, there are numerous and different types of automobiles in the world. The following types are: Cars, buses, trucks, vans, and some motorcycles in the category, but cars are the most typical of all the automobiles.

Automobile safety on the other hand is describe as the study and practice of design, construction, equipment and regulation to minimize the occurrence and consequences (fatalities, lost of lives and resources) of automobiles accidents.

1.2 WHY DO WE NEED AUTOMOBILE SAFETY DEVICES

Due to the recent comfortable usage of automobile vehicles on our roads, there is great amount of modern facilities on our vehicles such as air condition systems, high class entertainment (stereo, video a, the use of mobile phones while driving, comfortable seats in vehicles, and many more) tends to be a distracting factor(s) for many a driver on our roads today. However, due to these above stated factors and lots more, the automobile safety devices are severely needed to reduce a vast number of road fatalities if not possible to eradicate accidents at all cost.

The safety devices such as: lane departure warning system, advance braking system, global positioning system (GPS), advance driver warning systems, airbags system (ABS), the speedometer, vehicle collision avoidance systems and many more, are the modern inventions that are all geared to contribute immensely to either the prevention of road accidents where there could be many fatalities, lost of lives and resources.

Moreover, the safety devices will drastically reduce the severity of large automobile accidents. During the past decades, accidents has claimed hundreds of thousands of lives in the world, lost of millions of dollars are spent on repairs of crashed or damaged vehicles and the communities that surrounds them on our roads and thus contribute to the financial troubles of many people in the world today and in some cases even creates monetary deficit to some governmental organizations and nongovernmental organizations. As a result of these menace, automobile industries are inventing such new safety device technologies to serve as a good remedy to the situation at hand. Another very good need of road safety device is the increase of comfort ability and safety of the vehicles, drivers, passengers, pedestrians and the community in which we live

1.3 OBJECTIVES

Due to the frequent fatal road accidents caused by automobile vehicles in the world, and has been a very serious concern of how best engineers and companies could come up with measures of preventing or minimizing this grave life taking menace. The purpose(s) of this study is/are, thus:

- To critically study the main causes of the automobile accidents that is claiming so many precious lives and valuable properties in our society and the world at large.
- Be able to analyze the root causes of the road accidents and find out means of minimizing it.
- Initiating the best possible means or technique of how this menace of automobile road accidents can be seriously minimized or prevented at all cost to prevent the loss of lives and properties in the world.
- Be able to design and develop an instruments/devices that can serve as a safety alert to both the traffic police officer/controller, this device shall help in reducing accidents by serving as alerts or signal through:
    - Sending a vibratory alert to the driver when sleepy, drunk or sick while driving,
    - Sending red light alert/indicator signal to the road traffic police that the coming or going vehicle`s driver is either, sick, drunken, sleepy or in severe rescue need so that he/she can urgently stop the vehicle and inspect what is going on with the driver of the vehicle, and the passengers on board.

- To also alert both passengers on the vehicle, driver in other vehicles and pedestrians about the need of taking precautions to avoid causing accidents with the said car in trouble.
-

1.4 MOTIVATIONS

Nothing is of greater interest and motivating to me than the prevention and protection of our valuable and precious life and properties. I found out that thousands of souls perished annually all over the world due to road accidents, and the greater amount of which stands out to be youths in their prime ages (30-40) who could have been key contributors in our today`s development agendas. In this regard I thought it as a motivating factor to write my thesis on the automobile safety so that I can contribute in helping to save lives and resources that are lost from accidents. Saving the lives of these youths who are the core and the gems of our society where they are seen as the major labor force on which we depend for our success in the world. These above reasons are the key to my selection of this topic and I the messages in this work will be absorbed very well to save our lives and properties that we always lost in road accidents.

CHAPTER TWO

2.1 GENERAL VEHICLE SAFETY FEATURES

Many people consider fuel consumption, comfort and price to be the important factors to consider when purchasing a vehicle. But what is your main priority when using a vehicle? If your main priority is to arrive at your final destination safely, then considering safety features as a top priority when purchasing a vehicle makes sense.

Figure 2.1: Showing the usage of car (driver and passenger)

With so many safety features available, which ones should you consider? In a Public Opinion Survey done by Transport Canada, airbags (71%), seatbelts (33%) and anti-lock brake systems (28%) are the three most common safety features that Canadians recognize on their vehicles. While these three safety features are very important, there are other features that can keep you and your family safe. Since we have already looked at the importance of head restraints, let us take a brief look at some other important safety features.

2.1.1 Airbag

An airbag is a vehicle safety device. It is an occupant restraint system consisting of a flexible fabric envelope or cushion designed to inflate rapidly during an automobile collision. Its purpose is to cushion occupants during a crash and provide protection to their bodies when they strike interior objects such as the steering wheel or a window. Modern vehicles may contain multiple airbag modules in various sides and frontal locations of the passenger seating positions, and sensors may deploy one or more airbags in an impact zone at variable rates based on the type, angle and severity of impact; the airbag is designed to only inflate in moderate to severe frontal crashes. Airbags are normally designed with the intention of supplementing the protection of an occupant who is correctly restrained with a seatbelt. Most designs are inflated through pyrotechnic means and can only be operated once. Newer side-impact airbag modules consist of compressed air cylinders that are triggered in the event of a side impact vehicle impact.

The first commercial designs were introduced in passenger automobiles during the 1970s with limited success. Broad commercial adoption of airbags occurred in many markets during the late 1980s and early 1990s with a driver airbag, and a front passenger airbag as well on some cars; and many modern vehicles now include four or more units.

Figure: 2.2: The driver and passenger front airbags, after having been deployed, in a British Peugeot 306 car.

2.1.2 Terminology of Airbags

Various manufacturers have over time used different terms for airbags. General Motors' first airbag modules, in the 1970s, were marketed as the Air Cushion Restraint System (ACRS). Common terms in North America include nominal role as a supplement to active restraints, i.e., seat belts. Because no action by the vehicle occupant is required to activate or use the airbag, it is considered a passive device. This is in contrast to seat belts, which are considered active devices because the vehicle occupant must act to enable them. Note that this is not related to active and passive safety, which are, respectively, systems designed to prevent accidents in the first place and systems designed to minimize accidents once they occur. For example, the car's Anti-lock Braking System will qualify as an active-safety device while both its seatbelts and airbags will qualify as passive-safety devices. Further terminological confusion can arise from the fact that passive devices and systems those requiring no input or action by the vehicle occupant can themselves operate in an active manner; an airbag is one such device. Vehicle safety professionals are generally careful in their use of language to avoid this sort of confusion, though advertising principles sometimes prevent such syntactic caution in the consumer marketing of safety features. In contrast, the aviation safety community uses the terms *active* and *passive* in the opposite manner.

2.1.3 History of Airbags

In 1967, a breakthrough occurred in the development of airbag crash sensors when Allen K. Breed invented a mechanically-based ball-in-tube component for crash detection, an electromechanical sensor with a steel ball attached to a tube by a magnet that would inflate an airbag under a 30 mille-second window. Sodium azide instead of compressed air was also used for the first time during inflation. Breed Corporation then marketed this innovation first to Chrysler. A similar "Auto-Ceptor" crash-restraint, developed by Eaton, Yale & Towne Inc. for Ford was soon offered as an automatic safety system in the USA, while the Italian Eaton-Livia company offered a variant with localized air cushions.

Figure:2.3: In 1994, Ford of Europe made airbags standard equipment in all the Cars they built

2.1.4 Origins of Airbags

The airbag specified for automobile use traces it origins to air-filled bladders as early as 1941 Reported in 1951, German engineer Walter Linderer designed an airbag. Linderer filed German patent #896,312 on October 6, 1951 which was issued on November 12, 1953, approximately three months after American John Hetrick was issued U.S. patent #2,649,311 earlier on August 18, 1953. Linderer's airbag was based on a compressed air system, either released by bumper contact or by the driver. Later research during the 1960s proved that compressed air could not blow Linderer's airbag up fast enough for maximum safety, thus making it an impractical system.

John W. Hetrick, an industrial engineer and member of the United States Navy, designed the original safety cushion commonly referred to as an airbag. It was designed based on his experiences with compressed air from torpedoes during his service in the navy, as well as a need to provide protection for his family in their automobile during accidents. Hetrick worked with the major American automobile corporations at the time, but they chose not to invest in it. In Japan, YasuzaburouKobori invented an airbag in 1963, on which technology current airbags are based, for which he was awarded patents in 14 countries. He died in 1975 without seeing widespread adoption of airbag systems.

Airbags for passenger cars were introduced in the United States in the mid-1970s, when seat belt usage rates in the country were quite low. Ford built an experimental fleet of cars with airbags in 1971, followed by General Motors in 1973 on Chevrolet vehicles. The early fleet of experimental GM vehicles equipped with airbags experienced seven fatalities, one of which was later suspected to have been caused by the airbag.

In 1974, GM made the ACRS or "Air Cushion Restraint System" available as a regular production option (RPO code AR3) in full-size Cadillac, Buick and Oldsmobile models. The GM cars from the 1970s equipped with ACRS have a driver side airbag, a driver side knee restraint (which consists of a padded lower dashboard) and a passenger side airbag. The passenger side airbag protects both front passengers and unlike most newer ones, it integrates a knee cushion, a torso cushion and it also has dual stage deployment which varies depending on the force of the impact. The cars equipped with ACRS have lap belts for all seating positions but they do not have shoulder belts. These were already mandatory equipment in the United States on closed cars without airbags for the driver and outer front passenger seating positions.

The development of airbags coincided with an international interest in automobile safety legislation. Some safety experts advocated a performance-based occupant protection standard rather than a standard mandating a particular technical solution, which could rapidly become outdated and might not be a cost-effective approach. As countries successively mandated seat belt restraints, there was less emphasis placed on other designs for several decades.

2.1.5 Frontal Airbag

The auto industry and research and regulatory communities have moved away from their initial view of the airbag as a seat belt replacement, and the bags are now nominally designated as Supplemental Restraint System (SRS) or Supplemental Inflatable Restraints.

In 1981, Mercedes-Benz introduced the airbag in Germany as an option on its high-end S-Class (W126). In the Mercedes system, the sensors would automatically pre-tension the seat belts to reduce occupant's motion on impact (now a common feature), and then deploy the airbag on impact. This integrated the seat belts and airbag into a restraint system, rather than the airbag being considered an alternative to the seat belt.

In 1987, the Porsche 944 turbo became the first car in the world to have driver and passenger airbags as standard equipment. The Porsche 944 and 944S had this as an available option. The same year also saw the first airbag in a Japanese car, the Honda Legend.

Figure: 2.4.Demonstrating the steps in using airbag

Audi was relatively late to offer airbag systems on a broader scale; until the 1994 model year, for example, the 80/90, by far Audi's 'bread-and-butter' model, as well as the 100/200, did not have airbags in their standard versions. Instead, the German automaker until then relied solely on its proprietary procon-ten restraint system.

In Europe, airbags were almost entirely absent from family cars until the early 1990s. The first European Ford to feature an airbag was the face lifted Escort MK5b in 1992; within a year, the entire Ford range had at least one airbag as standard. By the mid-1990s, European market leaders such as Vauxhall/Opel, Rover, Peugeot, Renault and Fiat had included airbags as at least optional equipment across their model ranges. By the end of the decade, it was very rare to find a mass market car without an airbag, and some late 1990s products, such as the Volkswagen Golf Mk4 also featured side airbags. The Peugeot 306 was a classical example of how commonplace airbags became on mass market cars during the 1990s. On its launch in early 1993 most of the range did not even have driver airbags as an option. By 1999 however, side airbags were available on several variants.

During the 2000s side impact airbags were commonplace on even low to mid-range vehicles, such as the smaller-engine versions of the Ford Fiesta and Peugeot 206, and curtain airbags were also becoming regular features on mass market cars. The Toyota Avensis, launched in 1998, was the first mass market car to be sold in Europe with a total of nine airbags. Although in some countries, such as Russia, airbags are still not standard equipment on all cars, such as those from Lada.Variable force deployment front airbags were developed to help minimize injury from the airbag itself.

2.1.6 Side airbags:

There are essentially two types of side airbags commonly used today, the side torso airbag and the side curtain airbag. The side airbags is placed on the side of the seats as can be seen on the diagram below. The side airbags are meant to protect passenger's sides from heavy knocks that may arise as a result of accidents. In such accidents, passengers are usually prevented from suffering from serious injuries that may emanate from knocks from other vehicles or during accidents where cars happen to summersault while having passengers on board the vehicle.

Figure: 2.5a: (left) Side airbag inflated permanently for display purposes, and(right) deployed curtain airbag and side torso airbag in a Citroën C4

Most vehicles equipped with side curtain airbags also include side torso airbags. However some exceptions such as the Chevrolet Cobalt, 2007-09 model Chevrolet Silverado/GMC Sierra, and 2009-12 Dodge Ram do not feature the side torso airbag.

2.1.7 Side Torso Airbag

Side-impact airbags or side torso airbags (side thorax/abdomen airbags) are a category of airbag usually located in the seat, and inflate between the seat occupant and the door. These airbags are designed to reduce the risk of injury to the pelvic and lower abdomen regions. Some vehicles are now being equipped with different types of designs, to help reduce injury and ejection from the vehicle in rollover crashes.

More recent sideairbagdesigns include a two chamber system; a firmer lower chamber for the pelvic region and softer upper chamber for the ribcage

Figure: 2.5b Showing the Side Torso Airbag

The Swedish company Autoliv AB, was granted a patent on side impact airbags, and they were first offered as an option in 1994 on the 1995 model year Volvo 850, and as standard equipment on all Volvo cars made after 1995.

Some cars, such as the 2010 Volkswagen Polo Mk.5 have combined head and torso side airbags. These are fitted in the backrest of the front seats, and protect the head as well as the torso.

2.1.8 Side Tubular or Curtain Airbag

In late 1997 the 1998 model year BMW 7-series and E39 5-series were fitted with a tubular shaped head side airbags, the "Head Protection System (HPS)" as standard equipment.[24] This airbag was designed to offer head protection in side impact collisions and also maintained inflation for up to seven seconds for rollover protection. However, this tubular shaped airbag design has been quickly replaced by an inflatable 'curtain' airbag.

In May 1998 Toyota began offering a side curtain airbag deploying from the roof on the Progress. In 1998 the Volvo S80 was given roof-mounted curtain airbags to protect both front and rear passengers. Curtain airbags were then made standard equipment on all new Volvo cars from 2001 except for the C70. The 2006 model C70 convertible received the world's first door-mounted side-curtain airbags that deployed upwards. Roll-sensing side curtain airbags found on vehicles more prone to rollovers such as SUVs and pickups will deploy when a rollover is detected instead of just when an actual collision takes place. Often there is a switch to disable the feature in case the driver wants to take the vehicle off-road.

Curtain airbags have been said to reduce brain injury or fatalities by up to 45% in a side impact with an SUV. These airbags come in various forms (e.g., tubular, curtain, door-mounted) depending on the needs of the application.[26] Many recent SUVs and MPVs have a long inflatable curtain airbag that protects all 3 rows of seats.

2.1.9 Knee Airbag

The second driver's side and separate knee airbag was used in the 1996 model Kia Sportage vehicle and has been standard equipment since then. The airbag is located beneath the steering wheel. The Toyota Aventis became the first vehicle sold in Europe equipped with a driver's knee airbag. The Euro NCAP reported on the 2003 Aventis, "There has been much effort to protect the driver's knees and legs and a knee airbag worked well." Since then certain models have also included front passenger knee airbags, which deploy near or over the glove compartment in a crash. Knee airbags are designed to reduce leg injury. The knee airbag has become increasingly common from 2000.

2.1.10 Rear curtain airbag

In 2008, the Toyota iQ launched featuring the first production rear curtain shield airbag to protect the rear occupants' heads in the event of a rear end impact.

2.1.11 Seat Cushion

In 2008 the Toyota iQ added a seat cushion airbag in the passenger seat. This is to prevent the pelvis from diving below the lap belt during a frontal impact. Later Toyota models such as the Yaris added the feature to the driver's seat as well.

2.1.12 Center Airbag

Figure: 2.6: Center airbag on seats

2.1.13 Seat Belt Airbag

In 2009, Toyota developed the first production rear-seat center airbag designed to reduce the severity of secondary injuries to rear passengers in a side collision. This system deploys from the rear center console first appearing in on the redesigned Crown Majesta. In late 2012 General Motors with supplier Takata introduced a front center airbag, it deploys from the driver's seat.

In 2009, the S-class ESF safety concept car showcased seatbelt airbags. They will be included standard on the production Lexus LFA, the 2011 and newer Ford Explorer offers rear seatbelt airbags as an option, they will also be optional on the 2013 Ford Flex and Standard on the 2013 Lincoln MKT. Ford will eventually introduce inflatable seat belts on other Ford models globally. Cessna Aircraft also now feature seatbelt airbags. They are now standard on the 172,182, and 206.

2.1.14 Motorcycles Airbag

Figure 2.7: Airbag on a motorcycle

Various types of airbags were tested on motorcycles by the UK Transport Research Laboratory in the mid-1970s. In 2006Honda introduced the first production motorcycle airbag safety system on its Gold Wing motorcycle. Honda claims that sensors in the front forks can detect a severe frontal collision and decide when to deploy the airbag, absorbing some of the forward energy of the rider and reducing the velocity at which the rider may be thrown from the motorcycle. Airbag suits have also been developed for use by Motorcycle Grand Prix riders. In their earlier form, they were connected to the motorcycle by a cable and deployed when the cable became detached from its mounting clip, inflating to protect the back of the rider. The French manufacturer, Helite, specializes exclusively in developing airbag jackets for motorcyclists, snowmobile riders and horseback riders. Further developments were conducted by Dainese and led to an autonomous system on board the leathers, without a cable connected to the bike. Instead, an electronic system detects a fall and triggers the inflation of the nitrogen airbags to protect the rider's upper body.

2.1.15 How airbags work

Figure: 1.8: An Airbag control unit (ACU) from a Geo Storm

The design is conceptually simple; a central "Airbag control unit" (ACU) (a specific type of ECU) monitors a number of related sensors within the vehicle, including accelerometers, impact sensors, side (door) pressure sensors, wheel speed sensors, gyroscopes, brake pressure sensors, and seat occupancy sensors. When the requisite 'threshold' has been reached or exceeded, the airbag control unit will trigger the ignition of a gas generator propellant to rapidly inflate a fabric bag. As the vehicle occupant collides with and squeezes the bag, the gas escapes in a controlled manner through small vent holes. The airbag's volume and the size of the vents in the bag are tailored to each vehicle type, to spread out the deceleration of (and thus force experienced by) the occupant over time and over the occupant's body, compared to a seat belt alone.

The signals from the various sensors are fed into the Airbag control unit, which determines from them the angle of impact, the severity, or force of the crash, along with other variables. Depending on the result of these calculations, the ACU may also deploy various additional restraint devices, such as seat belt pre-pensioners', and/or airbags (including frontal bags for driver and front passenger, along with seat-mounted side bags, and "curtain" airbags which cover the side glass). Each restraint device is typically activated with one or more pyrotechnic devices, commonly called an initiator or electric match. The electric match, which consists of an electrical conductor wrapped in a combustible material, activates with a current pulse between 1 to 3 amperes in less than 2 milliseconds. When the conductor becomes hot enough, it ignites the combustible material, which initiates the gas generator. In a seat belt pre-tensioner, this hot gas is used to drive a piston that pulls the slack out of the seat belt. In an airbag, the initiator is used to ignite solid propellant inside the airbag inflator. The burning propellant generates inert gas which rapidly inflates the airbag in approximately 20 to 30 milliseconds. An airbag must inflate quickly in order to be fully inflated by the time the forward-traveling occupant reaches its outer surface. Typically, the decision to deploy an airbag in a frontal crash is made within 15 to 30 milliseconds after the onset of the crash, and both the driver and passenger airbags are fully inflated within approximately 60-80 milliseconds after the first moment of vehicle contact. If an airbag deploys too late or too slowly, the risk of occupant injury from contact with the inflating airbag may increase. Since more distance typically exists between the passenger and the instrument panel, the passenger airbag is larger and requires more gas to fill it.

Older airbag systems contained a mixture of sodium azide (NaN_3), KNO_3, and SiO_2. A typical driver-side airbag contains approximately 50-80 g of NaN_3, with the larger passenger-side airbag containing about 250 g. Within about 40 milliseconds of impact, all these components react in three separate reactions that produce nitrogen gas. The reactions, in order, are as follows.

(1) $2\ NaN_3 \rightarrow 2\ Na + 3\ N_2\ (g)$

(2) $10\ Na + 2\ KNO_3 \rightarrow K_2O + 5\ Na_2O + N_2\ (g)$

(3) $K_2O + Na_2O + 2\ SiO_2 \rightarrow K_2O_3Si + Na_2O_3Si$ (silicate glass)

The first reaction is the decomposition of NaN_3 under high temperature conditions using an electric impulse. This impulse generates to 300°C temperatures required for the decomposition of the NaN_3 which produces Na metal and N_2 gas. Since Na metal is highly reactive, the KNO_3 and SiO_2 react and remove it, in turn producing more N_2 gas. The second reaction shows just that. The reason that $KNO_3$is used rather than something like $NaNO_3$ is because it is less hygroscopic. It is very important that the materials used in this reaction are not hygroscopic because absorbed moisture can de-sensitize the system and cause the reaction to fail. The final reaction is used to eliminate the K_2O and Na_2O produced in the previous reactions because the first-period metal oxides are highly reactive. These products react with SiO_2 to produce a silicate glass which is a harmless and stable compound.

According to a patent, the particle size of the sodium azide, potassium nitrate, and silicon dioxide are important. The NaN_3 and KNO_3 must be between 10 and 20 microns, while the SiO_2 must be between 5 and 10 microns.

There has been a recent effort to find alternative compounds that can be used in airbags which have less toxic byproducts. In a journal article publish by Akiyoshiet. Al., it was found that for the reaction of the Sr complex nitrate, (Sr ($NH_2NHCONHNH_2$) · $(NO_3)_2$ of carbohydrazide (SrCDH) with various oxidizing agents resulted in the evolution of N_2 and CO_2 gases. Using $KBrO_3$ as the oxidizing agent resulted in the most vigorous reaction as well as the lowest initial temperature of reaction. The N_2 and CO_2 gases evolved made up 99% of all gases evolved. Nearly all the starting materials won't decompose until reaching temperatures of 500°C or higher so this could be a viable option as an air bag gas generator. In a patent containing another plausible alternative to NaN_3 driven airbags, the gas generating materials involved the use of guanidine nitrate, 5-amino tetrazole, bitetrazole dehydrate, nitroimidazole, and basic copper nitrate. It was found that these non-azide reagents allowed for a less toxic, lower combustion temperature reaction and more easily disposable air bag inflation system front airbags normally do not protect the occupants during side, rear, or rollover accidents. Since airbags deploy only once and deflate quickly after the initial impact, they will not be beneficial during a subsequent collision. Safety belts help reduce the risk of injury in many types of crashes. They help to properly position occupants to maximize the airbag's benefits and they help restrain occupants during the initial and any following collisions.

In vehicles equipped with a rollover sensing system, accelerometers and gyroscopes are used to sense the onset of a rollover event. If a rollover event is determined to be imminent, side-curtain airbags are deployed to help protect the occupant from contact with the side of the vehicle interior, and also to help prevent occupant ejection as the vehicle rolls over.

Figure1.9: Some cars provide the option to turn off airbags.

Airbags are designed to deploy in frontal and near-frontal collisions more severe than a threshold defined by the regulations governing vehicle construction in whatever particular market the vehicle is intended for: U.S. regulations require deployment in crashes at least equivalent in deceleration to a 23 km/h (14 mph) barrier collision, or similarly, striking a parked car of similar size across the full front of each vehicle at about twice the speed. International regulations are performance based, rather than technology-based, so airbag deployment threshold is a function of overall vehicle design. Unlike crash tests into barriers, real-world crashes typically occur at angles other than directly into the front of the vehicle, and the crash forces usually are not evenly distributed across the front of the vehicle. Consequently, the relative speed between a striking and struck vehicle required to deploy the airbag in a real-world crash can be much higher than an equivalent barrier crash. Because airbag sensors measure deceleration, vehicle speed is not a good indicator of whether an airbag should have deployed. Airbags can deploy due to the vehicle's undercarriage striking a low object protruding above the roadway due to the resulting deceleration.

The airbag sensor is a MEMS accelerometer, which is a small integrated circuit with integrated micro mechanical elements. The microscopic mechanical element moves in response to rapid deceleration, and this motion causes a change in capacitance, which is detected by the electronics on the chip that then sends a signal to fire the airbag. The most common MEMS accelerometer in use is the ADXL-50 by Analog Devices, but there are other MEMS manufacturers as well.

Initial attempts using mercury switches did not work well. Before MEMS, the primary system used to deploy airbags was called a "rolamite". A rolamite is a mechanical device, consisting of a roller suspended within a tensioned band. As a result of the particular geometry and material properties used, the roller is free to translate with little friction or hysteresis. This device was developed at Sandia National Laboratories. The rolamite and similar macro-mechanical devices were used in airbags until the mid-1990s when they were universally replaced with MEMS. Nearly all airbags are designed to automatically deploy in the event of a vehicle fire when temperatures reach 150-200 °C (300-400 °F).[44] This safety feature, often termed auto-ignition, helps to ensure that such temperatures do not cause an explosion of the entire airbag module.

Today, airbag triggering algorithms are becoming much more complex. They try to reduce unnecessary deployments and to adapt the deployment speed to the crash conditions. The algorithms are considered valuable intellectual property. Experimental algorithms may take into account such factors as the weight of the occupant, the seat location, seatbelt use, and even attempt to determine if a baby seat is present.

2.1.16 Inflation

When the frontal airbags are to deploy, a signal is sent to the inflator unit within the airbag control unit. An igniter starts a rapid chemical reaction generating primarily nitrogen gas (N_2) to fill the airbag making it deploy through the module cover. Some airbag technologies use compressed nitrogen or argon gas with a pyrotechnic operated valve ("hybrid gas generator")while other technologies use various energetic propellants. Propellants containing the highly toxic sodium azide (NaN_3) were common in early inflator designs. The azide-containing pyrotechnic gas generators contain a substantial amount of the propellant. The driver-side airbag would contain a canister containing about 50 grams of sodium azide. The passenger side container holds about 200 grams of sodium azide.

The alternative propellants may incorporate, for example, a combination of nitro guanidine, phase-stabilized ammonium nitrate (NH_4NO_3) or other nonmetallic oxidizer, and a nitrogen-rich fuel different than azide (e.g. tetrazoles, triazoles, and their salts). The burn rate modifiers in the mixture may be an alkaline metal nitrate (NO_3-) or nitrite (NO_2-), dicyanamide or its salts, sodium borohydride ($NaBH_4$), etc. The coolants and slag formers may be e.g. clay, silica, alumina, glass, etc.[46] Other alternatives are e.g. nitrocellulose based propellants (which have high gas yield but bad storage stability, and their oxygen balance requires secondary oxidation of the reaction products to avoid buildup of carbon monoxide), or high-oxygen nitrogen-free organic compounds with inorganic oxidizers (e.g. tricarboxylic acids with chlorates (ClO_3) or per chlorates (ClO_4-) and eventually metallic oxides; the nitrogen-free formulation avoids formation of toxic nitrogen oxides).From the onset of the crash, the entire deployment and inflation process is about 0.04 seconds. Because vehicles change speed so quickly in a crash, airbags must inflate rapidly to reduce the risk of the occupant hitting the vehicle's interior.

2.1.17 Variable-force deployment

Advanced airbag technologies are being developed to tailor airbag deployment to the severity of the crash, the size and posture of the vehicle occupant, belt usage, and how close that person is to the actual airbag. Many of these systems use multi-stage inflators that deploy less forcefully in stages in moderate crashes than in very severe crashes. Occupant sensing devices let the airbag control unit know if someone is occupying a seat adjacent to an airbag, the mass/weight of the person, whether a seat belt or child restraint is being used, and whether the person is forward in the seat and close to the airbag. Based on this information and crash severity information, the airbag is deployed at either a high force level, a less forceful level, or not at all.

Adaptive airbag systems may utilize multi-stage airbags to adjust the pressure within the airbag. The greater the pressure within the airbag, the more force the airbag will exert on the occupants as they come in contact with it. These adjustments allow the system to deploy the airbag with a moderate force for most collisions; reserving the maximum force airbag only for the severest of collisions. Additional sensors to determine the location, weight or relative size of the occupants may also be used. Information regarding the occupants and the severity of the crash are used by the airbag control unit, to determine whether airbags should be suppressed or deployed, and if so, at various output levels.

Figure: 1.10: Post-deployment view of a SEAT Ibiza airbag

2.1.18 Post-deployment of airbags

A chemical reaction produces a burst of nitrogen to inflate the bag. Once an airbag deploys, deflation begins immediately as the gas escapes through vent(s) in the fabric (or, as it's sometimes called, the cushion) and cools. Deployment is frequently accompanied by the release of dust-like particles, and gases in the vehicle's interior (called effluent). Most of this dust consists of cornstarch, French chalk, or talcum powder, which are used to lubricate the airbag during deployment. Newer designs produce effluent primarily consisting of harmless talcum powder/cornstarch and nitrogen gas. In older designs using an azide-based propellant (usually NaN_3), varying amounts of sodium hydroxide nearly always are initially present. In small amounts this chemical can cause minor irritation to the eyes and/or open wounds; however, with exposure to air, it quickly turns into sodium bicarbonate (baking soda). However, this transformation is not 100% complete, and invariably leaves residual amounts of hydroxide ion from NaOH. Depending on the type of airbag system, potassium chloride may also be present.

For most people, the only effect the dust may produce is some minor irritation of the throat and eyes. Generally, minor irritations only occur when the occupant remains in the vehicle for many minutes with the windows closed and no ventilation. However, some people with asthma may develop a potentially lethal asthmatic attack from inhaling the dust. The dust-like particles and gases can cause irreparable cosmetic damage to the dashboard and upholstery, so minor collisions which result in the deployment of airbags can be costly accidents, even if there are no injuries and there is only minor damage to the vehicle exterior.

2.2 SPEEDO METER

A speedometer or a speed meter is a gauge that measures and displays the instantaneous speed of a land vehicle. Now universally fitted to motor vehicles, they started to be available as options in the 1900s, and as standard equipment from about 1910 onwards. Speedometers for other vehicles have specific names and use other means of sensing speed. For a boat, this is a pit log. For an aircraft, this is an airspeed indicator.

The speedometer was invented by the Croatian Josip Belušić in 1888, and was originally called a velocimeter. The dashboard instrument cluster in your car organizes a variety of sensors and gauges, including the oil pressure gauge, coolant temperature gauge, gauge, tachometer and more. But the most prominent gauge -- and perhaps the most important, at least in terms of how many times you look at it while you're driving -- is the speedometer. The job of the speedometer is to indicate the speed of your car in miles per hour, kilometers per hour or both. Even in late-model cars, it's an analog device that uses a needle to point to a specific speed, which the driver reads as a number printed on a dial.

As with any emerging technology, the first speedometers were expensive and available only as options. It wasn't until 1910 that automobile manufacturers began to include the speedometer as standard equipment. One of the first speedometer suppliers was Otto Schulze Autometer (OSA), a legacy company of Siemens VDO Automotive AG, one of the leading developers of modern instrument clusters. The first OSA speedometer was built in 1923 and its basic design didn't change significantly for 60 years. In this article, we're going to look at the history of speedometers, how they work and what the future may hold for speedometer design.

Figure:2.11: Speedometer,tachometer and fuel gauge of a car

The eddy current speedometer has been used for over a century and is still in widespread use. Until the 1980s and the appearance of electronic speedometers it was the only type commonly used. Originally patented by a German, Otto Schulze on 7 October 1902,[2] it uses a rotating flexible cable usually driven by gearing linked to the output of the vehicle's transmission. The early Volkswagen Beetle and many motorcycles, however, use a cable driven from a front wheel.

When the car or motorcycle is in motion, a speedometer gear assembly will turn a speedometer cable which then turns the speedometer mechanism itself. A small permanent magnet affixed to the speedometer cable interacts with a small aluminum cup (called a *speed cup*) attached to the shaft of the pointer on the analogue speedometer instrument. As the magnet rotates near the cup, the changing magnetic field produces eddy currents in the cup, which themselves produce another magnetic field. The effect is that the magnet exerts a torque on the cup, "dragging" it, and thus the speedometer pointer, in the direction of its rotation with no mechanical connection between them.

The pointer shaft is held toward zero by a fine torsion spring. The torque on the cup increases with the speed of rotation of the magnet (which is driven by the car's transmission). Thus an increase in the speed of the car will twist the cup and speedometer pointer against the spring. The cup and pointer will turn until the torque of the eddy currents on the cup is balanced by the opposing torque of the spring, and then stop. Since the torque on the cup is exactly proportional to the car's speed, and the spring's deflection is proportional to the torque, the angle of the pointer is also proportional to the speed. At a given speed the pointer will remain motionless and pointing to the appropriate number on the speedometer's dial.The return spring is calibrated such that a given revolution speed of the cable corresponds to a specific speed indication on the speedometer. This calibration must take into account several factors, including ratios of the tail shaft gears that drive the flexible cable, the final drive ratio in the differential, and the diameter of the driven tires.

2.2.1 Electronic speedometer

Many modern speedometers are **electronic**. In designs derived from earlier eddy-current models, a rotation sensor mounted in the transmission delivers a series of electronic pulses whose frequency corresponds to the (average) rotational speed of the **driveshaft**, and therefore the vehicle's speed, assuming the wheels have full traction. The sensor is typically a set of one or more magnets mounted on the output shaft or (in transaxles) differential crown wheel or a toothed metal disk positioned between a magnet and a **magnetic field sensor**. As the part in question turns, the magnets or teeth pass beneath the sensor, each time producing a pulse in the sensor as they affect the strength of the magnetic field it is measuring.[1] Alternatively, in more recent designs, some manufactures rely on pulses coming from the ABS wheel sensors.

A computer converts the pulses to a speed and displays this speed on an electronically-controlled, analog-style needle or a digital display. Pulse information is also used for a variety of other purposes by the ECU or full-vehicle control system, e.g. triggering ABS or traction control, calculating average trip speed, or more mundanely to increment the odometer in place of it being turned directly by the speedometer cable.

Another early form of electronic speedometer relies upon the interaction between a precision watch mechanism and a mechanical pulsate driven by the car's wheel or transmission. The watch mechanism endeavors to push the speedometer pointer toward zero, while the vehicle-driven pulsate tries to push it toward infinity. The position of the speedometer pointer reflects the relative magnitudes of the outputs of the two mechanisms.

2.2.2 Error of speedometers

Most speedometers have tolerances of some ±10%, mainly due to variations in tire diameter. Sources of error due to tire diameter variations are wear, temperature, pressure, vehicle load, and nominal tire size. Vehicle manufacturers usually calibrate speedometers to read high by an amount equal to the average error, to ensure that their speedometers never indicate a lower speed than the actual speed of the vehicle, to ensure they are not liable for drivers violating speed limits.

Excessive speedometer error after manufacture can come from several causes but most commonly is due to nonstandard tire diameter, in which case the error is

$$\text{Percentage error} = 100 \times (1 - \text{new diameter}/\text{standard diameter})$$

Nearly all tires now have their size shown as "T/A_W" on the side of the tire, and the tires

$$\text{Diameter in millimetres} = 2 \times T \times A/100 + W \times 25.4$$

$$\text{Diameter in inches} = T \times A/1270 + W$$

For example, a standard tire is "185/70R14" with diameter = 2*185*(70/100) + (14*25.4) = 614.6 mm (185x70/1270 + 14 = 24.20 in). Another is "195/50R15" with 2*195*(50/100)+(15*25.4) = 576.0 mm (195x50/1270 + 15 = 22.68 in). Replacing the first tire (and wheels) with the second (on 15" = 381 mm wheels), a speedometer reads 100 * (1-(576/614.6)) = 100 * (1 - 22.68/24.20) = 6.28% higher than the actual speed. At an actual speed of 100 km/h (60 mph), the speedometer will indicate 100 x 1.0628 = 106.28 km/h (60 * 1.0628 = 63.77 mph), approximately.

In the case of wear, a new "185/70R14" tyre of 620 mm (24.4 inch) diameter will have ~8mm tread depth, at legal limit this reduces to 1.6mm, the difference being 12.8mm in diameter or 0.5 inches which is 2% in 620 mm (24.4 inches).

2.2.3 International Agreements on Errors of Speedometer

In many countries the legislated error in speedometer readings is ultimately governed by the United Nations Economic Commission for Europe (UNECE) Regulation 39which covers those aspects of vehicle type approval which relate to speedometers. The main purpose of the UNECE regulations is to facilitate trade in motor vehicles by agreeing uniform type approval standards rather than requiring a vehicle model to undergo different approval processes in each country in which it is to be sold.

European Union member states must also grant type approval to vehicles meeting similar EU standards. The ones covering speedometers are similar to the UNECE regulation in that they specify that:

- The indicated speed must never be less than the actual speed, i.e. it should not be possible to inadvertently speed because of an incorrect speedometer reading.
- The indicated speed must not be more than 110 percent of the true speed plus 4 km/h at specified test speeds. For example, at 80 km/h, the indicated speed must be no more than 92 km/h.

The standards specify both the limits on accuracy and many of the details of how it should be measured during the approvals process, for example that the test measurements should be made (for most vehicles) at 40, 80 and 120 km/h, and at a particular ambient temperature. There are slight differences between the different standards, for example in the minimum accuracy of the equipment measuring the true speed of the vehicle.

The UNECE regulation relaxes the requirements for vehicles mass produced following type approval. At Conformity of Production Audits the upper limit on indicated speed is increased to 110 percent plus 6 km/h for cars, buses, trucks and similar vehicles, and 110 percent plus 8 km/h for two- or three-wheeled vehicles which have a maximum speed above 50 km/h (or a cylinder capacity, if powered by a heat engine, of more than 50 cm^3). European Union Directive 2000/7/EC, which relates to two- and three-wheeled vehicles, provide similar slightly relaxed limits in production.

-Australia

There were no design rules in place for speedometers in Australia prior to July 1988. They had to be introduced when speed cameras were first used. This means there are no legally accurate speedometers for these older vehicles. All vehicles manufactured on or after 1 July 2007, and all models of vehicle introduced on or after 1 July 2006, must conform to UNECE Regulation 39.

The speedometers in vehicles manufactured before these dates but after 1 July 1995 (or 1 January 1995 for forward control passenger vehicles and off-road passenger vehicles) must conform to the previous Australian design rule. This specifies that they need only display the speed to an accuracy of +/- 10% at speeds above 40 km/h, and there is no specified accuracy at all for speeds below 40 km/h. All vehicles manufactured in Australia or imported for supply to the Australian market must comply with the Australian Design Rules.

The state and territory governments may set policies for the tolerance of speed over the posted speed limits that may be lower than the 10% in the earlier versions of the Australian Design Rules permitted, such as in Victoria. This has caused some controversy since it would be possible for a driver to be unaware that he is speeding should his vehicle be fitted with an under-reading speedometer

-United Kingdom

The amended Road Vehicles (Construction and Use) Regulations 1986 permits the use of speedometers that meet either the requirements of EC Council Directive 75/443 (as amended by Directive 97/39) or UNECE Regulation 39.The Motor Vehicles (Approval) Regulations 2001permits single vehicles to be approved. As with the UNECE regulation and the EC Directives, the speedometer must never show an indicated speed less than the actual speed. However it differs slightly from them in specifying that for all actual speeds between 25 mph and 70 mph (or the vehicles' maximum speed if it is lower than this), the indicated speed must not exceed 110% of the actual speed, plus 6.25 mph.For example, if the vehicle is actually travelling at 50 mph, the speedometer must not show more than 61.25 mph or less than 50 mph.

Figure 2.12b: A speedometer showing mph and km/h along with an odometer and a separate "trip" odometer (both showing distance traveled in miles)

-United States

Federal standards in the **United States** allow a maximum 5 mph error at a speed of 50 mph on speedometer readings for commercial vehicles. Aftermarket modifications, such as different tire and wheel sizes or different differential gearing, can cause speedometer inaccuracy.

2.2.4 How to measure speed using speedometer

If you've read about automotive trade studies, you'll know that speed is very simply defined: it's the distance you travel divided by the time you take. So if you go 200 kilometers and it takes you four hours to do it, your average speed is 50 kilometers per hour. Measuring your average speed after you've traveled is not actually that much help, especially if a police officer is asking you questions.

What we're talking about here is average speed; what you need to know as a motorist is your instantaneous speed: the speed you're going at any given moment. Figuring that out is a lot harder than you think. If you've seen traffic cops (or speed cameras) by the side of the road, you'll probably be aware that they use radar beams to check speeds. The radar gun (handheld or mounted inside the speed camera) shoots an invisible electromagnetic beam at your car at the speed of light. Your car reflects the beam back again, modifying it very slightly. The gun figures out how the beam has been affected and, from that, calculate your speed. Now in theory we could all have radar guns mounted in our cars, shooting beams out at lamp-posts and buildings and waiting for the reflections to come back—but that's an awful lot of bother! Isn't there a simpler way of finding out how quickly we're going?

Figure: 1.12b: Showing the Reading of Speedometer

What we really need is a way of figuring out how fast the car's wheels are turning. If we know how big the wheels are, we can then figure out the speed fairly easily. But how do you measure a wheel's rate of rotation? Even that problem isn't simple. Imagine how much harder it must have seemed in the early days of motoring, back in 1902, when German engineer Otto Schulze invented the first practical solution: the eddy-current speedometer.

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2.2.5 How speedometers work

1. When the engine turns over, the driveshaft turns to make the wheels spin round.
2. The speedometer cable, powered by the driveshaft, turns as well.
3. The cable spins a magnet around at the same speed inside the speed cup. The magnet rotates continually in the same direction (in this case, counter-clockwise).
4. The spinning magnet creates eddy currents in the speed cup.
5. The eddy currents make the speed cup rotate counter-clockwise as well in an attempt to catch up with the magnet. Remember that the magnet and the speed cup are not joined together in any way—there's air in between them.
6. The hair spring tightens, restraining the speed cup so it can turn only a little way.
7. As the speed cup turns, it turns the pointer up the dial, indicating the car's speed

2.2.5.1 How mechanical (eddy-current) speedometers work

Here's what we want out of our speedometer. We have the car's wheels rotating at a certain speed and we want to know, with a simple pointer and dial, what that speed is. So we need to connect the spinning wheels to the pointer in some clever fashion. Even that is pretty tricky: the wheels are racing around but the pointer, some distance away, merely flicks back and forth. How do we convert continuous, spinning motion into intermittent, flicker, pointer motion? The answer is to use magnetism! The shaft that turns the car's wheels is connected to the speedometer by a long, flexible cable made of twisted wires. The cable is a bit like a mini driveshaft: if one end of the cable rotates, so does the other even though the cable is long and bendy. At the top end, the cable feeds into the back of the speedometer. When it rotates, it turns a magnet inside the speedometer case at the same speed. The magnet rotates inside a hollow metal cup, known as the speed cup, which is also free to rotate, though restrained by a fine coil of wire known as a hairspring.

However, the magnet and the speed cup are not connected together: they're separated by air. The speed cup is attached to the pointer that moves up and down the speedometer dial. As the speedometer cable rotates, it turns the magnet at the same speed. The spinning magnet creates a fluctuating magnetic field inside the speed cup and, by the laws of electromagnetism that means electric currents flow inside the cup as well. In effect, the speed cup turns into a kind of electricity generator. But, unlike in a proper generator (the kind that makes electricity for your home in a power plant), the currents in the speed cup have nowhere to go: there's nothing to carry their power away. So the currents just swim about uselessly in swirling eddies we call them eddy currents for that very reason. Since they're electric currents, and they're moving in an electrical conductor inside a magnetic field, another law of electromagnetism says they will create motion. The currents actually make the speed-cup rotate in such a way that it tries to catch up with the spinning magnet. But the hairspring stops the cup from rotating very far so it just turns a little bit instead, pulling the pointer up the dial as it does so. The faster the car moves, the faster the cable turns, the quicker the magnet spins, the bigger the eddy currents it generates, the greater the force on the speed cup, and the more it's able to pull the pointer up the dial. If you can't picture all that clearly, take a look at the little animation below.

1) A magnet connected to one of the wheels (or more likely to a driveshaft attached to one of the wheels) rotates at high speed.

2) Every time it makes one complete revolution, it passes a Hall-effect (or other magnetic) sensor and the field from the magnet triggers the sensor.

3) A circuit amplifies the signals from the sensor and translates them into your instantaneous speed and distance traveled.

4) A digital display on the dashboard acts as both a speedometer and odometer, displaying the speed and distance side by side.

Pretty much all speedometers produced until the 1980s worked this way much like Schulze's original, patented design. But there are drawbacks. First, there are lots of mechanical parts to wear out (which makes them inaccurate) or fail suddenly. If the speedometer cable breaks, the whole contraption instantly becomes useless and it takes a mechanic to make a repair. Long speedometer cables are particularly impractical, which has always been something of a problem in large commercial vehicles such as trucks and buses. Eddy-current speedometers are also less than ideal for bicycles, not least because there isn't really room to mount a large speedometer on the handlebars! And it's not just the cable that poses a problem: it can be difficult to read a conventional speedometer dial if you're racing down the freeway, especially at night: do youreally want to take your eyes off the road to figure out where the needle is on the dial? Some people prefer to see their speed as a simple number on a well-lit digital display.

Electronic speedometers work in a completely different way. Small magnets attached to the car's rotating drive shaft sweep past tiny magnetic sensors (either reed switches or Hall-effect sensors) positioned nearby. Each time the magnets pass the sensors, they generate a brief pulse of electric current. An electronic circuit counts how quickly the pulses arrive and converts this into a speed, displayed electronically on an LCD display. Since the circuit is measuring the number of wheel rotations, it can also keep a count of how far you've traveled, doubling-up as an odometer (distance-measuring meter). Electronic speedometers can also display speeds with analog pointers and dials, just like traditional eddy-current Speedos: in that case, the electronic circuit drives a highly controllable electric motor (called a stepper motor) that rotates the pointer through an appropriate angle. Electronic speedometers are more reliable and compact than mechanical ones and the motion sensors can be any distance from the display that shows you your speed, making them suitable for any kind of vehicle from a bicycle to a 40-ton trucks

2.2.6 Advanced Driver Assistance Systems (Adas) For Trucks

Since a couple of years, advanced driver assistance systems (ADAS) are known from high-end passenger cars. They have been adapted for trucks and other heavy-duty vehicles. Besides dedicated data provided by radar sensors and cameras, many of these systems use information from the CAN-based in-vehicle networks. In some applications, the ADAS actions are forwarded into the CAN networks, for example to brake the truck or to accelerate the speed.

Figure: 1. 13: The truck of the year 2013, Iveco is equipped with anLDWS. In addition, the heavy-duty, long-haul truck implements ACCand ESC functionality as well as an AEBS

Truck traffic is increasing and safety is becoming more important. Ninety percent of the accidents are caused by driver error. In order to handle difficult traffic situations in the future, the truck makers, suppliers, and independent researcher are working to make vehicles smarter than before, helping the driver to avoid potentially dangerous situations. Today's advanced driver assistance systems (ADAS) include, for example, warning systems and driver awareness support. In most cases, the driver is simply warned when something is wrong. The next step in safety is to improve the electronic systems, so that they can assist the driver in avoiding a crash. They support the trucker in driving the vehicle, for example in dangerous situations.

2.2.7 **Adaptive Cruise Control** (Acs)

Convoy driving is both tiring and monotonous, but is an everyday business of truckers. ACC (adaptive cruise control) offers stress-free driving with the traffic flow, while maintaining proper speed and distance to the traffic ahead. With ACC, drivers can select a constant speed without getting too close to the vehicle ahead. They are able to stop a vehicle even from high-speed to a standstill by communicating via CAN to the brake system. The ACC system is able to detect if the vehicle in front begins to move again and will notify the driver in this case via an acoustic signal. If the driver confirms the signal, his vehicle will accelerate automatically, all the while maintaining proper following distance, up to the pre-selected speed or the speed permitted by the flow of traffic. Modern ACC systems warn the driver promptly before possible rear-end collisions. With predictive brake preconditioning, they can shorten the stopping distance, possibly enough to save lives. Some ACC systems are combined with a forward collision warning (FCW) or a curve speed warning (CSW) function.

In the European Eurofot field test, ACC was evaluated. MAN (Germany) participated in the 4-year research project with a total of 57 trucks belonging to 21 haulage companies. The trucks tested in European long-haul transport were equipped with the MAN's adaptive cruise control and lane guard driver assistance system (LGS). They drove more than 7,5 million km. The test studied the effectiveness of electronic driver assistance systems in road traffic with respect to safety, the environment, utilization and acceptance by drivers. Due to ACC, it was possible to reduce heavy braking and critical events such as sudden evasive maneuvers, for example, by more than 35 percent. The number of occasions, on which the distance to the vehicle ahead was critical was halved on average. Where ACC was not used, an average of six critical events occurred on a typical daily run of approximately 600 km: with the system, this was reduced to just one. ACC also makes a contribution to environmentally friendly driving, with the fuel consumption of the vehicles operated during the test decreasing by two percent while their average speed increased by around one percent. Utilization of the lane guard system convinced with improvement in keeping the vehicle on track as well as smoother steering behavior. LGS also positively influenced drivers with respect to their willingness to use direction indicators when changing lanes.

ACC and LGSare offered in the heavy truck series and successively in coaches of the MAN and Neoplan brands. LGS is also available in the vehicles of the light and medium TG series. MAN is applying the valuable lessons learned from the field test to the optimization and further development of driver assistance systems. Similarly, the data collected is already being used for the requirements analyses for up-coming projects.

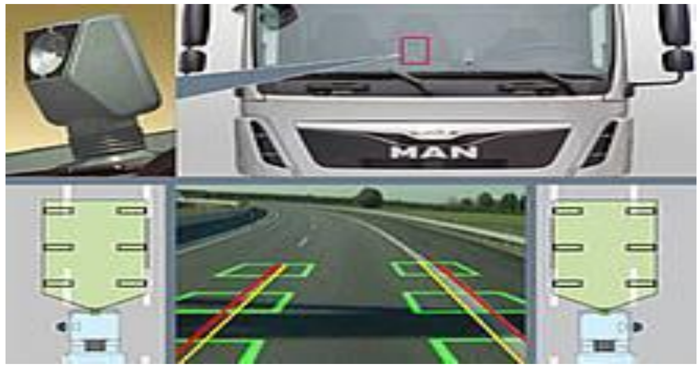


Figure: 1.14: MAN truck with ACC and LDWS improved safety

At the IAA exhibition in Hanover (Germany), Knorr-Bremse (Germany) showed camera and assistance systems from its North American subsidiary Bendix, in the shape of Auto Vue and Safety Direct. The Auto Vue system warns when departing the lane. The Safety Direct is a kind of "black box" that records vehicle data not continuously but only in critical situations. The data acquired can be used for driver training purposes as well as providing a source of information following an accident. Through the use of smart environment sensor systems based on advanced radar and video technology, the functionalities of the EBS and ABS brake control systems can be substantially expanded in the context of driver assistance systems.

2.2.8 **Advanced emergency braking system** (AEBS)

At the IAA fair, Daimler received for its Actros and Antos trucks the certificate for the AEBS (advanced emergency braking systems) by the German Federal Motor Transport Authority (KBA). This was the first certificate of approval to be issued in Europe in relation to the international regulation. The mentioned trucks were proven to meet the legal requirements that will in fact not become mandatory until the second stage of the Regulation takes effect in 2018. The Mercedes-Benz Actros equipped with the ABA 3 third-generation emergency braking system initiate full autonomous braking in situations involving stationary obstacles. The truck is thus able not only to mitigate the consequences of rear-end collisions, as hitherto, but also to prevent such accidents from happening in the first place.

Driver assistance systems can play a significant role in the prevention of road traffic accidents. In 2009, the EU Commission, under its general safety Regulation 661/2009/EC, initiated a series of measures aimed at improving road traffic safety. This prescribes the phased mandatory introduction of three important driver assistance systems with relevance to road safety for all new vehicles throughout Europe:

- In a first step, it makes mandatory the installation of electronic vehicle stability control systems (EVSC), known also as ESP (electronic stability program) or ESC (electronic stability control), in all new vehicles of existing models (passenger cars, buses, trucks and trailers) with effect from 1 November 2014. The positive impact of such systems can already be seen in the market and has been proven in several studies. The considerable benefits of these systems, for heavy touring coaches and trucks and their trailers in particular, are undisputed. Installation in all new vehicles earlier than proposed in the EU Regulation would therefore be both possible and desirable.
- A second step makes lane departure warning systems (LDWS) and advanced emergency braking systems (AEBS) mandatory for all new commercial vehicles. This relates to new type approvals granted from 1 November 2013 for buses with more than 9 seats and trucks with a permissible gross vehicle weight of over 3,5 ton, and to all newly registered vehicles with effect from 1 November 2015.

AEBS systems are designed to identify automatically an emergency situation and to alert the driver to take appropriate braking or steering action himself in order to prevent an accident or, in the event that the driver does not react, to activate the vehicle's braking system in order to avoid an accident or minimize its consequences.

The adaptive cruise control (ACC) and emergency braking systems (EBS) that are currently available on the market are able to recognize and react to moving targets, in other words to vehicles driving or slowing down ahead. The IAA 2012 saw the introduction of the ABA 3 system, which is now also effective in situations involving stationary obstacles such as construction site safety vehicles or vehicles that have broken down, and to take the initiative to brake the vehicle to a standstill and so completely prevent a rear-end collision. Such systems have a significant part to play in reducing accidents in the way that they help inattentive drivers to recognize critical situations and are able to reduce kinetic energy through autonomous braking.
By the way, Actros trucks implement twelve CAN networks with more than 30 electronic control units (ECU) running at 500 kbit/s or 667 kbit/s. Some of them are connected to the AEBS system. The increasing bandwidth requirements makes Daimler’s engineer interested in the CAN FD protocol, which allows higher bit-rates and provides optionally longer data fields.

Figure: 2.15: The On Guard Max system by Wabco reacts to moving and stopped vehicles

The EBS 7 electronic braking system by Knorr-Bremse goes into volume production beginning of this year. One key advantage of this system is that it is installed outside the cab on the vehicle frame. This has several benefits – not only in the cab, where space is at a premium, but also in terms of wiring, because there are in any case multiple connections located around the frame. The system combines the company's anti-lock braking system (ABS), anti-slip regulation (ASR), and EABS. Another advantage of this electronic system compared to ABS alone is the shorter response time, leading to a further reduction in stopping distances.

Knorr-Bremse's focus on improved safety is not limited to tractor vehicles but also extends to semitrailers and trailers. The company's TEBS unit for trailers brings together electronic controls, pneumatics and sensors in a single unit. It offers extended functionalities through the integration of electronic leveling control (ELC). The use of a second, trailer-based CAN network makes for a significant reduction in system complexity in the trailer. The recently introduced ST7-430 trailer brake from Knorr-Bremse is a two-piston disc brake for 22,5-inch wheels. It is designed for 9-ton trailer axles. Due to its optimized disc and caliper it weighs around five kilogram less than its predecessor, thereby boosting efficiency in the trailer.

2.3 BRAKE COLLISION SYSTEM.

2.3.1 Putting the Brakes on Collisions

In 2011, more than 3,700 fatalities resulted from large-truck crashes in the United States. Oftentimes, improper decisions by passenger car drivers are responsible for these collisions. When 2,000- to 4,000-pound passenger vehicle darts in front of an 80,000-pound tractor-trailer rig, prompt assessment, reaction, and effective braking systems are critical to prevent a crash.

New braking standards enacted by NHTSA in 2009 mandate a loaded truck-tractor traveling at 60 mph must come to a complete stop within 250 feet, rather than the old standard of 355 feet. This is a 30 percent reduction in truck-tractor stopping distance. The standards are being phased in during a four-year period, with the most common three-axle truck-tractors meeting the new stopping distance in August 2011 and two-axle and severe duty truck-tractors meeting the new rule by August 2013. NHTSA estimates the braking requirement will save 227 lives, prevent 300 serious injuries, and reduce property damage costs by more than $169 million annually.

2.3.2 Assisting Drivers with Collision Safety Systems

Another big area of safety improvement has been in collision safety systems, which include forward collision warning, lane change assistance, and lane departure warning. These systems assist drivers by quickly recognizing and responding to potentially dangerous driving situations, such as sideswipes, rear-end collisions, or following too closely. Reactions range from audible and visual warnings to alert distracted or drowsy drivers to automatic braking to eliminate or mitigate an impending crash. NHTSA is expected to announce a decision on whether to mandate collision safety systems for commercial vehicles by late 2013.

While radar-based collision mitigation technology was first introduced five years ago, continuous innovation has brought major advancements in improved object tracking performance and stationary object warning capabilities. By using advanced radar sensors with improved object resolution and tracking, the systems are designed to minimize false warnings. One of the highlights of this cutting-edge technology includes the ability to perform evasive maneuver checks, giving the system visibility into adjacent lanes. If the system recognizes the potential for a rear-end collision and detects an object in an adjacent lane, it "understands" the driver cannot perform an evasive maneuver, and the system will apply the service brakes sooner. The earlier the system brakes, the higher the likelihood of avoiding a crash or reducing the energy of the crash.

The Federal Motor Carrier Safety Association has named "failure to keep in proper lane," which is often caused by driver distraction or fatigue, as the third-most-cited reason for a fatal truck accident, Lane departure warning systems use a forward-looking, vision-based camera designed to monitor the road ahead and the vehicle's position in the lane, detecting and notifying the driver of lane drifts, weaving, or lane changes that occur without a turn signal. Heavy-duty technology advancements are improving driver and highway safety.

In just over a decade following the 1956 Federal Aid Highway Act, the brand-new interstate highways laced up the nation coast to coast and border to border. The result was a boom for commercial trucking, which became -- and remains -- the number one way to connect large cities with small ones and the goods with the people. To accomplish this, Class 8 (tractor-trailer) truck drivers alone travel more than 175 billion miles a year, with many of them averaging 100,000 miles or more of driving each year. With all of those miles, truck manufacturers, fleet operators, and drivers have a great responsibility to keep the roads we share safe for all drivers and the communities that surround them. That's why the industry is constantly innovating with safety technology, such as stopping systems, stability control, collision mitigation, lane departure warnings, and other driver-assist functions. Those of us in the transportation industry understand that innovation is more than a business plan; it's a way to save lives and improve efficiency.

Regulatory agencies obviously stay very close to technology advancements that make our roads safer. Just as they have done with the passenger car industry, the National Highway Traffic Safety Administration continues to update federal safety standards for commercial vehicles to ensure that safety remains a priority. During the past five years, NHTSA has spent considerable time studying tractor-trailer safety standards and has recommended changes to strengthen regulations, covering everything from braking standards to electronic stability control and collision safety systems. To meet the increasing demand for safety while also balancing investment requirements, manufacturers have been working on the development and delivery of integrated, or combined, active braking system technologies that improve vehicle stability in certain conditions and reduce the likelihood of a multitude of crash types. The result is that increasingly sophisticated and effective technology has become more widely available and accepted by the fleet community.

2.4 SEAT BELTS

A seat belt, also known as a safety belt, is a vehicle safety device designed to secure the occupant of a vehicle against harmful movement that may result during a collision or a sudden stop. A seat belt functions to reduce the likelihood of death or serious injury in a traffic collision by reducing the force of secondary impacts with interior strike hazards, by keeping occupants positioned correctly for maximum effectiveness of the airbag (if equipped) and by preventing occupants being ejected from the vehicle in a crash.

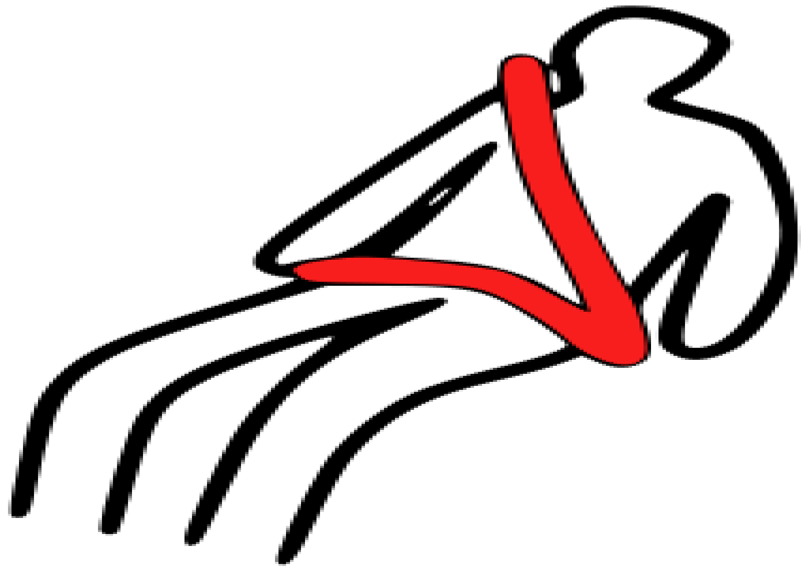


Figure 2.16: Demonstrating the use of seat belts.

2.4.1 History of seat belts

Seat belts were invented by English engineer George Cayley in the early 19th century, though Edward J. Claghorn of New York, was granted the first patent (U.S. Patent 312,085, on February 10, 1885 for a safety belt).Claghorn was granted United States Patent #312,085 for a Safety-Belt for tourists, painters, firemen, etc. who are being raised or lowered, described in the patent as "designed to be applied to the person, and provided with hooks and other attachments for securing the person to a fixed object."In 1911, Benjamin Foulois had the cavalry saddle shop fashion a belt for the seat of Wright Flyer Signal Corps 1. He wanted it to hold him firmly in his seat so he could better control his aircraft as he bounded along the rough field used for takeoff and landing. It was not until World War II that seat belts were fully adopted in military aircraft, and even then, it was mainly for safety reasons, not improved aircraft control.

In 1946, Dr. C. Hunter Shelden had opened a neurological practice at Huntington Memorial Hospital in Pasadena, California. In the early 1950s, Dr. Shelden had made a major contribution to the automotive industry with his idea of retractable seat belts. This came about greatly in part from the high number of head injuries coming through the emergency rooms. He investigated the early seat belts whose primitive designs were implicated in these injuries and deaths. His findings were published in the November 5, 1955 *Journal of the American Medical Association* (JAMA) in which he proposed not only the retractable seat belt, but also recessed steering wheels, reinforced roofs, roll bars, door locks and passive restraints such as the air bag. Subsequently in 1959, Congress passed legislation requiring all automobiles to comply with certain safety standards.

American car manufacturers Nash (in 1949) and Ford (in 1955) offered seat belts as options, while Swedish Saab first introduced seat belts as standard in 1958. After the Saab GT 750 was introduced at the New York Motor Show in 1958 with safety belts fitted as standard, the practice became commonplace.

However, the first modern three point seat belt (the so-called *CIR-Griswold restraint*) used in most consumer vehicles today was patented in 1955 (US Patent 2,710,649) by the Americans Roger W. Griswold and Hugh DeHaven, and developed to its modern form by Swedish inventor Nils Bohlin for Swedish manufacturer Volvo—who introduced it in 1959 as standard equipment. In addition to designing an effective three-point belt, Bohlin demonstrated its effectiveness in a study of 28,000 accidents in Sweden. Unbelted occupants sustained fatal injuries throughout the whole speed scale, whereas none of the belted occupants were fatally injured at accident speeds below 60 mph. No belted occupant was fatally injured if the passenger compartment remained intact Bohlin was granted U.S. Patent 3,043,625 for the device. The world's first seat belt law was put in place in 1970, in the state of Victoria, Australia, making the wearing of a seat belt compulsory for drivers and front-seat passengers.

2.4.2 Types of seat belt:

There are various types of seat belts but the following types are discussed below with detailed pictures.

- **Two-point (a lap):** A lap belt is a strap that goes over the waist. This was the most commonly installed type of belt prior to legislation requiring 3-point belts, and is primarily found in older cars. Some coaches are equipped with lap belts, as are passenger air craft seats.

Figure: 1.17: A lap ("2-point") belt in use

Until the 1980s, three-point belts were commonly available only in the front outboard seats of cars; the back seats were only often fitted with lap belts. Evidence of the potential of lap belts to cause separation of the lumbar vertebrae and the sometimes associated paralysis, or "seat belt syndrome", led to progressive revision of passenger safety regulations in nearly all developed countries to require 3-point belts first in all outboard seating positions and eventually in all seating positions in passenger vehicles. Since September 1, 2007, all new cars sold in the U.S. require a lap and shoulder belt in the center rear seat. Besides regulatory changes, "seat belt syndrome" has led to tremendous liability for vehicle manufacturers. One Los Angeles case resulted in a $45 million jury verdict against the Ford Motor Company; the resulting $30 million judgment (after deductions for another defendant who settled prior to trial) was affirmed on appeal in 2006.

Sash type

A "sash" or shoulder harness is a strap that goes diagonally over the vehicle occupant's outboard shoulder and is buckled inboard of his or her lap. The shoulder harness may attach to the lap belt tongue, or it may have a tongue and buckle completely separate from those of the lap belt. Shoulder harnesses of this separate or semi-separate type were installed in conjunction with lap belts in the outboard front seating positions of many vehicles in the North American market starting at the inception of the shoulder belt requirement of the U.S. National Highway Traffic Safety Administration's Federal Motor Vehicle Safety Standard 208 on 1 January 1968. However, if the shoulder strap is used without the lap belt, the vehicle occupant is likely to "submarine", or slide forward in the seat and out from under the belt, in a frontal collision. In the mid-1970s, 3-point belt systems such as Chrysler's "Uni-Belt" began to supplant the separate lap and shoulder belts in American-made cars, though such 3-point belts had already been supplied in European vehicles such as Volvos, Mercedes, and Saabs for some years.

- **Three-point**

A 3-point belt is a Y-shaped arrangement, similar to the separate lap and sash belts, but unitized. Like the separate lap-and-sash belt, in a collision the 3-point belt spreads out the energy of the moving body over the chest, pelvis, and shoulders. Volvo introduced the first production three-point belt in 1959 The first car with three point belt was a Volvo PV 544 that was delivered to a dealer in Kristianstad on August 13, 1959. However, the first car model to feature the three point seat belt as a standard item was the 1959 Volvo 122, first outfitted with a two-point belt at initial delivery in 1958, replaced with the three point seat belt the following year.[14] The three point belt was developed by Nils Bohlin who had earlier also worked on ejection seats at Saab.[15] Volvo then made the new seat belt design patent open in the interest of safety and made it available to other car manufacturers for free.

Figure: 2.18:A 3-point seat belt

2.4.3 Seat belt locking retractors

The purpose of locking retractors is to provide the seated occupant the convenience of some free movement of the upper torso within the compartment, while providing a method of limiting this movement in the event of a crash. Most modern seat belts are stowed on spring-loaded reels called "retractors" equipped with inertial locking mechanisms that stop the belt from extending off the reel during severe deceleration. There are two main types of inertial seat belt lock. A webbing-sensitive lock is based on a centrifugal clutch activated by rapid acceleration of the strap (webbing) from the reel. The belt can be pulled from the reel only slowly and gradually, as when the occupant extends the belt to fasten it. A sudden rapid pull of the belt — as in a sudden braking or collision event — causes the reel to lock, restraining the occupant in position. A vehicle-sensitive lock is based on a pendulum swung away from its plumb position by rapid deceleration or rollover of the vehicle. In the absence of rapid deceleration or rollover, the reel is unlocked and the belt strap may be pulled from the reel against the spring tension of the reel. The vehicle occupant can move around with relative freedom while the spring tension of the reel keeps the belt taut against the occupant. When the pendulum swings away from its normal plumb position due to sudden deceleration or rollover, a pawl is engaged, the reel locks and the strap restrains the belted occupant in position. Dual-sensing locking retractors use both vehicle G-loading and webbing payout rate to initiate the locking mechanism.

2.5 Pretensioners and web clamps

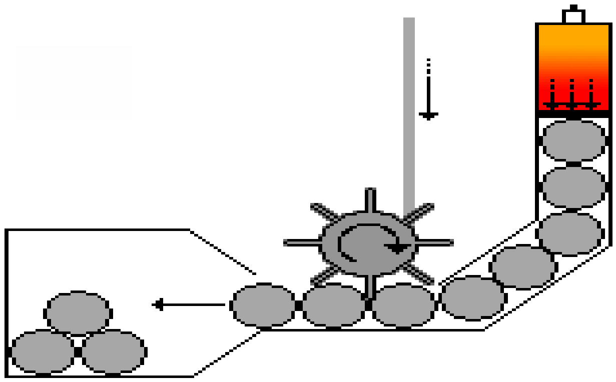


Figure 2.19: Pyro technique pretensioners diagram

Seatbelts in many newer vehicles are also equipped with "pretensioners" and/or "Web clamps".

- Pre-tensioners preemptively tighten the belt to prevent the occupant from jerking forward in a crash. Mercedes-Benz first introduced pretensioners on the 1981 S-Class. In the event of a crash, pretensioners will tighten the belt almost instantaneously. This reduces the motion of the occupant in a violent crash. Like airbags, pretensioners are triggered by sensors in the car's body, and most pretensioners use explosively expanding gas to drive a piston that retracts the belt. Pretensioners also lower the risk of "submarining", which is when a passenger slides forward under a loosely worn seat belt. An alternative approach being looked at by major car companies is the CG-Lock technology whereby the occupant is held in position via the lap belt in order to prevent the passenger from coming out of position in the event of a crash. Some systems also pre-emptively tighten the belt in fast accelerations and strong decelerations even if no crash has happened.
- Web clamps clamp the webbing in the event of an accident and limit the distance the webbing can spool out (caused by the unused webbing tightening on the central drum of the mechanism). These belts also often incorporate an energy management loop ("rip stitching") in which the lower part of the webbing is looped and stitched with a special stitching. The function of this is to "rip" at a predetermined load, which reduces the load transmitted through the belt to the occupant, reducing injuries to the occupant.

A study demonstrated that standard automotive 3-point restraints fitted with pyrotechnic or electric pretensioners were not able to eliminate all interior passenger compartment head strikes in rollover test conditions. Electric pretensioners are often incorporated on vehicles equipped with pre-crash systems, they are designed to reduce seat belt slack in a potential collision and assist in placing the occupants in a more optimal seating position.

2.5.1.1 Inflatable seat belt

The inflatable seatbelt was invented by Donald Lewis and tested at the Automotive Products Division of Allied Chemical Corp Inflatable seatbelts have tubular inflatable bladders contained within an outer cover. When a crash occurs the bladder inflates with a gas to increase the area of the restraint contacting the occupant and also shortening the length of the restraint to tighten the belt around the occupant, improving the protection. The inflatable sections may be shoulder-only or lap and shoulder. The system supports the head during the crash better than a web only belt. It also provides side impact protection. In 2013, Ford began offering rear seat inflatable seat belts on a limited set of models, such as the Explorer and Flex.

Figure 2.20: Automatic seat belt in a Honda Civic

Seatbelts that automatically move into position around a vehicle occupant once the adjacent door is closed and/or the engine is started were developed as a countermeasure against low usage rates of manual seat belts, particularly in the United States. The first car to feature Automatic Shoulder belts as standard equipment was the 1981 Toyota Cressida, but the history of the belts go back further. The 1972 VolkswagenESVW1Experimental Safety Vehicle presented passive seat belts. Volvo tried to develop a passive three point seatbelt. In 1973 Volkswagen announced they had a functional passive seat belt. The first commercial car to use automatic seat belts was the 1975 Volkswagen Rabbit. Automatic seat belts received a boost in the United States in 1977 when Brock Adams, United States Secretary of Transportation in the Carter Administration, mandated that by 1983 every new car should have either airbags or automatic seat belts. By early 1978, Volkswagen had reported 90,000 Rabbits sold with automatic seat belts. A study released in 1978 by the United States Department of Transportation claimed that cars with automatic seatbelts had a fatality rate of .78 per 100 million miles, compared with 2.34 for cars with regular, manual belts. In 1981, Drew Lewis, the first Transportation Secretary of the Reagan Administration, influenced by studies done by the auto industry, "killed" the previous administration's mandate; the decision was overruled in a federal appeals court the following year,[] and then by the Court. In 1984, the Reagan Administration reversed its course,[46] though in the meantime the original deadline had been extended; Elizabeth Dole, then Transportation Secretary, proposed that the two passive safety restraints be phased into vehicles gradually, from vehicle model year 1987 to vehicle model year 1990, when all vehicles would be required to have either automatic seat belts or driver side air bags.[43] Though more awkward for vehicle occupants, most manufacturers opted to use less expensive automatic belts rather than airbags during this time period.

When driver side airbags became mandatory on all passenger vehicles in model year 1995, most manufacturers stopped equipping cars with automatic seat belts. Exceptions include the 1995-1996 Ford Escorts/Mercury Tracer and the Eagle Summit Wagon which had automatic safety belts along with dual airbags.

2.5.2 Systems of seat belts

- Manual lap belt with automatic motorized shoulder belt — When the door is opened, the shoulder belt moves from a fixed point near the seat back on a track mounted in the door frame of the car to a point at the other end of the track near the windshield. Once the door is closed and the car is started, the belt moves rearward along the track to its original position, thus securing the passenger. The lap belt must be fastened manually.

- Manual lap belt with automatic non-motorized shoulder belt — this system was used in American-market vehicles such as the Hyundai Excel and Volkswagen Jetta. The shoulder belt is fixed to the aft upper corner of the vehicle door, and is not motorized. The lap belt must be fastened manually.

- Automatic shoulder and lap belts — This system was mainly used in General Motors vehicles, though it was also used on some Honda Civic hatchbacks and Nissan Sentra coupés. When the door is opened, the belts go from a fixed point in the middle of the car by the floor to retractors on the door. Passengers must slide into the car under the belts. When the door closes, the seat belt retracts into the door. The belts have normal release buttons that are supposed to be used only in an emergency, but in practice are routinely used in the same manner as manual seat belt clasps disadvantages.

- Automatic belt systems generally offer inferior occupant crash protection in systems with belts attached to the door rather than a sturdier fixed portion of the vehicle body, a crash that causes the vehicle door to open leaves the occupant without belt protection. He or she will, in that case, usually be thrown from the vehicle and suffer greater injury or death. Because many automatic belt system designs compliant with the US passive-restraint mandate did not meet the safety performance requirements of Canada—which were not weakened to accommodate automatic belts—vehicle models which had been eligible for easy importation in either direction across the US-Canada border when equipped with manual belts became ineligible for importation in either direction once the US variants got automatic belts and the Canadian versions retained manual belts. Two such models were the Dodge Spirit and Plymouth Acclaim.

- Automatic belt systems also present several operational disadvantages. Motorists who would normally wear seat belts must still fasten the manual lap belt, thus rendering redundant the automation of the shoulder belt. Those who do not fasten the lap belt wind up inadequately protected by only the shoulder belt; in a crash without a lap belt such a vehicle occupant is likely to "submarine" (be thrown forward under the shoulder belt) and be seriously injured. Motorized or door-affixed shoulder belts hinder access to the vehicle, making it difficult to enter and exit—particularly if the occupant is carrying items such as a box or a purse. Vehicle owners tend to disconnect the motorized or door-affixed shoulder belt to alleviate the nuisance of entering and exiting the vehicle, leaving only a lap belt for crash protection. Also, many automatic seat belt systems are incompatible with child safety seats, or compatible only with special modifications.

2.5.3 Experimental Designs of Seat Belts

Research and development efforts are ongoing to improve the safety performance of vehicle seatbelts. Some experimental designs have included:

- *Criss-cross* Experimental safety belt presented in the Volvo SCC. It forms a cross-brace across the chest.*3+2 Point Seatbelt*: Experimental safety belt from Autoliv similar to the criss-cross. The 3+2 improves protection against rollovers and side impacts
- *Four points "belt and suspenders"*: An experimental design from Ford where the "suspenders" are attached to the backrest, not to the frame of the car.

- ***In rear seats:***

In 1955 (as a 1956 package), Ford offered lap only seat belts in the rear seats as an option within the *Lifeguard* safety package. In 1967, Volvo started to install lap belts in the rear seats. In 1972, Volvo upgraded the rear seat belts to a three point belt. In crashes, unbelted rear passengers increase the risk of belted front seat occupants' death by nearly five times.

- **Child occupants**

As with adult drivers and passengers, the advent of seat belts was accompanied by calls for their use by child occupants, including legislation requiring such use. Generally children using adult seat belts suffer significantly lower injury risk when compared to non-buckled children.

The UK extended compulsory seatbelt wearing to child passengers under the age of 14 in 1989. It was observed that this measure was accompanied by a 10% *increase* in fatalities and a 12% *increase* in injuries among the target population In crashes, small children who wear adult seatbelts can suffer "seat-belt syndrome" injuries including severed intestines, ruptured diaphragms and spinal damage. There is also research suggesting that children in inappropriate restraints are at significantly increased risk of head injury, one of the authors of this research has been quoted as claiming that "The early graduation of kids into adult lap and shoulder belts is a leading cause of child-occupant injuries and deaths." As a result of such findings, many jurisdictions now advocate or require child passengers to use specially designed child restraints. Such systems include separate child-sized seats with their own restraints and booster cushions for children using adult restraints. In some jurisdictions children below a certain size are forbidden to travel in front car seats."

Figure: 2. 21: Examples of warning lights on a car dashboard.

In North America, cars sold since the early 1970s have included an audiovisual reminder system consisting of a light on the dashboard and a buzzer or chime reminding the driver and passengers to fasten their belts. Originally, these lights were accompanied by a warning buzzer whenever the transmission was in any position except park if either the driver was not buckled up or, as determined by a pressure sensor in the passenger's seat, if there was a passenger there not buckled up. However, this was considered by many to be a major annoyance, as the light would be on and the buzzer would sound continuously if front-seat passengers were not buckled up.

Therefore, people who did not wish to buckle up would defeat this system by fastening the seatbelts with the seat empty and leaving them that way.

By the mid-1970s, auto manufacturers modified the system so that a warning buzzer would sound for several seconds before turning off (with the warning light), regardless of whether the car was started. However, if the driver was buckled up, the light would appear, but with no buzzer. New cars sold in the United States in 1974 and the first part of the 1975 model year were sold with a special "ignition interlock", whereby the driver could not start the car until the seat belt was fastened; however, this system was short-lived.

Today, the belt warning light may stay on for several minutes after the car is started if the driver's seat belt is not fastened.

In Europe and some other parts of the world, most modern cars include a seat-belt reminder light for the driver and some also include a reminder for the passenger, when present, activated by a pressure sensor under the passenger seat. Some cars will intermittently flash the reminder light and sound the chime until the driver (and sometimes the front passenger, if present) fastens their seatbelts.

2.5.4 Legislation on the use of seat belts

Observational studies of car crash morbidity and mortality, experiments using both crash test dummies and human cadavers indicate that wearing seat belts greatly reduces the risk of death and injury in the majority of car crashes. This has led many countries to adopt mandatory seat belt wearing laws. It is generally accepted that, in comparing like-for-like accidents, a vehicle occupant not wearing a properly fitted seat belt has a significantly and substantially higher chance of death and serious injury. One large observation studying using US data showed that the odds ratio of crash death is 0.46 with a three-point belt, when compared with no belt. In another study that examined injuries presenting to the ER pre- and post-seat belt law introduction, it was found that 40% more escaped injury and 35% more escaped mild and moderate injuries.

The effects of seat belt laws are disputed by those who observe that their passage did not reduce road fatalities. There was also concern that instead of legislating for a general protection standard for vehicle occupants, laws that required a particular technical approach would rapidly become dated as motor manufacturers would tool up for a particular standard which could not easily be changed. For example, in 1969 there were competing designs for lap and 3-point seat belts, rapidly-tilting seats, and air bags being developed. But as countries started to mandate seat belt restraints the global auto industry invested in the tooling and standardized exclusively on seat belts, and ignored other restraint designs such as air bags for several decades.

- **Risk compensation**

Some have proposed that the number of deaths was influenced by the development of risk compensation, which says that drivers adjust their behavior in response to the increased sense of personal safety wearing a seat belt provides.

In one trial subjects were asked to drive go-karts around a track under various conditions. It was found that subjects who started driving unbelted drove consistently faster when subsequently belted similarly, a study of habitual non-seatbelt wearers driving in freeway conditions found evidence that they had adapted to seatbelt use by adopting higher driving speeds and closer following distances. A 2001 analysis of US crash data aimed to establish the effects of seatbelt legislation on driving fatalities and found that previous estimates of seatbelts effectiveness had been significantly overstated. According to the analysis used, seatbelts were claimed to have decreased fatalities by 1.35% for each 10% increase in seatbelt use. The study controlled for endogenous motivations of seat belt use, which it is claimed creates an artificial correlation between seat belt use and fatalities, leading to the conclusion that seatbelts cause fatalities. For example, drivers in high risk areas are more likely to use seat belts, and are more likely to be in accidents, creating a non-causal correlation between seatbelt use and mortality. After accounting for the endogeneity of seatbelt usage, Cohen and Einav found no evidence that the risk compensation effect makes seatbelt wearing drivers more dangerous, a finding at variance with other research.

- **Increased traffic**

Other statistical analyses have included adjustments for factors such as increased traffic, and other factors such as age, and based on these adjustments, a reduction of morbidity and mortality due to seat belt use has been claimed. However, Smeed's law predicts a fall in accident rate with increasing car ownership and has been demonstrated independently of seat belt legislation. Buses/Motor coaches: In the European Union, all new long distance buses and coaches must be fitted with seat belts. Australia has required lap/sash seat belts in new coaches since 1994. These must comply with Australian Design Rule 68, which requires the seat belt, seat and seat anchorage to withstand 20g deceleration and an impact by an unrestrained occupant to the rear.

2.5.5 Lane Departure Warning System Based Virtual Lane Boundary

Nowadays, an important social and economic problem is traffic safety. In 1999, according to world report on road accidents about 800,000 people died globally in road related accidents, causing losses of around US $518 billion. A considerable fraction of these accidents is due to single vehicle lane departure crashes that are mostly caused by inattention, drowsiness, intoxication, incapacitation, unintended steering wheel motions or utilization of cell phones .In this condition, some lane departure warning systems (LDWS) are developed to aid the driver

in avoiding or mitigating lane departure crashes through warnings to the driver. A warning system should give as much warning time as possible, while triggering few, if any, false alarms.

Currently, the most common approach to preventing lane departure is the use of roadside rumble strips (RRS) on road shoulders. When a vehicle drifts off the road, its tire hits the RRS, which vibrates the vehicle, and makes a loud noise, alerting the driver to take corrective action. However, RRS does require an infrastructure and does not exist on a majority of roadways, and adding RRS can be expensive. Furthermore, RRS presents a difficult issue to determine the rumble-strip distance threshold. Placed too close to the road boundary guarantees that no lane departures will be missed, yet it increases the frequency of false alarms. Placement further from the road edge reduces false alarms, but decreases the effectiveness of the warning in terms of driver response. An alternative approach is TLC based method, and when the TLC is below a specified threshold an alarm is triggered. TLC, first proposed by Godthelp, is defined as the time predicted before a specified location on the vehicle will cross the lane boundary. A lane departure warning system (LDWS) should give as much warning time as Possible while triggering few, if any, false alarms. In this paper, a virtual lane boundary based LDWS (VLWM) is proposed to approach this goal. VLWM allows the driver to drift beyond the physical lane boundary by adding a virtual lane boundary. Accounting for the driving habit of the driver, lane geometry, and the local driver behavior changes, the virtual lane width is determined using a fuzzy-logic inference method. When the vehicle is predicted to exceed the virtual lane boundary, an alarm is triggered. Real world driving data are used to test the LDWSs. Compared with time-to-lane-crossing (TLC) based method, the VLWM has a much lower false alarm rate, while their warning time is almost similar.

Meanwhile VLWM has a much longer warning time than the roadside rumble strip (RRS), while the false alarm rate is almost as low as that of the RRS.

In general, TLC based method provides more warning time than RRS, because warnings are triggered when a driver is predicted to be in danger. However, this prediction can be wrong, and therefore, the false alarm rate is generally much higher than with RRS. So,

RRS has a low false alarm rate, but a short warning time. Conversely, TLC based method, as it is normally implemented, has a much higher false alarm rate than RRS, with a longer warning time.

The first step to develop an onboard LDWS is a robust detection of lane boundaries.

Numerous methods have been developed to estimate the lane shape and the vehicle position in the lane. They can be classified into region-based methods and edge-based methods. For a thorough review on lane detection methods, we refer the readers to reference. Based on some kind of lane boundary estimation, some authors have worked on lane departure warning systems.

These methods can be classified into TLC based methods, vehicle heading direction based methods and methods that are based on onboard electronic implementation of the static rumble strip.TLC based methods have long warning time, but they usually have high false alarm rates. Vehicle heading direction based methods would fail in curved roads with dashed lane markings, and these methods don't present their warning time. For electronic rumble strip based methods, the offsets of the rumble strips are difficult to be determined. Some lane departure warning systems (Supplied by Assist Ware Corporation, and Iteris Corporation) have recently become commercially available for heavy truck applications. They use computer vision and highly specialized algorithms to detect lane markings, and when necessary the systems generate a warning to the driver. But these systems cannot adapt themselves to the driving habits of the drivers. Alane departure warning system (LDWS) is developed to detect when the vehicle begins to drift from the road. The LDWS uses a velocity sensor and a camera to determine the vehicle's state relative to the lane and the local structure of the lane ahead. A decision module interprets these states to determine if the vehicle is in danger of drifting out of the Warning Interface Decision Module lane and Host Vehicle State Estimate Module travel lane.

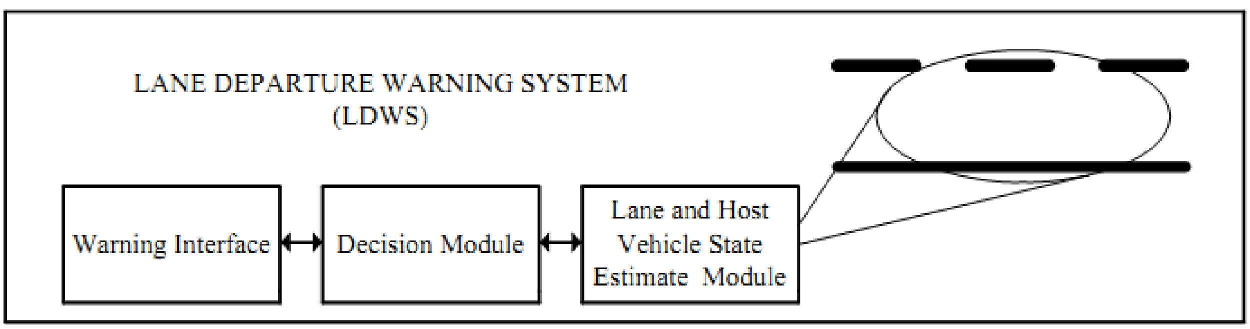


Figure 2.21: The block diagram of the proposed lane departure warning system (LDWS).

A LANE DEPARTURE WARNING SYSTEM BASED ON VIRTUAL LANE BOUNDARY

If so, the system provides a warning to the driver. To overcome the demerits of RRS and TLC based methods, a virtual lane boundary based lane departure warning method is developed (In this paper, VLWM is used to stand for virtual lane boundary based lane departure warning method). The virtual lane width is determined by a fuzzy logic based method. Compared with RRS, the VLWM has a much longer warning time, with a false alarm rate similar to the RRS. Meanwhile, VLWM has a much lower false alarm rate than the TLC based methods, while the warning time is almost as long as that of the TLC based methods. The methods in [12] and [13] use fuzzy logic reference, also. They are electronic implementations of the static rumble strip, using the lateral position and velocity of the vehicle as inputs to estimate the offset of the rumble strip. Their performances are similar to those of TLC based methods. The rest of this paper is organized as follows: Section 2 describes the used lane geometry and vehicle state estimate method. Section 3 presents the virtual boundary based lane departure warning method (VLWM). Experiment results are provided in section 4 and section 5 gives the conclusion.

2.5.5.1 Lane geometry and vehicle state estimate

In order to determine if the vehicle is in danger of departing the road, a LDWS must accurately and reliably estimate the vehicle's position and orientation relative to the road, and the geometry of lane ahead. This study uses our previous developed lane detection and tracking method to estimate the lane geometry and the vehicle position and orientation within the lane. A camera mounted on the vehicle acquires visual information about the road, and the desired information is extracted from the acquired images by means of computer vision technology in real time. Video sequences are obtained at 25 frames per second. Firstly, a deformable template model of the projective projection of the lane boundaries is used assuming that the lane boundaries are parabolas in the ground plane. Then, the lane detection problem is formulated as a maximum a posterior (MAP) estimate problem. Due to the non-concavity of the function involved, a Taboo search algorithm is used to obtain the global maxima. The model parameters calculated completely determine the position of the vehicle inside the lane, its heading direction, and the width and curvature of the lane. The lane detection result in the first frame is used to initialize a lane tracker. The lane shape and vehicle position in the sequence of consecutive images are recursively estimated using a particle filter, which has multiple hypotheses capability and can perform nonlinear filtering. Fig. 2 shows some of results of the

Figure2.22: Some results of the used lane detection algorithm.

used lane detection algorithm. The lane detection and tracking approach can handle the situations where the lane boundaries in an image have relatively weak local contrast or where there are strong distracting edges. Because this paper focuses on the construction of a lane departure warning model, it does not address the lane detection algorithm in details. We refer the readers to reference [16] for details on the used lane detection and tracking method. The state outputs and accuracies of the used lane detection and tracking method are given in Table 1.

State variable	Range	Accuracy	Units
Lateral offset (d)	[-240,240]	3	centimeters
Lateral velocity (v_l)	[-200,200]	3	centimeters/second
Lane width (W)	[280,420]	3	centimeters
Lane curvature (C)	[-0.01,0.01]	0.0001	1/meter
Heading direction (θ)	[-45,45]	0.5	degrees
Velocity (v)	[0,50]	0.15	meters/second

Table 1. The outputting state range and accuracy of the used lane geometry and vehicle state estimate method.

Virtual Lane Boundary Based Lane Departure Warning Method allows the driver to drift past the physical lane boundary before being alerted to possible danger. This is a more realistic model of driver behavior, as certain drivers tend to drift beyond the lane boundary during normal driving. Allowing this drifting to occur reduces the number of false alarms. There are two parameters in the VLWM algorithm: look ahead time, T, and virtual lane width beyond the physical lane boundary.

The look ahead of time is how far in the future the system is willing to predict future vehicle state. The virtual lane width is a distance beyond the physical lane boundary, which the driver is allowed to occupy. A warning is not triggered when the vehicle is predicted to exceed the physical lane boundary. Rather, it is triggered when the vehicle is predicted to exceed the virtual lane boundary, at time T from now, which is usually beyond the physical lane boundary.

If the following relation is true, then an alarm is triggered: Lp> Lv. Where Lp is the predicted vehicle lateral position, and Lv = Wv, is the virtual lane boundary. Fig.24 shows the sketch of the lane. After the states v, vl, C, d, μ, W are determined by the method presented by section 2, the location Lp of the host vehicle in time T can be determined (see Fig 24. below). There are many ways to compute the predicted lateral position Lp, here we use a 1^{st} order kinematic approach, where d Virtual lane boundary Road shoulder Physical laneboundary x and yLanecenter Radius =1/ C

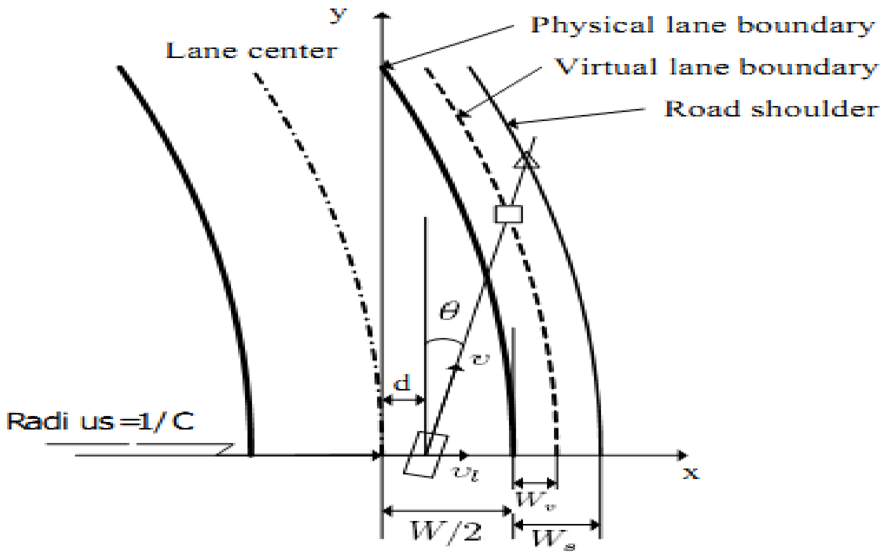


Figure 2.23: Projected vehicle path for the vehicle lateral position calculation.

$$L_p = \begin{cases} d + Tv_l - \dfrac{W}{2}, & v_l \geq 0, \\ -d - Tv_l - \dfrac{W}{2}, & v_l < 0. \end{cases}$$

Other models are possible, such as 2nd order models which use lateral acceleration information, or data-centric approaches such as memory based learning which use a distribution of actual future lateral positions calculated using training data. The decision-making part of the VLWM system requires some inputs and produces an adjustment to the Wv to adapt to the driver behaviors. Driver behavior does change with road geometry, and driver behavior does change over time. Accounting for driver's behavior changes due to road geometry and time results in a more complete alarm decision model, which may improve lane departure warning system performance. Here, we model the driving habit, the curve-cutting behavior, and the local behavior of the driver. Different drivers have different driving habits. The "loose" drivers have a larger spread in lateral position than the "tight" driver, indicating that the "loose" driver weaves more than the"tight"driver. It is a difficult task to model the driver habit. Here, the long- time lateral position standard deviation δm of the vehicle in the lane is used to reflect the driver habit. Curve-cutting is a behavior in which drivers tend to shift toward the inside of a curve. Reference has shown that when people negotiate curves, their eyes tend to focus on the inside of the curve. Also, when traversing a curve, if the driver starts at the outside, shifts inwards, and then backout, the radius of curvature is maximized and lateral forces are minimized, resulting in a smoother drive. Curve cutting behavior can cause additional false alarms, particularly if exceeds the lane boundary. It is possible to account for this by temporarily increasing the virtual lane boundary on the direction toward the inside of the curve, allowing the driver more freeways.

It is possible to adapt to local deviations by looking at a lagged (by the window size) moving average of the vehicle’s lateral position. By doing so, a warning system would know when the driver’s behavior has changed, although it could not infer the reason for that change. When the driver is hugging one side of the lane, the narrow virtual lane could generate false alarms. This shift in lateral position could occur for many reasons: construction zones, passing trucks, a narrow shoulder on the opposite side, driver behavior, etc. If we assume that all such short term changes are due to external circumstances or decisions made by the driver, rather than to inattention or drowsiness, the alarm decision model can be modified to allow the driver more latitude in these circumstances.

Fuzzy-logic-based Virtual Lane Boundary Width Determination

				$1/C$		
				small	medium	large
δ_m	small	M_p	small	M	S	S
			medium	M	M	S
			large	L	M	M
	medium	M_p	small	M	M	S
			medium	L	M	S
			large	L	L	M
	large	M_p	small	L	M	S
			medium	L	L	M
			large	L	L	L

Table 2: Rules used to determine the virtual lane width for VLWM system

Determination of the width of the virtual lane is the key of the proposed LDWS. By adjusting the width of the virtual lane, we aim to approach the goal that the proposed method has low false alarm rate and long warning time. So, the decision-making part of theVLWM system is required to take the road construction, the curvature C, and the lateral position standard deviation δm, the local lateral position mean Mp inputs and produce the width of the virtual lane boundary. Here, a supervisory approach using a rule-based system is selected. The selection of a rule-based system is guided by the need to express heuristics and human expertise employed during driving. The rules of human expertise can be summarized in a rule set, as shown in Table 2. The rules are reformatted as IF-THEN rules, e.g. IF (δm is small) and (Mp is large) and (1/C is medium) THEN (Wv is medium). These rules represent the heuristics of how the VLWMbehaves. At any point in the input space, only one of the rules is active. In this meaning, the rule base is simply a set of linguistic descriptions.

The rule base forms the input/output structure of the fuzzy-logic system, and enables us to develop the input and output membership function. The input variables consisting of 1/C, δm, and Mp, isfuzziffied in order to be treated by the fuzzy rule base. For each input, there are three input membership functions representing the fuzzy set small, medium, and large. The input space U is simply the expected working range to be included in the fuzzy set. The range for the lane radius 1/C is A

Described by the set notation as U1/C = [400, 1200]. The lower bound is decided by according to the construction design standard of highway. Defining the upper bound to be 1,200m is because the curve-cutting behaviors usually happen when the radii of the lanes are small. For the lateral position standard deviation δm, U is defined as Uδm = [0.15, 0.45]. This range is selected by taking into account the ranges of the lateral position deviations of a great deal of drivers. Δm is calculated using long time of driving data of a driver, typically 10 hours of data. Ideally, the mean of the lateral position should be about zero. When the lateral position of the vehicle is about 0.8m, the wheels of the vehicle will cross the lane edge. So, U is defined as Ump = [0, 0.8] for the average of the vehicle lateral position in the short time segment. Mpis calculated using the recent 6s' dada of lateral position.

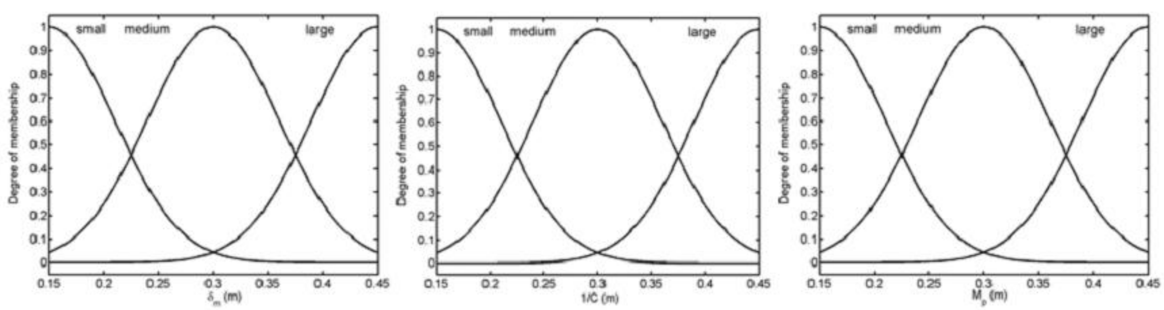


Figure 24 (a):VLWM input membership function for δm (μ small, μ medium, μ large), 1/C(μ small, μ medium, μ large), and Mp(μ small, μ medium, μ large).

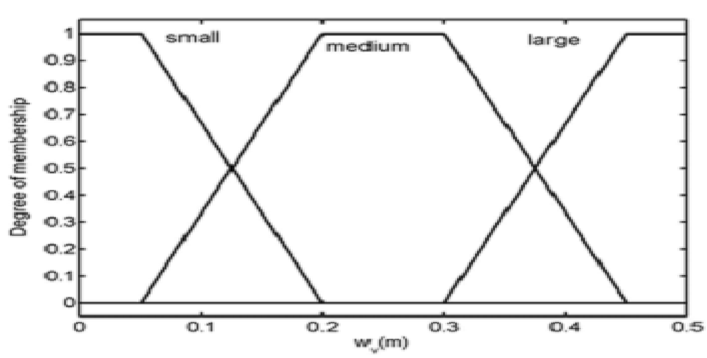


Figure 24(b):VLWM output membership function for Wv (μ small, μ medium, μ large).

The Gaussian-shaped input membership functions used in the VLWM are given in for 1/C, δm, and Mp, the membership functions μ small, μ medium, and μ large have adequate support across U. It is noted that the expected range of the inputs may exceed or be less than U. Values outside the expected ranges are set to the nearest range extremum. If 1/C < 400, for example, let 1/C = 400. Three output membership functions for one output Wv are specified representing the fuzzy sets small (S), medium (M), and large (L). The trapezoidal membership functions are shown in figure above. For this implementation, the ranges in Wv = [0, 0.5] m.

The VLWM system uses Mamdani-style inference. The inference process is performed in four steps: fuzzification of the input variables, rule evaluation, aggregation of the rule outputs and defuzzification. Fuzzification step takes the crisp inputs, and determines the degree to which these inputs belong to each of the appropriate fuzzy sets. Rule evaluation step takes the fuzzified inputs, and applies them to the antecedents of the fuzzy rules. Because the fuzzy rules have multiple antecedents, a fuzzy operator AND is used to obtain a single number that represents the result of the antecedent evaluation.

This number is then applied to the consequent membership function. Aggregation of the rule outputs is the process of unification of the outputs of all the rules. This is done by taking the membership functions of all of the rules' consequents, after the rule evaluation process, and combining them into a single fuzzy set by summation operator. Aggregation is done separately for each output variable. Defuzzification, which turns the output fuzzy set into a crisp number, is the last step in the Mamdani inference system. It is actually equivalent to finding the center of gravity (COG) of the fuzzy set in the output range [0, 0.5].

2.5.5.2 Experiment Method of LDWS

LDWS performances are evaluated using two metrics: warning time and false alarm rate.An LDWS should give as much warning time as possible, while having few false alarms.

The warning time is the time between the alarm trigger and the first tire touching the edge of the shoulder. It measures how much reaction time the driver would have to prevent the outside tire from crossing a road shoulder.

In this application, all the lane departure events (explained below) form a validation set of warning V. Warnings from the proposed VLWM would form the evaluation set E.

Warnings in E, which coincide with elements in V, are classified as hits H. The set F are those warnings in E, which are not an element of the validation set H. In a similar manner, a miss is classified as the set M comprising the elements in V, which are not an element of H. We denote the false alarm rate as follows: one is the number of alarms per hour which is in $F \cup M$ and the other is the ratio of the element number of $F \cup M$ to the element number of the E.

To evaluate a warning system, there have to be positive examples of lane departure events. Since vehicle state during lane change can be similar to vehicle state during lane departures due to unintended steering input or inattention. We choose to use lane changes as surrogate lane departure events because true lane departures which involve an accident are very rare. Even if the data contain a true road departure, it would be difficult to evaluate system performance using just one example of a road departure. In this experiment, about 50 hours of data that are from fifteen drivers are used, and the details of the data used are shown in Table 3. Here, LCN represents the lane change number; Mlp and δm represent the mean and the standard deviation of the lateral position, respectively.

Driver	T_D (hour)	LCN	M_{lp}(m)	δ_m(m)
D(1)	3.52	78	0.08	0.24
D(2)	4.10	115	0.08	0.31
D(3)	2.56	82	0.04	0.29
D(4)	3.12	76	-0.05	0.41
D(5)	4.25	158	0.07	0.27
D(6)	2.82	74	0.06	0.37
D(7)	3.56	102	0.09	0.28
D(8)	4.36	109	-0.07	0.30
D(9)	2.84	86	0.01	0.33
D(10)	3.50	93	0.10	0.46
D(11)	3.25	106	0.08	0.44
D(12)	2.80	68	-0.08	0.29
D(13)	3.22	122	0.09	0.33
D(14)	2.65	91	0.16	0.32
D(15)	3.23	115	0.05	0.28
Total	49.78	1475		

Table 3: Details of the data used in LDWS experiment

When the vehicle is predicted to be beyond the virtual lane boundary, an alarm is triggered. For a given driver, the algorithm is run over all the data for that driver. This results in a set of alarm triggers, E. All the lane change events are recorded as the validation set of the alarms, V. For each alarm trigger, the neighborhood is searched. If a lane change is found, then it is marked as a true alarm. Otherwise, it is marked as a false alarm. When an alarm is triggered, all future alarms are suppressed until the driver has not been in an alarm state for the previous six seconds. For a lane change, if not an alarm trigger corresponding to it, then a miss happens.

The warning time is calculated as follows: When an alarm triggers, search forward in the data up to a certain point (usually about 4 seconds or so) and see if a lane change is found. If a lane change is found, then find the point where the vehicle's outside wheel first exceeds the (virtual) shoulder width. There are now two points: the alarm trigger point, and the shoulder excursion point. The difference in time between these two points is the warning time. In this experiment, the width of the host vehicle is 1.80m, and the width of the lanes is 3.6m. For the calculation of the warning time of the RRS, the virtual road shoulder width Ws equals to 0.9m and the infra structure based roadside rumble strips system is simulated using a warning threshold set 0.3m beyond the physical lane boundary. The look ahead times of the TLC based method and the VLWM are 1.0

	False alarm number			False alarm rate(%)			(False alarm number)/hour		
Driver	RRS	TLC	VLWM	RRS	TLC	VLWM	RRS	TLC	VLWM
D(1)	0	12	3	0	13	4	0	3.4	1
D(2)	5	46	13	4	29	10	1.2	11	3
D(3)	2	25	8	2	23	9	<1	10	3
D(4)	7	68	13	8	47	14	2	22	4
D(5)	0	52	10	0	25	6	0	12	2.4
D(6)	4	47	8	5	39	10	1.4	17	3
D(7)	0	31	8	0	23	7	0	9	2
D(8)	4	46	13	4	30	11	1	11	3
D(9)	3	43	13	3	33	13	1	15	4.6
D(10)	12	98	18	11	51	16	3.4	28	5
D(11)	10	87	17	9	45	14	3	27	5
D(12)	1	27	5	1	28	7	<1	10	1.8
D(13)	4	42	11	3	26	8	1.2	13	3.4
D(14)	2	27	6	2	23	6	<1	10	2.3
D(15)	3	38	9	3	25	7	1	12	2.8

Table 4: Comparison of false alarm number and false alarm rate of different LDWS warning methods

While the RRS has a low false rate, which is acceptable for most drivers, the warning time is also low. TLC can provide great warning time. However, as Table 5 shows, this comes at the expense of additional false alarms. The warning time increases by over 80%. The false alarm rate rises dramatically, though. For D (4), D (10) and D (11), there is an alarm about every 3minutes, which is clearly unacceptable. The lowest alarm rate is equal to the highest alarm rate generated by the roadside rumble strips system.

For the VLWM system, the false alarm rate decreases drastically, especially for driver D(4), D(10) and D(11). They have large lateral position standard deviations. For all the drivers, the false alarm rate is below 5 alarms per hour, which is acceptable. The reduction of the false alarm rate comes at the expense of short warning time. For D (10), the warning time of the VLWM is 0.23s shorter than the warning time of the TLC. But the warning time of the VLWM system has a large improvement than the RRS, about 70%, while the false alarm rate is acceptable. The warning time provided by the system is related to the look ahead time, T, and the width of the road shoulder. The wider the road shoulder is the longer the warning time is. When the system has long look ahead time, the warning time is also long with high false alarm rate. The developed VLWM has a much longer warning time than RRS, with a false alarm rate similar to the RRS. Meanwhile, VLWM has a much lower false alarm rate than TLC based method, while the warning time is almost as long as that of TLC based method. In a word, VLWM has better performance than the RRS and the TLC based methods.

CHAPTER THREE

3.1 HUMAN RELATED FACTORS OF ROAD ACCIDENTS

The majority of road crashes are caused by human error. Research has shown that driver error accounts for over 57% of all fatal and injury crashes on our roads. The main causes of death and injury on our roads remain speeding, drink- driving and non-wearing of seat-belts, tailgating, use of mobile phones, bad drivers behavior and etc.

3.1.1 Human Error in Road Accidents

A comprehensive study of road safety found that human error was the sole cause in 57% of all accidents and was a contributing factor in over 90%. In contrast, only 2.4% were due solely to mechanical fault and 4.7% were caused only by environmental factors. Other studies have reported similar results.

Why do humans make so many driving errors? The answer is that they don't. Humans have limited information processing abilities and must rely on three fallible mental functions: **perception, attention** and **memory**. When a driver fails to avoid an accident because the situation exceeds these limitations, it is often called **human error.** In reality, it is often the situation that is primarily responsible, not the driver's response to it. It is a well known bias of human judgment to commit the "fundamental attribution error," to vastly overrate human factors to vastly underrate situation factors when trying to explain why events have occurred.

In this study, I shall provide a brief overview of human information processing limitations and explain how they can interact with situational factors to contribute to road accidents. This is a "first-principles" approach to accident investigation because it draws on knowledge of basic human psychological processes. Instead of looking at the driver from the outside, I try to understand his/her mental processing and how it interacts with the environment.

However, the overview is general, so I will ignore many details and equivocations that would be required in a more scientific dissertation. Moreover, the article will discuss only information processing and leave response, reaction time, etc. for another day. Lastly, although I cast doubts in human related errors in terms of road accidents, a similar analysis would apply to other areas of man-machine error. Because most traffic accidents are the product of several factors, the probability of accidents can be reduced in a number of different ways. There is no doubt that the following activities have prevented the increase in accidents that would normally result from increases in traffic density.

There are the following main approaches that if it can be thoroughly followed and observed, it can leads to preventing road accidents:

- **Education and training of**

  (a) Children in school by road-traffic instructors and school teachers; and of

  (b) Adolescents in the principles of safe driving and in good driving attitudes; by

  (c) Refresher courses for older drivers to bring home safe-driving principles and to refresh their knowledge of traffic law; and by means of

  (d) Newspaper, radio television, and other publicity, to draw the attention of all road users both to dangers and to safe practices on the road**.**

- **Enforcement by Law**

  (a) Adopting reasonable and enforceable traffic laws which, at the same time, are best designed to prevent accidents;

  (b) Concentrating the time and energy of traffic officers on the offences, locations, and times that feature frequently in accidents; and

  (c) Thoroughly testing new drivers to ensure they will not be liable to cause accidents.

- **Engineering of vehicles and roads: Vehicle engineering, comprising**

  (a) Regular inspection for a "warrant of fitness" to ensure that the main components of the vehicle are safe;

  (b) Improving the design of the vehicle to give ease of vision and control to the driver and so reduce the likelihood of injury in an accident;

  (c) Fitting safety equipment, such as seat belts.

- **Road or traffic engineering comprises**

  (a) the design of new roads which are inherently safe (separating opposing traffic flows, eliminating cross traffic, and providing wide shoulders and traffic lanes and good visibility)

  (b) Improving existing roads by realignment, improving vision, and resurfacing slippery surfaces;

  (c) Regulating traffic movement by installing traffic signals, traffic islands, road markings, and regulatory signs such as "stop" and "give way" signs; and (d) assisting the driver with warning and destination signs to avoid danger and confusion.

Below you will find more information on the following general causes of accidents on our roads.

3.1.2 Human Information Processing Overview

People driving down a highway are bombarded with a steady flow of information. Most of the information is visual input, the road itself, other vehicles, pedestrians, signs, the passing scenery, etc. Moreover, the driver may be processing other information sources such as auditory input (listening to the radio, talking on a cell phone, carrying on a conversation with another passenger), or internal input (remembering directions or planning what to make for dinner).

If the visual information flow is low, there may be enough mental resource to carry on all tasks simultaneously. But attention demands may exceed supply when:

- the flow becomes a torrent (driving fast)
- the information is low quality (poor visibility)
- resources must be focused on a particular subset of information (a car close ahead)
- the driver's capacity is lowered by age, drugs, alcohol or fatigue.

There may not be enough mental resource for all tasks. The driver then "attends" only a subset of the available information, which is used to make decisions and to respond. All other information goes unnoticed or slips from memory.

In sum, information processing works like this: the information from the visual and possibly auditory environment is detected by the senses **("pre-attentive" stage)** while other information may be recalled from memory. If there is too much to process, the driver attends an information subset and the rest is ignored ("attentive stage"). Lastly, the driver makes a decision and possibly a responses based on the attended information.

Research has shown that accidents occur for one of three main reasons. The first is perceptual error. Sometimes critical information was below the threshold for seeing - the light was too dim, the driver was blinded by glare, or the pedestrian's clothes had low contrast. In other cases, the driver made a perceptual misjudgment (a curve's radius or another car's speed or distance). The second, and far more common cause, is that the critical information was detectable but that the driver failed to attend/notice because his mental resources were focused elsewhere. Often times, a driver will claim that she/he did not "see" a plainly visible pedestrian or car. This is entirely possible because much of our information processing occurs outside of awareness which have amazingly shown that we may be **less** likely to perceive an object if we are looking directly at it than if it falls outside the center of the visual field. This **"in-attention blindness phenomenon"** is doubtless the cause of many accidents.

Lastly, the driver may correctly process the information but fail to choose the correct response ("I'm skidding, so I'll turn away from the skid") or make the correct decision yet fail to carry it out ("I meant to hit the brake, but I hit the gas.

A Hypothetical Example

To illustrate how analysts use this information processing approach to investigate accident causes, I will use a hypothetical example. A common situation occurs when a driver strikes an "object" another car, pedestrian or bicycle and the analyst must attribute the accident's cause. (I'll refer to "object" in order to avoid using the standard laboratory term, "target"!).

Mr. X, age 55, is driving down a secondary road, Hobart St., at 9:00 PM in an unfamiliar part of town. He is late because he promised to pick up his wife at 08:45. Mr. X is listening to the hockey game on the car radio while he looks for Front St., where his wife said to turn in order to reach his destination. Ms. Y, wearing a dark blue coat and white hat, crosses in the middle of **west field junction** without looking. Mr. X does not see her and strikes Ms Y with his car. Police arrive and question Mr. X, who says that he never saw the pedestrian. Mr. X admits that he has had a few beers but his blood alcohol content is .06, within the legal limit. The police do not charge him with DUI. What caused the accident?

Detailed Description of Information Processing Stages

a. Pre-attentive Stage and Attention

The figurebelow schematically depicts the two information processing stages, "pre-attentive" (or "ambient) and "attentive" (or "focal"). Visual information is detected by the most elementary parts of the nervous system, the eyes, ears, etc. in the pre-attentive stage. At this point, the visual input is coarsely processed for raw sensory attributes such as color, shape, size, and location in the visual field. Meaning is not attached to an object, so Mr. X’s information processing system might register a blob of blue (coat) or white (hat) in the visual field, but would not yet interpret the blob as a person. In fact, he would not be consciously aware that it was there.

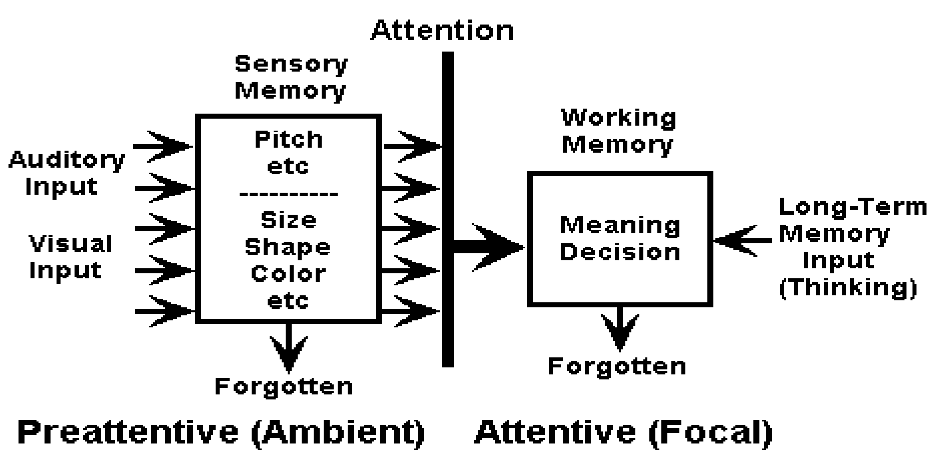


Figure3.25: Showing pre-attentive (ambient) and ambient (focal)

This pre-attentive stage has four important properties:

- It is automatic and occurs without volition, so we are unaware that we are doing it.
- Information remains in sensory memory for only a small fraction of a second. If not penetrating the attention filter, it is then permanently lost.
- It only analyzes as far as basic properties of color, size, location, etc. The meaning of the blue blob is unknown.
- It has a very large capacity. It can process the entire visual field simultaneously.

This last property is critical, because the vast quantity of information is too large for subsequent processing stages to handle. There needs to be a mechanism for selecting an information subset for more detailed analysis.

This mechanism is called "attention" and is sometimes depicted as a spotlight that focuses processing on a selected part of the visual field - it defines an area of 3-D space for detailed examination. Attention is usually viewed as a filter the driver uses to focus his limited mental resources to important parts of the visual field and to exclude extraneous parts.

To see how this all works in practice, imagine a driver moving through the environment. Some sensory information (a blob of blue) registers in the peripheral field, where acuity is low. Something is there, but the driver doesn't know what it is. Next, the driver involuntarily moves his eyes and the attention spotlight toward the object for further processing. In doing so, the driver causes the object's image to fall on the fovea, the area of the retina with the highest resolution. The blob becomes a well-defined shape.

Note that the driver's eye is automatically drawn to the potential object. Given that there are many objects in the visual field, why is the driver's attention drawn to any one in particular? Research shows that some object properties make then "pop out" and automatically attract attention. This is a complex topic but generally speaking, objects are more likely to pop-out and be conspicuous if they:

- are large
- have high brightness contrast
- move or flicker rapidly or suddenly appear
- are meaningful. We can often "automatically" detect and respond to a highly familiar cue if someone says our name, we immediately notice.
- are expected

This automatic attraction of attention is important in driving. Research shows that drivers spend half or more of their time looking directly ahead to the point where the road meets the horizon (generally the focus of expansion). If it weren't for pop out, the driver would fail to see any object that was not straight ahead on the road.

However, this very simple model ignores a few details. The attention beam has variable intensity, so the driver may examine a large area with low attention or a small area with great attention. On a sunny day with no distractions, the driver can open the beam up and take in the entire scene. On a dark night in rain, visibility is poor, so the driver might narrow the bean and make it more powerful. If the driver sees a hazard such as a stalled car, the driver might narrow the beam even more and direct all its power on the car. Attention has a fixed capacity, which can be distributed to different purposes.

However, don't take the beam metaphor too literally. The driver can divide attention to both the road and to a cell phone conversation. There is no problem as long as there is enough attention to go around. If conditions (high speed, poor visibility, cell phone static, etc) cause the attention demand to exceed the supply, then the driver cannot attend all tasks simultaneously and some information will be lost. In addition, people can direct attention toward specific objects rather than to locations in space. A driver looking for a blue building will notice blue objects more readily.

Lastly, there are two distinct sources of attention control. As described above, attention may be automatically attracted. In addition, however, the driver can also voluntarily control the beam, as he does when scanning the visual field.

b. Attentive Stage and Working Memory

Sensory information passed through the attention filter resides temporarily in a processing stage called "working" or short-term memory. Working memory is like a scratch pad where people collect the information (visual, auditory, knowledge stored in the permanent long-term memory) needed to interpret sensory input and to make decisions. Working memory, however, has two severe limits that often play a role in accidents:

- Information remains in working memory for a short time, maybe 30 seconds, if it is not used or refreshed. The driver could refresh working memory, for example, by continuously looking at the blue blob. Once the driver looks away, the blue blob must be processed or it will be lost within a very short time.
- Older Information may be flushed out at any time by newer input. Working memory has very low capacity, so new information may chase out old. For example, several studies show that recall of road signs is remarkably poor. The researchers stopped drivers a few hundred yards after a road sign and found that recall was as low as 18%, although the signs had been seen only seconds before. Presumably, new information had pushed the signs out of working memory. Since working memory records all sorts of information, a few words from radio or cell phone, could also fill it up and cause other objects to be forgotten.

Perhaps the best way to understand the limitations of working memory is by means of the classic "Cocktail Party Phenomenon," which everyone has experienced. You are at a cocktail party and having a conversation with someone. You understand the words of your partner. You are also aware of the buzz of other conversations, although they are unintelligible. In terms of information processing, the system is only decoding these conversations as far as the sensory level and not for meaning. We are so fast at interpreting speech sounds, that we are generally unaware that detecting the sounds and interpreting them are separate mental processes. The buzz sounds come into working memory, but you do not have the capacity to interpret both your partner's "sounds" as well as those of other conversations in the room.

However, someone behind you might say your name. This automatically attracts your attention to this other conversation. You can now understand that conversation but your partner's words become a meaningless buzz. If you try to switch back to your partner, the first thing out of your mouth will likely be "What did you just say?" because his last words, detected as a meaningless buzz, if at all, are already gone.

We can now at least partially answer the question as to why people can look directly at an object and still not see it. First, we are not conscious of sensory input until it is stored in working memory. If it doesn't get through the attention filter, it doesn't exist for us. Second, once stored in working memory, information is easily forgotten. If we haven't refreshed or stored the information in long-term memory, it may be lost.

c. Attentive Processing and Long-Term Memory

Once in working memory, the driver interprets the blue shape's meaning by finding information in another area of memory called "long-term" memory. This is the permanent store of information and knowledge that we all carry around in our heads.

Recall that attention can be controlled automatically or purposefully. Some retrieval from long-term memory (as when recognizing a familiar object) seems to occur automatically with little or no attention expenditure. However, sometimes we actively search memory (as when trying to recall instructions or making plans). This requires attention resources and adds a load to working memory. In other words, thinking or recalling information can also cause information to be lost from working memory.

What Caused the Collision?

In the hypothetical situation described above, the accident would not have occurred if everything had worked properly. Mr. X would:

- detect Ms. Y's blue coat or white hat as a blob
- turn eyes toward her to define the shape
- retrieve the necessary information from memory to identify the shape as a person
- decide to apply brakes
- apply brakes

We will discuss how the accident conditions relate to the first three factors.

d. Pre-attentive Processing: Sensory Detection

The starting point of any visual analysis is the question: Should Mr. X have detected Ms. Y. After all, if the conditions would have made Ms. Y undetectable at the sensory level (it was too dark, etc.), then no further information processing would have been possible.

"Contrast" is the most important variable in determining whether Ms. Y was detectable. An object's visibility is determined, not by its absolute brightness (actually "luminance")or color, but by the relative brightness or color between the object and its background. If visibility limitation is a possible factor, then it is important to perform a visibility analysis: determine the viewer's eye position and then measure the light coming from the object and also the light coming from the background. Finally, calculate the contrast.

The next step is to determine whether the actual contrast was sufficiently high for object detection. This is not straightforward, however, since many factors affect the minimum contrast necessary to see an object in a given set of circumstances. These factors can be divided into two classes, environmental and driver:

Environmental

- Size: Size is not the physical size in inches or centimeters but rather "visual angle," which roughly gives the size of the retinal image.
- Distance: Generally speaking, the closer the more visible - visual angle grows with decreasing distance.
- Visual Field location: Vision is best when objects are imaged in the fovea, the highest resolution part of the eye. This occurs when the driver looks directly at the object. If the driver saw the object in the peripheral field (the corner of the eye), then the visibility estimate must be lowered to account for the reduced vision. There may be exceptions, however, as moving objects may become more visible in the periphery.
- Duration: Visibility increases with longer duration, although there are a few exceptions to this rule.
- Motion/Flicker: These can make an object more visible. The influence of motion on visibility depends, however, on several other factors such as size and velocity.
- Masking and Camouflage: Objects are also harder to see when the background has forms or textures and easiest when the background is uniform.
- Glare: Humans adapt to the light levels around them. When a very bright light, one that is far above current adaptation level, suddenly appears, it can reduce visibility (disability glare) and cause drivers to look away (discomfort glare). The glare effect is most obvious at night when the driver is adapted to a lower brightness. The sudden appearance of headlights can temporarily blind. Even after the headlights pass, vision is still poorer due to their effect on driver light adaptation level. Glare effects increase greatly with age and are major problems for older drivers.
- Weather: Rain, snow and fog all decrease visibility

Driver

- Age: contrast sensitivity falls with age: The effect is small until about age 45, when the effect increases rapidly. Moreover, older drivers are more likely to have eye diseases, which further impair vision.
- Adaptation State: Visibility is best when the driver is adapted to the same mean luminance as the background.
- Optical Status: Visibility decreases when the driver is not wearing optical correction for the viewing distance.
- Arousal Level (sleepy vs. awake): Humans are often less able to detect objects when their arousal level is low. Fatigue, alcohol, drugs and other medication can affect arousal level.
- Uncertainty: Visibility is best when the user knows when and where the object will be located. Any spatial or temporal uncertainty raises threshold. Most real world viewing situations involve at least some uncertainty.
- Expectation: Viewers can be greatly affected by their expectations. If a driver comes to the same intersection everyday and has never seen a pedestrian, it is less likely that s/he will see the figure walking out from behind the car. Research suggests that humans inhibit attention in visual field locations where input is not expected.

A visibility analysis would note that Ms Y was wearing a dark blue coat, which would have little contrast against the dark background existing at 9:00 PM. On the other hand, the white hat would show up very well. The hat is unfortunately small compared to the coat and might still be less visible than the coat. In an actual investigation, the analyst would have to use a light meter to make readings of the pedestrian's clothing and the background and then estimate size and distance in order to calculate exact values. The reading would ideally be taken at the same date and time and under the same weather conditions as the actual accident. If not possible, then the analyst would have to use other sources of data to estimate contrast.

If Mr. X were looking straight ahead or perhaps searching for the Front St. sign, Ms. Y would likely be seen only in the low resolution peripheral field as she steps off the curb. This significantly increases the contrast needed to see her. Further, note the interesting paradox that as Mr. X approaches Ms. Y, her image becomes bigger (and more detectable) but falls further in the peripheral field (making her less detectable). If Ms. Y were running, the motion would increase her visibility more than if she had strolled casually. Any car headlights or bright neon signs causing glare would further increase necessary contrast.

Lastly, the contribution of some environmental factors is very difficult to estimate numerically. More often than not, there is no simple way to factor in the effects of background masking, driver light adaptation, odd shapes, etc.

Now for the driver. Mr. X is 55 years old, so there is an age loss of contrast sensitivity, a factor of about 1.8. Moreover, he had had a few beers, so his blood alcohol level was .06. Although this is below the legal limit, research shows that .06 is a high enough BACto seriously impair vision. This is an important point to remember for litigation: *even though a driver is within legal limits,* *he may still be functionally impaired*, especially if there are negative environmental factors such as low lighting or poor roadway design. By the way, was he wearing optical correction? Was the correction correct? Does he have any eye disorders?

Mr. X knows that pedestrians probably cross at intersections and has developed an expectation that pedestrians, if they appear, are likely to be there. He would not expect to see Ms. Y cross in the middle of the block, further decreasing detect ability. If Mr. X had frequently driven down the same stretch of highway and never seen a pedestrian there before, then his expectations would be even greater that no pedestrian was likely to appear.

In this case, there are many factors, which would make Ms. Y difficult to see: the low light level of night time driving, Ms. Y's dark coat produced low contrast (assuming a black background), her location in the peripheral field, the driver's age, his blood alcohol level, and his expectations.

e. Attentive Processing: Attention and Working Memory

Let's assume that Ms. Y's contrast level were above detection threshold. The next step is to assess the likely operation of attention and working memory. We would want to look at all sources of input to working memory and to examine any factors affecting Mr. X's attention capacity.

Mr. X was driving on a dark, unfamiliar street with low visibility and looking for the Front St. sign. He was possibly listening to the radio and/or trying to recall his wife's directions. Since he was late, he was probably driving fast.

All of these factors would combine to stress attention capacity. The large number of information sources (visual, radio, recall) and low visibility conditions would overload attention, so some information was ignored. The visual attention beam would undoubtedly become very narrow and weaker (to conserve resources), so that he would have a very difficult time seeing objects in the peripheral field. Since he would probably be looking either directly ahead or up at street signs, the chances of seeing Ms. Y, crossing at an unexpected location in the middle of the block, would be very poor.

The fast driving would cause working memory to continually fill and require the rapid loss of old information. It is quite possible that Mr. X could have looked directly at Ms. Y but still not recall seeing her either because the information was filtered out due to attention being allocated elsewhere (listening to the radio, recalling directions, planning the next turn, etc.) or was displaced from working memory before it could be properly interpreted and stored in long-term memory.

Moreover, factors lowering Mr. X's attention capacity undoubtedly contributed to the accident. At 55 years old, his age probably had a modest effect. The .06 BAC also likely contributed to lowering his attention capacity.

3.1.3 Use of Mobile/Cell Phones While Driving

Driving is a complex task, requiring drivers to use and coordinate a number of skills. Any lapse in concentration increases the risk of the vehicle being involved in a crash .Driving while using a hand held mobile phone can cause both physical and mental distraction which impairs driving performance.

Using a mobile phone while driving can significantly impair a driver's:

- reaction time
- visual search patterns
- ability to maintain speed and position on the road
- ability to judge safe gaps in the traffic
- general awareness of other road users.

Research shows that using a mobile phone while driving increases the risk of crashing by at least four times. The most common types of crashes associated with mobile usage are **'run-off-the-road' crashes** and **'rear end' crashes.** Using a mobile phone while driving can bring even greater danger to novice drivers as they may experience difficulty in balancing the many demands on their driving - from perceptual, mental and physical tasks. Research has found novice drivers who use a mobile phone spend less time looking at the road ahead. They are also more likely to wander over the road (across traffic lanes) and take longer to notice driving hazards.

Safe driving tips for using a mobile phone

- Never read or send text messages while driving
- Use voicemail instead of answering your phone while driving
- Pull over safely and park to make or receive a call
- Plan breaks in your trip for phone calls
- Tell your family and friends not to call when you know you'll be driving
- Never look up phone numbers while driving

A mobile phone can be important in an emergency. If you need to use your mobile phone to call for help, stop and park safely where you will not endanger other road users.

Learner's Permit (L) and Provisional (P1) drivers are banned from using **any** type of mobile phone function while driving. The mobile phone usage on roads includes:

- using hands-free mode including Bluetooth technology
- loudspeaker operation
- text messaging.

Figure: 3.26. Showing the use of mobile phones while driving

How do mobile phones distract drivers?

Using a mobile phone while driving distracts you in many ways:

- **Physical distraction** - for example handling the phone while driving or taking your hand off the steering wheel to dial a phone number or to answer/end a call.
- **Visual distraction** - for example taking your eyes off the road.
- **Cognitive (mental) distraction** - for example doing two mental tasks at the same time, like having a conversation and driving.

Why is it dangerous to use a mobile phone while driving?

Research shows that dialing and talking on a mobile phone while driving can lead to:

Riskier decision making	Deciding when it is safe to turn in traffic is a complex task. Using a mobile phone while driving affects judgment and concentration and you may fail to choose a safe gap. When making a decision to turn across oncoming traffic, you also tend not to consider the environmental conditions such as, when it is raining or the roads are slippery. If you don't make safe turns you could crash.
Slower reactions	You generally react slower when using a mobile phone, particularly when you're deep in conversation. You may take longer to respond to traffic signals or completely miss them.
Slower and less controlled braking	During a mobile phone call your brake reaction time is slower, and you brake with more force and less control which results in shorter stopping distances available between yourself and the car in front.
Wandering out	You're more likely to wander out of your lane when you're using

of your lane	a mobile phone, even on a straight road with little traffic.
Not being alert to your surroundings	When using a mobile phone, you tend to spend less time checking your mirrors and what's going on around you. This affects your ability to monitor and negotiate traffic safely.

Why is talking to a passenger different to talking on a mobile?

If a dangerous situation develops, your passenger can stop talking and let you concentrate on driving. On a mobile phone, the person you're talking to isn't aware of the danger and will keep talking, further distracting you when your full concentration is needed.

Why is text messaging even more dangerous?

Text messaging while driving results in physical, visual and cognitive distraction. Research shows that retrieving and sending text messages increases the amount of time a driver spends not looking at the road. Your eyes maybe taken off the road for up to four times longer when text messaging compared to when not text messaging when driving.

Figure:3.27: Showing two different drivers texting while driving

This can lead to:

- incorrect lane changes
- wandering from your lane
- Missing road signs and hazards like pedestrians, cyclists and other vehicles.
- Crashes or collision with the upcoming vehicle.

The more you talk the less you see!

Even the best drivers have difficulty in processing two or more pieces of information at the same time, especially if the tasks are similar or they demand more attention than the driver can give at one time.

For example, it is more difficult to drive safely and have a simple conversation in a complex driving situation such as in peak hour, on unfamiliar roads, at night or in wet weather. It is less difficult to drive safely in light traffic while having a simple conversation with a passenger.

It is more difficult to drive safely and have a complex conversation in light traffic. Complex conversation needs more attention and takes your mind off the road. When your mind is not on the road, someone could die.

3.1.4 Bad Driving Habits and Road Safety

There are numbers of things that other drivers do that can be extremely irritating and dangerous. Bad Tailgating, poor lane discipline, not indicating and undertaking are just a few of the bad habits that frequently and are very annoying. Aside from the inconvenience to other road users, this kind of inconsiderate driving is also very dangerous .As the driver is moving from one lane to another without thinking of the dangers he may cause to other drivers and the traffic in general, this bad driving behavior usually leads to crashes and most cases resort to fatalities where both human lives and properties are both lost. Bad driver's behavior must not be encouraged and drivers must be seriously aware of the dangers that they may cause on our roads during trafficking.

Bad drivers' behavior may include the following:

- Tailgating
- Undertaking
- Over speeding
- Road raging or aggressive driving
- Drink and driving

Figure: 3.28: Bad driver`s behavior on roads

3.1.4.1 Tailgating

This is probably one of the greatest offences. Some drivers are extremely impatient, some people do it without thinking, just following traffic they get a bit close, but then they back off as you accelerate way.

Some drivers tailgate deliberately though and these are the ones that are the most dangerous. They sit behind you flashing their headlights in an effort to move you, but of course there is nowhere to go as you are in the process of overtaking and there is no room to pull in on the left. To this kind of driver, the two second rule means that they can just about cope with another vehicle in front of them before they decide to intimidate them by driving inches away.

Figure: 3.29: Driver Tailgating

3.1.4.2 *Undertaking*

Tailgaters that don't get their way will often resort to undertaking if they can. Yes, there are also those selfish individuals out there that hog the middle and the outside lane. They have no idea that there is a queue of traffic waiting to get past them, probably because they are in their own little world thinking about what to have for dinner. This causes some individuals to lose patience and start to undertake without been patient.

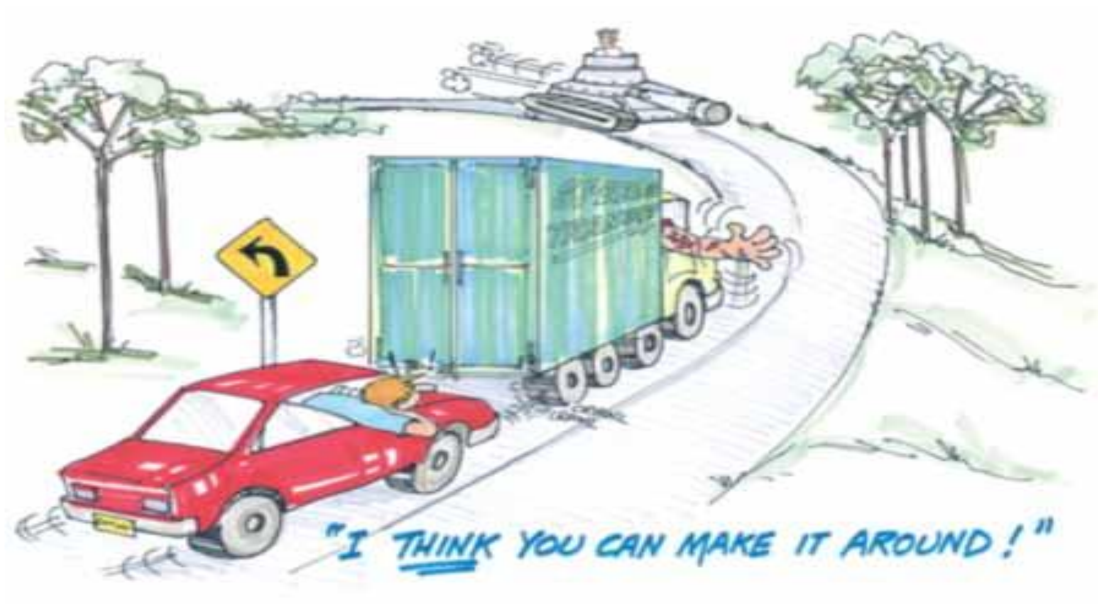


Figure: 3.30:A driver undertaking at a sharp curve

Poor lane discipline – Some drivers are all over the place and they don't seem to realize that they are supposed to stay in between those white dashed lines.

Indicators – Some people have no idea what these pretty orange flashing lights are actually for! They move here and there and go wherever they please without any thought of letting the rest of the road users know what their intentions are.

These are just a few of the things that can be particularly irritating about other drivers and their habits. Below are some other annoyances;

- Cutting corners, particularly at junctions.
- No headlights in conditions that require them.
- Throwing cigarettes out the window.
- Leaving main beam on, or dipping only at the last minute.
- Inappropriate use of the horn.
- Impatient people pushing in ahead of a queue of traffic.

3.1.4.3 Over speeding

SPEED is the single biggest factor contributing to road deaths in Ireland. Over 40% of fatal collisions are caused by excessive or inappropriate speed.

A 5km/h difference in speed could be the difference between life and death for a vulnerable road user like a pedestrian.

- Hit by a car at 60km/h, 9 out of 10 pedestrians will be killed

- Hit by a car at 50km/h, 5 out of 10 pedestrians will be killed
- Hit by a car at 30km/h, 1 out of 10 pedestrians will be killed

Speed has been identified as a key risk factor in road traffic injuries, influencing both the risk of a road crash as well as the severity of the injuries that result from crashes. Excess speedis defined as exceeding the speed limit. Inappropriate speedis defined as driving at a speed unsuitable for the prevailing road and traffic conditions.

Excess and inappropriate speeds are responsible for a high proportion of the mortality and morbidity that result from road crashes. Controlling vehicle speed can prevent crashes happening and can reduce the impact when they do occur, lessening the severity of the injuries sustained by the victims.

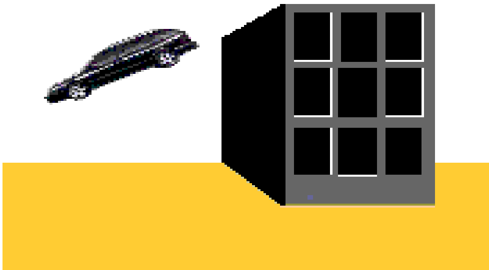


Figure: 31. (a) Dropping off 3 storey building is equivalentto crashing at 50km/h

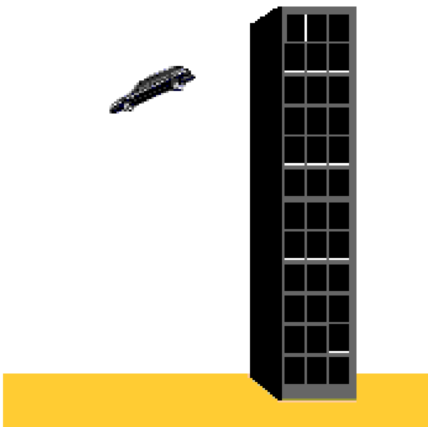


Figure: 31. (b) Dropping off 12 storey building is equivalentto crashing at 100km/h

THERE'S NO SUCH THING AS SAFE SPEEDING

Figure 3.32: Speed limit

Choose your speed and you choose your consequences

In a 60 km/h zone, travelling at:

- 65 km/h, you are twice as likely to have a serious crash
- 70 km/h, you are four times as likely to have a serious crash
- 75 km/h, you are 10 times as likely to have a serious crash
- 80 km/h, you are 32 times more likely to have a serious crash than if you drive at 60 km/h.

In rural out of town areas, travelling just 10 km/h faster than the average speed of other traffic, you are twice as likely to have a serious crash.

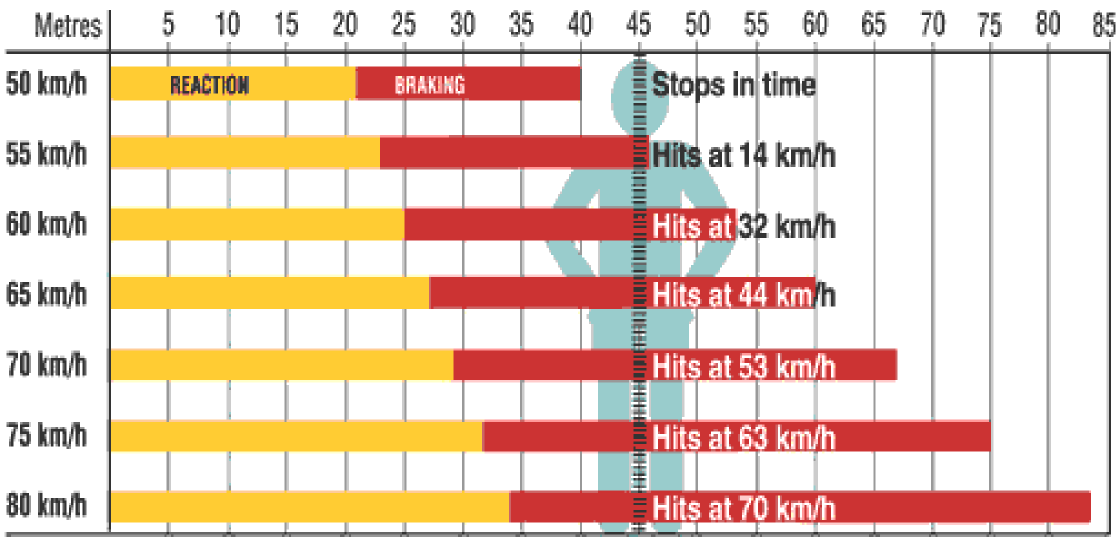


Figure: 33 (a) Stopping distance in Wet conditions

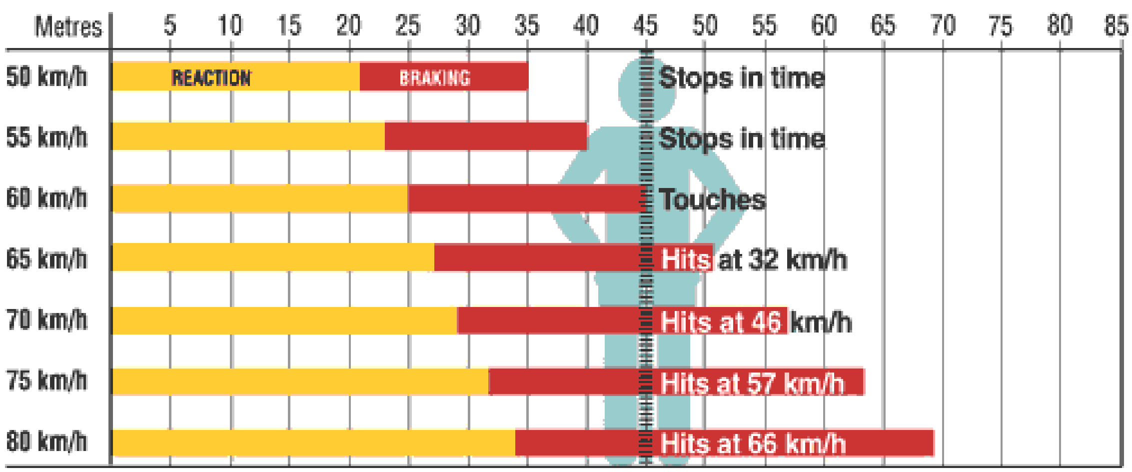


Figure: 33 (b) Stopping Distance in dry conditions

Images provided by Holroyd City Council Australia.

Changing lanes without signaling is an example of aggressive driving.

3.1.4.4 Road Rage or Aggressive Driving

One of the big issues with aggressive driving and road rage is that the driving public and the police define "aggressive" very differently. Surveys show that many drivers don't consider certain behaviors -- like honking the car horn or changing lanes without signaling -- to be aggressive at all. One survey found that only 47 percent of American drivers consider driving 10 miles per hour over the speed limit to be a kind of aggressive driving, though law enforcement officials tend to disagree.

There's a wide range of aggressive-driving behaviors, some of which are potentially much more dangerous than others. Dr. James divides aggressive driving into three areas -- impatience and inattentiveness, power struggles, and recklessness and road rage.

- **Impatience and inattentiveness** - these can be categorized by behaviors like driving through red lights, rolling through stop signs, blocking intersections, speeding and not using signals when turning or changing lanes. Drivers who engage in these behaviors often say that their schedules are very busy, that they've run out of time or that their mind was on something else. This is the lowest level of aggressive driving -- behaviors that are annoying and could trigger road rage in another, but are less risky than other negative behaviors.

- **Power struggles** - these are more serious, and they include preventing someone from moving over into your lane, using gestures or **obscene language** or humiliate or threaten other drivers, tailgating and cutting off another driver or **braking** without warning as an act of retaliation. These behaviors stem from an unhealthy mentality in which drivers feel as if they're the target of malicious acts. Many people feel a sense of entitlement and self-righteousness when behind the wheel of a car -- it's common for them to feel that someone who makes a mistake needs to be punished. Most of us have wished for another driver to feel guilt or shame for an action we've deemed stupid or dangerous -- according to Dr. James, that's the first step to entering into a power struggle.

- **Recklessness and road rage** -- the most serious incidents include behaviors like entering into a duel with another car, racing at dangerous speeds and committing assault with a weapon or your vehicle. In these cases, aggressive driving gives way to outright violence. While road rage isn't exactly a worldwide epidemic, studies have shown that incidents have increased each year. Skeptics point out that this could be due to an increase in reporting incidents, however, and may not actually indicate an increase in cases.

3.1.4.5 Drink and Driving

Drink Driving is one of the main causes of road deaths in South Australia. Each year nearly a third of drivers and riders killed in road crashes have a blood alcohol concentration (BAC) over the legal limit of 0.05 - the majority more than three times over the legal limit.

Of these drivers and riders killed during 2007-2011, who were over the legal limit of 0.05:

- 89% were male
- 33% were aged 20-29 years
- 69% were killed on rural roads
- 73% were at least three to four times over the legal limit.

Drinking alcohol affects driving skills and increases the likelihood that the driver will engage in risk-taking behavior. You don't have to be drunk to be affected by alcohol. You might feel normal, but no one drives as well after drinking alcohol. Studies have also shown that a driver's risk of being involved in a casualty crash doubles for every increase of 0.05 above zero BAC.

While most of the attention is focused on people who drink and drive, cyclists and pedestrians affected by alcohol also risk being killed or injured on our roads. Alcohol has been identified as a significant risk factor in collisions involving a pedestrian with 42% of pedestrian fatalities found to have a blood alcohol concentration above the legal driving limit of 0.05. Over two thirds of those who had been affected by alcohol were found to have a blood alcohol concentration more than 4 times the legal limit.

Research also shows that a single drink increases the risk of death or serious injury by five times. Cyclists who are affected by alcohol were also less likely to wear a helmet. Those who have lost their driver's license and switch to cycling as a means of transport may be putting themselves at even greater risk if they continue to drink and use the roads.

Alcohol is a bigger road safety problem than all other drugs combined.

Remember

- Allow time to recover
- Alcohol affects people differently
- Keeping your BAC under .05
- Don't combine alcohol with drugs or other medicines
- Tips for getting home safely

- ***Allow time to recover***

  If you have been drinking, you have to allow time for the alcohol in your bloodstream to reduce before you drive. Cold showers, exercise, black coffee, fresh air or a big meal do not help to reduce your BAC. If you have had a heavy night of drinking, you may be over the limit for much of the next day – the more you drink, the more time you must allow. So, if you are planning to drink, then plan NOT to drive.

- ***Alcohol affects people differently***

  The effect of alcohol varies greatly from person to person and is influenced by a variety of factors, including:

- body size – a smaller person will have a higher BAC than a larger person
- body fat – people with a lot of body fat tend to have a higher BAC
- gender – a woman will almost always have a higher BAC than a man who drinks the same amount
- the length of time since the person has eaten
- level of fitness
- the health of their liver
- whether they drink regularly
- mood
- the type of drink consumed
- the person's efficiency in eliminating alcohol from the body (which may vary from time to time as well as from person to person).

Two people who drink the same amount can register quite different BACs.

- **Keeping your BAC under .05**

To help you avoid going over the limit try the following:

- Start with a soft drink or water.
- Drink light alcoholic drinks.
- Only have one type of drink.
- Alternate between alcohol and non-alcoholic drinks.
- Avoid drinking in rounds.
- Don't let people top up your glass.

It is safest not to drink any alcohol at all if you are going to drive.
Do NOT drive if there is any doubt about your BAC.

- **Don't combine alcohol with drugs or other medicines**

Do not drink alcohol when you are taking other drugs. Even small amounts of alcohol in combination with drugs or medications can reduce your ability to drive. This applies to medicines prescribed by your doctor, bought in a supermarket or pharmacy.

- **Tips for getting home safely**

If you are going to be drinking, plan an alternative way of getting home, other than driving. For example:

- designate a non-drinking driver
- catch a taxi home

- use public transport
- stay the night (make sure you are not still over the limit in the morning!)
- arrange for someone to pick you up
- only accept a lift if you are certain the driver has not been drinking or using other drugs.

Drink and drug driving penalties strengthened (in Australia)

In South Australia from** *1 February 2010*, **any person who commits a drink or drug driving offence will face tougher penalties, including:

- A three month license disqualification for a first court conviction when:

  - driving with a prescribed drug (including cannabis, speed or ecstasy) present in saliva or blood, or

  -driving with a blood alcohol concentration of 0.05 to 0.079.

- Heavier penalties for repeat offenders, with courts considering previous drink and drug driving offences during sentencing.
- An alcohol or drug dependency assessment may be required (depending on the number of previous drink or drug driving offences committed).

For example, if a person has, within the previous five years, expiated or been convicted of one of the following offences they will require an alcohol or drug dependency assessment.

- Three or more Category 1 offences.
- Two Category 1 offences and one Category 2 offence.
- Two or more serious drink driving offences.
- Two or more drug driving offences.

A blood sample must be taken from any person 10 years or older, who attends or is admitted to hospital for treatment as a result of a boat or motor vehicle accident (previously the minimum age was 14 years). In addition, South Australia Police will now be able to test boat operators for prescribed drugs (including cannabis, speed and ecstasy) under the same conditions as drug testing for vehicle drivers.

Definitions
Category 1 drink driving offence - an offence between 0.05 and less than 0.08 BAC
Category 2 drink driving offence - an offence between 0.08 and less than 0.15 BAC
A serious drink driving offence includes:
Driving under the influence of an intoxicating liquor
Refusing to provide a sample of breath or blood for alcohol testing
Driving with a BAC at or above 0.15
Driving with a BAC at or above 0.08 where a previous alcohol offence exists within the last 5 years.

Under the *Road Traffic Act 1961*, it is an offence to:

- drive with a prescribed concentration of alcohol (PCA)
- drive under the influence of alcohol or drugs (DUI)
- refuse to comply with directions from a police officer in relation to an alcohol test or breath analysis (Refusal to blow).

Prescribed concentration of alcohol

The prescribed concentration of alcohol (PCA) is the level of blood alcohol concentration (BAC) at, or above which, it is illegal to operate a motor vehicle. The PCA limit varies, depending on the type of license held. A person who drives, or attempts to drive a motor vehicle with more than the 'prescribed concentration' of alcohol in the person's blood is guilty of an offence (s47B(1)). The severity of the penalties imposed will depend on how much the driver exceeds the prescribed concentration of alcohol.

The PCA for holders of an unconditional licensee or qualified supervising drivers accompanying a learner driver is 0.05 BAC. The PCA for learner, provisional and probationary drivers, as well as drivers of buses, taxis, heavy vehicles and vehicles carrying dangerous goods are ZERO.

Where learner, provisional and probationary drivers are caught driving with a BAC greater than zero, they may be charged with both breaching their license conditions and the offence of driving with the prescribed concentration of alcohol.

"Drivers and riders can be stopped at random by any police officer at anytime, anywhere in South Australia, and tested for alcohol as well as prescribed drugs. This includes passengers acting as a qualified supervising driver for a learner driver".

Driving under the influence of drug

A person who drives, or attempts to drive a motor vehicle while so much under the influence of an intoxicating liquor or drug (either prescription or illicit) as to be incapable of exercising effective control of the vehicle is guilty of an offence (s47(1)).

Driving under the influence, more commonly referred to as DUI, is not the same as driving with the prescribed concentration of alcohol. Even if your BAC is less than 0.05, you may still be charged with DUI if your driving ability is impaired because of the effects of alcohol or other drugs. Factors that are likely to contribute towards this offence are the manner in which the vehicle was being driven and any signs of intoxication (including observations by the police and other witnesses), the smell of alcohol about the driver, unsteadiness, watery or bloodshot eyes and slow or slurred speech. The existing voluntary Alcohol Interlock Scheme will be phased out over a period of five years and transitional arrangements have been made for current participants so they can complete their time on the program. An alcohol interlock device is fitted to a motor vehicle to monitor a driver's BAC preventing the vehicle from being started or operated if the driver's BAC exceeds a zero reading

Driver Fatigue

Driver fatigue is a serious problem resulting in many thousands of road accidents each year. It is not possible to calculate the exact number of sleep related accidents but research shows that driver fatigue may be a contributory factor in up to 20% of road accidents, and up to one quarter of fatal and serious accidents. These types of crashes are about 50% more likely to result in death or serious injury as they tend to be high speed impacts because a driver who has fallen asleep cannot brake or swerve to avoid or reduce the impact. Sleepiness reduces reaction time (a critical element of safe driving). It also reduces vigilance, alertness and concentration so that the ability to perform attention-based activities (such as driving) is impaired. The speed at which information is processed is also reduced by sleepiness. The quality of decision-making may also be affected.

It is clear that drivers are aware when they are feeling sleepy, and so make a conscious decision about whether to continue driving or to stop for a rest. It may be that those who persist in driving underestimate the risk of actually falling asleep while driving. Or it may be that some drivers choose to ignore the risks (in the way that drink drivers do).

Crashes caused by tired drivers are most likely to happen:

- on long journeys on monotonous roads, such as motorways

- between 2am and 6am
- between 2pm and 4pm (especially after eating, or taking even one alcoholic drink)
- after having less sleep than normal
- after drinking alcohol
- if taking medicines that cause drowsiness
- after long working hours or on journeys home after long shifts, especially night shifts

Drivers most at risk

Young male drivers, truck drivers, company car drivers and shift workers are most at risk of falling asleep while driving. However, any driver travelling long distances or when they are tired is at risk of a sleep related accident. Young male drivers are most commonly involved in sleep-related road accidents, but this may be because they are more likely to drive in situations which are likely to lead to fatigue rather than because they are more susceptible to falling asleep at the wheel.

Similarly, shift workers and commercial vehicle drivers may have a higher risk of sleep-related crashes due to work-related factors. Many professional drivers, especially HGV drivers report increased levels of sleepiness and are involved in a disproportionately high number of fatigue-related accidents. However, two thirds of drivers who fall asleep at the wheel are car drivers. Most (85%) of the drivers causing sleep-related crashes are men, and over one third are aged 30 or under.

3.1.4.6 Sleep Disorders

Anyone who suffers from a sleep disorder that prevents them from getting sufficient sleep is likely to be excessively tired during their waking hours, and so to be at higher risk of falling asleep when driving. Those most at risk of suffering from a sleep disorder, such as sleep apnea, include professional drivers. It has been estimated that such drivers are between 6 and 15 times more likely to have a road traffic accident than those without the condition. This type of medical condition is often undiagnosed, and some drivers may be unwilling to seek help because they fear losing their driving license. However, there are established treatments for sleep apnea which allow drivers to retain their license, and therefore, their livelihood. Anyone suspecting that they have a sleep disorder is strongly advised to contact their GP.

How to avoid falling asleep at the wheel

Driving when you are tired greatly increases your accident risk. To minimize this risk

- Make sure you are fit to drive. Do not begin a journey if you are tired. Get a good night's sleep before embarking on a long journey.

- Avoid undertaking long journeys between midnight and 6am, when natural alertness is at a minimum
- Plan your journey to take sufficient breaks. A minimum break of at least 15 minutes after every two hours of driving is recommended
- If you feel sleepy, stop in a safe place. Do not stop on the hard shoulder of a motorway

- Avoid alcohol, large meals and medications that cause drowsiness.
- Establish a realistic driving plan that does not require long periods of driving without a good night's sleep and healthy breaks.
- Stay hydrated, get a lot of fresh air and incorporate environmental stimuli when possible (music, conversation, etc.). Remember, however, that too much stimuli can be distracting.
- Share the driving whenever possible.
- When driving, take a break at least every two hours.

The only reliable defense against driver fatigue is rest. This means uninterrupted sleep for at least six to nine hours each night and watching for signs of fatigue while driving.

- The most effective ways to counter sleepiness are to drink, for example, two cups of caffeinated coffee and to take a short nap (up to 15 minutes).

Most of the things that drivers do to try to keep themselves awake and alert when driving are ineffective, and should only be regarded as emergency measures to allow the driver time to find somewhere safe to stop. Drinking at least 150 mg of caffeine and taking a nap of around 15 minutes are the only measures that help to reduce sleepiness. But even these are temporary measures; sleepiness will return if the driver does not stop driving within a fairly short period of time.

The safest option is for drivers to avoid driving when sleepy, when they would normally be sleeping or when they are ill or taking medication which contra-indicates driving or using machinery. It is crucial that drivers plan journeys, especially long ones involving driving on motorways or other monotonous roads.

Drivers should:

- Try to ensure they are well rested, and feeling fit and healthy (and not taking medication which contra-indicates using machinery), before starting long journeys
- Plan the journey to include regular rest breaks (at least 15 minutes at least every two hours)
- If necessary, plan an overnight stop
- Avoid setting out on a long drive after having worked a full day
- Avoid driving into the period when they would normally be falling asleep
- Avoid driving in the small hours (between 2am and 6am)
- Be extra careful when driving between 2pm and 4pm (especially after having eaten a meal or drunk any alcohol)

- If feeling sleepy during a journey, stop somewhere safe, take drinks containing caffeine and take a short nap.

Alcohol and Medicines

Even small amounts of alcohol, well below the legal drink drive limit, will exacerbate driver sleepiness, so that a tired driver who has had some alcohol will be even more impaired and likely to crash. Many over-the-counter medicines, including remedies for coughs, colds, flu and hay fever, cause unwanted drowsiness which might impair driving. Warnings about drowsiness are not always clear so, for example, if the label says "may cause drowsiness", assume that it will do so.

Fatigue Detection and Warning Devices

There are devices to detect when drivers are feeling sleepy and to warn them. However, RoSPA is concerned that would rely on them, and may even be tempted to drive when they are tired, believing that the device will prevent an accident. It is far better for drivers to avoid driving when too tired, to plan their journeys safely and follow the advice in the Highway Code and guides.

Employers

Driving is the most dangerous work activity that most people do. It is estimated that around 150 people are killed or seriously injured every week in crashes involving someone who was driving, riding or otherwise using the road for work purposes. The majority of these tragedies can be prevented. HSE Guidelines, "Driving at Work", state that *"health and safety law applies to on-the-road work activities as to all work activities and the risks should be effectively managed within a health and safety system"*. Therefore, employers must assess the risks involved in their staff's use of the road for work and put in place all 'reasonably practicable' measures to manage those risks.

One of the most important things employers must do is ensure that their drivers are not at risk of falling asleep at the wheel.

Holiday and Travel Companies

One of the times when individual drivers may drive in the early hours of the morning is when they are catching, or returning from, an early flight or ship/ferry journey. Drivers returning from long haul flights, or coming off ships and ferries also often drive home after having had very little sleep in the previous 24 hours. Holiday companies, airlines and shipping lines should consider what advice and information they could offer to their customers, particularly as they sell alcohol to their passengers, which exacerbates the risk.

CHAPTER FOUR

4.1 THE ALGORITHM OF THESAFETY SYSTEM

The design for the prevention of road accidents through the help of various inbuilt devices combined as a single unit of safety device is not easy to come by or easily affordable, despite various available nature of automotive safety devices geared towards the prevention and protection of lives and properties, my thesis is mainly concerned with the aspect of road safety for the protection of lives and property in our society. The design concept works on the following principles with the combination of the devices working simultaneously together in systematic operational sequences .The design has been a combination of electrical, electronic and mechanical instruments.

4.2 Algorithm of the system

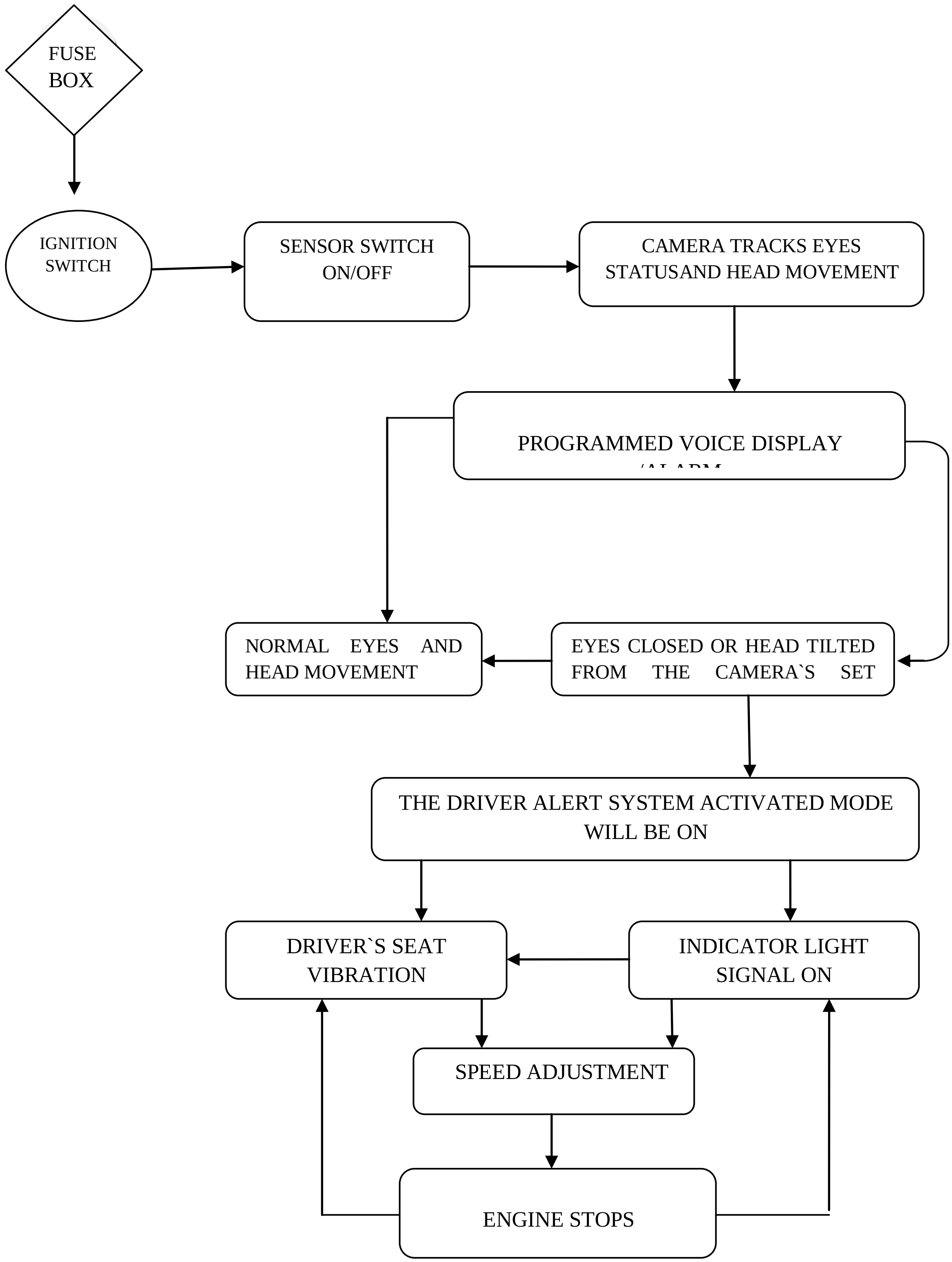


Figure 4.1: Flow chart of the design Safety Device

The device has an electrical fuses and cables that is attached to the vehicle`s electrical connection and a switch box that is operated automatically or manually by the driver. The automatic switch is activated immediately the driver insert the key into the vehicle and switch on the car and thus giving the system a live to start and will be indicated by showing a green light on the switch box that will be placed in front side of the driver`s dash board or the driver himself can activate the switch to manual mode by detaching the automatic connection from the system by a button with ON/OFF contacts. When the system is activated by either automatic or manual, it will send the signal to the camera that is placed right in front of the driver and zoom will cover the area of the driver`s chest up to his entire head to enable the reading of the driver`s eye movement and the action of his head. The front camera will read the blinking of the driver`s eyes within a set contact is normal (normal eyes blinking) there will be no alert from the system but if the eyes are remained closed up to this set limit of three –five seconds (without blinking the eyes), the camera will immediately flash for **three times (one flash per second**) and if the flash stops, there will be another set voice alert by the same system will be immediately high tone **“ALARMING”** for three times within another **three seconds**. Upon the flashing of the camera and the warning voice messages to the driver (by alarming), there will be followed by continuous vibration through the help of a vibratory device which is set right on the driver`s chair to immediately alert or awake him/her to prevent accident. The vibration of the system is attached to the car`s front side yellow signals(traffic signals) so that the drivers in front and rear and other road users including pedestrians and cyclists will immediately be notify about the condition of the car and could plan to avoid or the deviate to prevent collision with the car in question. As soon as the set period of about fifteen seconds vibration stops, there will be a followed speed adjustment by the system which will control the driver’s high speed and reduce to determined **speed of 35km per hour** as set- safe speed, though there is nothing like safe speed in driving. Upon the driver`s failure or stubbornness to stop, change a driver if available or stop to take a nap, there will a reoccurrence of the **“ALARMING”** for three times within another **three seconds** and then to be once again followed by at the same time vibration of the system and yellow lighting of the front side yellow lights and finally the speed will be re adjusted to a **maximum speed of 15km per hour**. If these speed change arises, the driver cannot increase the speed to any further, but s/he has to finally stop/off the engine.

Figure 4.2: sign of fatigue or drowsiness while driving

The figures 4.3: A sleeping driver bound to commit accidents.

4.3 How Facial Recognition System Work

Eyes are the most important features of the human face. So effective usage of eye movements as a communication technique in user-to-computer interfaces can find place in various application areas. Eye tracking and the information provided by the eye features have the potential to become an interesting way of communicating with a computer in a human-computer interaction (HCI) system. So with this motivation, designing a real-time eye feature tracking software is the aim of this project.

Basically, this thesis is aimed at designing and if possible develops an eye detector in the automobile industry for the prevention of road accidents. The eye detector will be directly placed at an angle of ninety (90) degrees in front of the driver`s seat in the vehicle, i.e. placed on the dash board of the vehicle, cameras trained on your face analyze slackening facial muscles, your blinking patterns and how long your eyes stay closed between blinks. Once it concludes you're no longer awake, the system kicks in to rouse you from your dangerous slumber. The purpose of this real-time eye-feature tracker will work on the following capabilities:

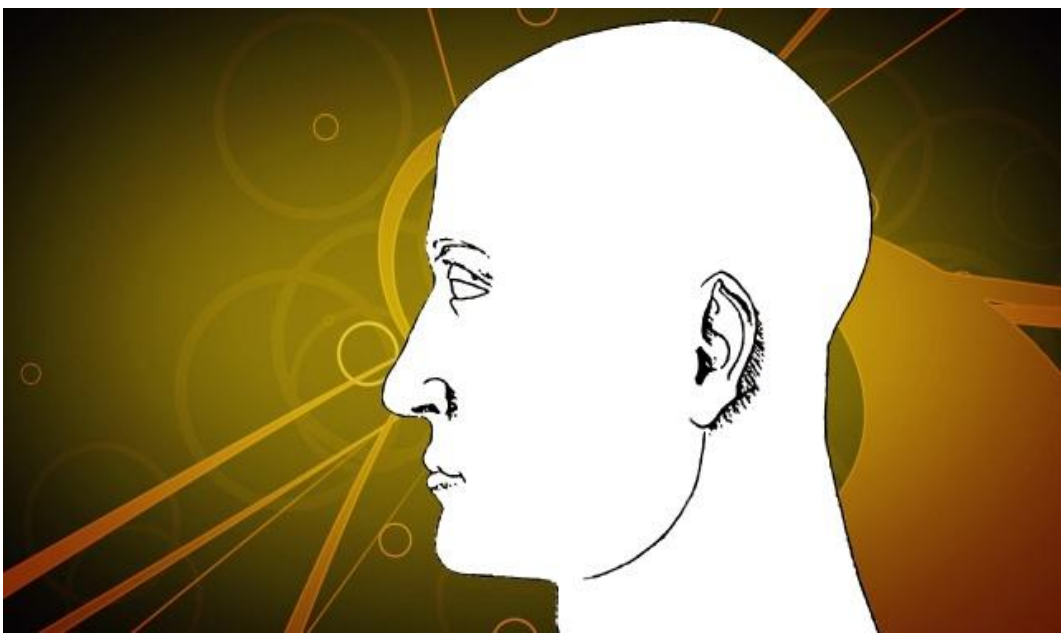


Figure 4.4: Face Tracking of A Driver

- Real-time face tracking with scale and rotation invariance
- Tracking the eye areas individually
- Tracking eye features
- Eye gaze direction finding
- Remote controlling using eye movements

Figure 4.5: The Driver's Movement and Eye Blinking Tracking

The camera will be set to focus on the driver`s movement there by reading the eyes blinking, the head nodding and twisting of the head as rightly stated above.

1: If the drivers head stays down for a set time /calculated period, the camera will be sending signal to the driver through a flash

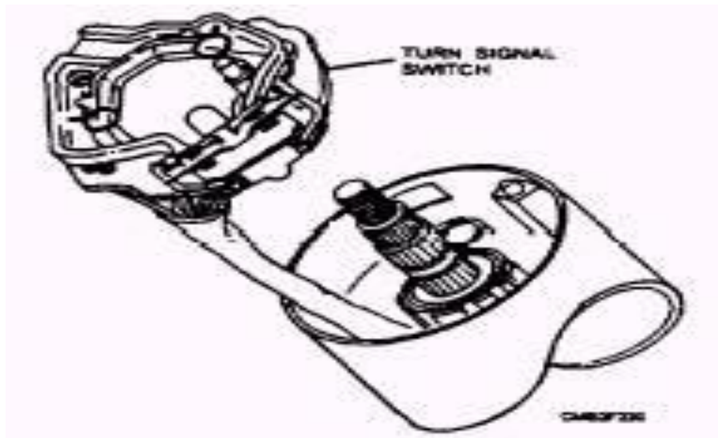
2. After the first flash, there will be an interval of a maximum of five seconds after which the focused lens on the river`s face will flash for the second time.

3. Upon the first and second flashing of the camera, the sensor will directly send an electrical signal through the connected indicator light signal that will be automatically signaling concurrently with the vibratory device attached on the driver's seat. The seat vibration will serve as a form of "wake up alarm" to wake the driver from his slumber or sleep. The driver of the vehicle should be very much aware of the dangers awaiting him/her upon the failure to stop and change driver or even for a break and take nap so as to avoid accidents due to drowsiness, fatigue or other human related deficiencies.

On a most important note, the seat vibration will be continuous for about a minimum of sixty seconds and a to a maximum limit of two more minutes so that the driver can be continually alerted and quickly come to his/her senses and be focused on the steering wheel to drive properly.

4.4 How the Indicator Signal Light SystemWorks

Vehicles that operate on any public road must be equipped with turn signals. These signals indicate a left or right turn by providing a flashing light signal at the rear and front of the vehicle. The turn-signal switch is located on the steering column (fig. 2-68). It is designed to shut off automatically after the turn is completed by the action of the canceling cam.



Figures 4.6 Typical turn-signal switch

A wiring diagram for a typical turn-signal system is shown in figure 2-69. A common design for a turn-signal system is to use the same rear light for both the stop and turn signals. This somewhat complicates the design of the switch in that the stoplight circuit must pass through the turn-signal switch. When the turn-signal switch is turned off, it must pass stoplight current to the rear lights. As a left or right turn signal is selected, the stoplight circuit is open and the turn-signal circuit is closed to the respective rear light. The turn signal flasher unit (fig. 2-70) creates the flashing of the turn signal lights. It consists basically of a bimetallic (two dissimilar metals bonded together) strip wrapped in a wire coil. The bimetallic strip serves as one of the contact points. When the turn signals are actuated, current flows into the flasher- first through the heating coil to the bimetallic strip, then through the contact points, then out of the flasher, where the circuit is completed through the turn-signal light. This sequence of events will repeat a few times a second, causing a steady flashing of the turn signals.

4.4.1 Backup Light System

Despite the fact that the backup light system provides visibility to the rear of the vehicle at night and a warning to the equipped vehicles is combined with the neutral safety switch; this designed safety system will add another dimension in playing a crucial role in saving many lives and properties,

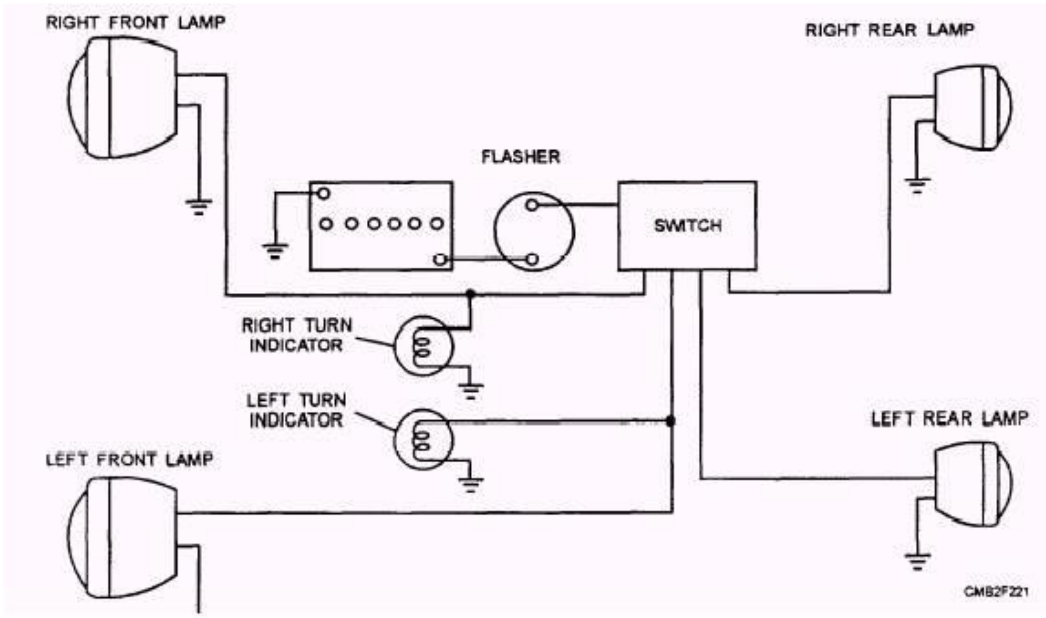


Figure4.7: Typical turn-signal wiring diagram

Whenever the vehicle is shifted into reverse, the backup light system has a fuse, gearshift-or transmission-mounted switch, two backup lights, and wiring to connect these components. The backup light switch closes the light circuit when the transmission is shifted into reverse. The most common backup light switch configurations are as follows: The backup light switch mounted on the transmission and operated by the shift lever. The backup light switch mounted on the steering column and operated by the gearshift linkage.

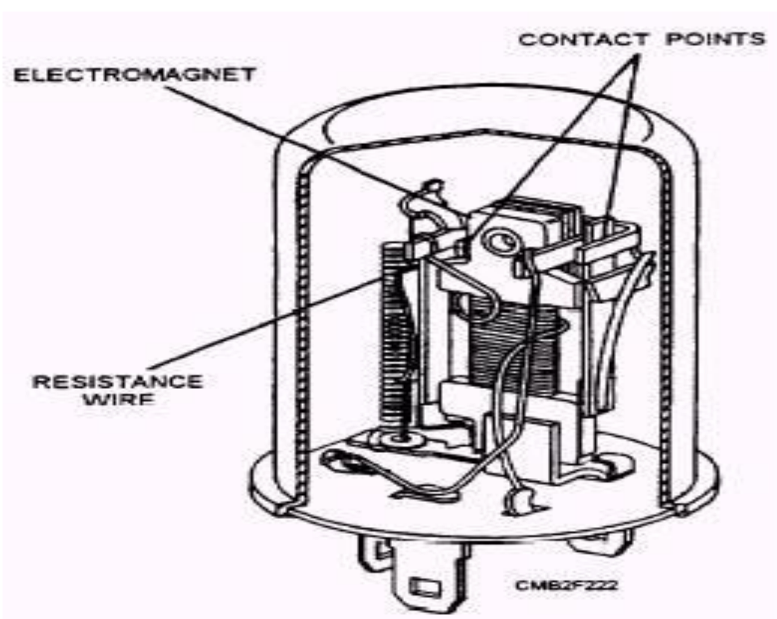


Figure 4.8: Turn signal flasher

The transmission or gear shift mounted backup light switch on many automatic transmissions. The lighting system of the vehicle will be directly connected or linked to the series of electrical wiring cables that are at the same time connected to the sensor wiring system which connects the eye detector camera, the driver’s seat vibration mechanism in the vehicle. The signal wiring coupled with interconnected wiring cables of the system will be working systematically in order of operation so as to deliver the intent of which it has been designed for. The light indicator signal is connected to the main switch box that at the same connects the other electrical/electronic cable connections of the safety device.

However, if at any point in time the eye detector camera has reached its maximum set limit of the number of flashes the light indicator signal will be switched on by the system and thus the light signal will at the same time be switch “ON” with the driver`s vibratory seat device .To ensure that the indicator lighting stops, the alerted sleepy ,fatigue ,dizzy or drunk driver has to stop the vehicle in order to enable him gain his consciousness back and so enable the safety alert system to be deactivated and let it go back to its safe operation mode.

4.5 Vibrating seat mechanism

Unlike the vibration from an incoming text message or phone call, a new use of the buzzing technology is meant to keep you alert in the car, not distracted. The seat vibration system is used in conjunction with the above safety features operational system. It will immensely help if not in total prevention of accidents but to reduce it to a greater percentage by simply alerting the driver from sleep and help in taking quick measure in preventing crashes and knocks.

However, “Vibrating alerts also may help drivers who do not hear beeping alerts due to hearing loss or competing noises, and may be preferred by drivers and passengers who might be annoyed by beeps, indicator light signals and shut crash avoidance features off.The seat vibration system works in a similar relationship with vehicle systems like Forward Collision Alert, Lane Departure Warning and Side Blind Zone Alert. Instead of relying on a visual or audio cue, the way those systems traditionally would, the Safety Alert system vibrates the driver's seat to provide a quick alert.

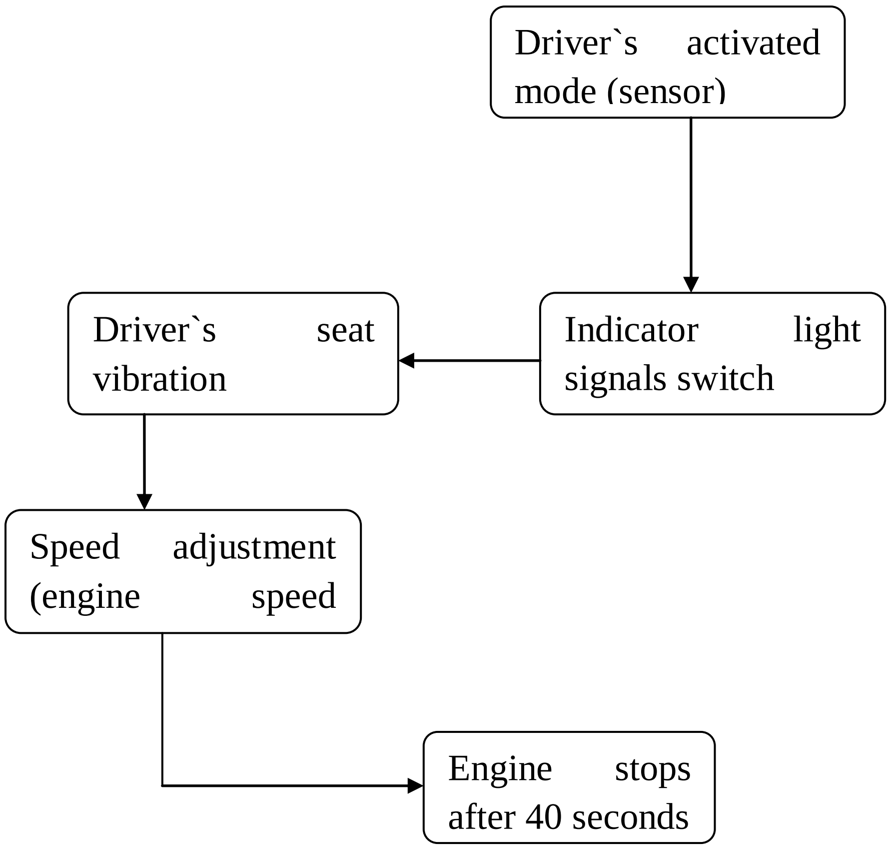


Figure 4.9: Showing the Seat Vibration Mechanism Flow Chart

"It's akin to someone tapping on your shoulder in a crowd to get your attention," General Motors Active Safety Technical Fellow Raymond Kiefer explained. The seat vibration works directly in connection with the sensor that connects the light indicator signals and the alarm. If the signals and alarm has gone up to their limit, then the vibration will immediately occur based on the settings of the sensor for a minimum period of vibration of about thirty seconds (30 sec) and a maximum of one minute (60 sec).There is a vibration mechanism consisting of a motor attached to the driver's seat, either on the shoulder area, on the laps or on the left and right sides of the driver`s seat.

The seat generates a vibrating pulse when a driver finds himself in a potentially precarious situation (sleepy, dizziness or drunken), such as drifting into a different traffic lane or coming too close to nearby objects when driving/running at speed.

The seat can vibrate on either the left or right side, on shoulder areas, on the driver`s lower laps depending on where the mechanism is placed or fixed. If the danger is alerted, the vibratory device will be activated and thus will only stop when it reaches either its minimum thirty seconds or maximum sixty seconds.

Technically, if all the warnings and the set alarm signals has gone on to their maximum limit as designed and programmed in the sensor, there will be no other option left but only the speed adjustment, i.e. reduction of the engine speed to a set speed range or determined **speed of 40km per hour** as set- safe speed so as to reduce the impact of any possible knocks or accidents in the event there happens to be any. And eventually ,the engine will be off after fifteen seconds to the reduce 35km per hour limit.

CHAPTER FIVE

5.1 Summary

This thesis consists of five chapters and each of the chapters deal with very important issues regarding general safety features, road safety and accident prevention. The objective of the thesis highlights points that the outcome of the work. On the first chapter deals with or highlights the introduction of the thesis, objectives and motivation. The introduction of the thesis gives you an insight into the safety of automobiles on our roads. The motivating factor for doing this work is the interest in saving human life and properties and the achievement of full satisfaction in dealing with vehicles on our roads.

On the second chapter, deals with the common and available lists of general safety features detailed photos explaining in detail their individual roles and functions. Generally safety features herein are the most common safety features common in our today`s world of automobiles and they play a crucial role in safety, protection and in general comfort. The airbag, seat belts, speedometers, and of course the newer devices that includes advance driver assistance system(adas),GPS, ABS, cruise control and the use of Cameras in monitoring and controlling the swift flow of traffic are both new inventions and technologies geared for the overall safety and satisfaction in the use of automobile.

In the third chapter I have mentioned and discuss about the real causes of accidents on our roads. Among all the causes of accidents by drivers, sleeping while driving, fatigue, drug abuse,use of mobile phones are the prominent ones that becomes the killer machine and claim the lives of the core of any society. Several researchers and reports have clearly indicated that majority of accidents caused annually are caused by youth drivers. Besides the mechanical failure and electrical problems of vehicles, human errors and human related causes of accidents are one of the common causes of automobile accidents that results to fatalities in accidents.

However, the fourth chapter comes solely discussing about possible algorithms that I have personally design to be able to develop in future to serve as a preventive device in alerting drivers, most especially drunk, sleepy, fatigue drivers. design safety device consists of an in built safety camera that will be fixed right in front of the driver`s dash board to read the driver`s eyes and head movement, it also has within the device a sensor that will read and sends electrical/electronic signal to the indicator light signals on the car as a warning to the driver and other road users. In this device also consist of a driver`s seat vibratory device that will be responsible for sending vibratory signal to the driver and it is designed to placed either on shoulder areas of the seat, under the lower area of left and right laps of the seat.

Finally the fifth chapter is a detailed summary, conclusion and recommendations thesis work "FEASIBILITY ANALYSIS AND ALGORITHM DEVELOPMENT OF A SAFETY DEVICE FOR AUTOMOBILES"

5.2 Conclusion

During the period of conducting this work, I have learned and realized that there are abundant safety features present in most new cars and also many other unknown that can be useful in helping us to save our lives. These features are all stated above on the table of content. There is also a record number of accidents that are caused as a result of human errors while drivers are driving but the most and terrible one that claims and will ever continue to claim many lives if proper care is not taken is the drink and drive, sleep and fatigue related problems. Road raging and too much honking seems to be a common problem in many under developed and developing countries where traffic jams are the order of the day. Improper traffic regulation and lack of adherence traffic rules seems to cause many problems and resorts to deaths and fatalities in most cases.

Use of road safety features should be a habitual behavior for all drivers and all those using the road as well. This should be used as an act of promoting road safety and accident preventive measures whereby innocent and valuable souls and properties that are perished on daily basis will be saved from the menace of automobile road accidents. The invention of the comfortable automobile vehicle devices such as radio/stereo, air conditioning, global positioning system (GPS), and all other related comfort able devices should not be used to distract driver's attention on the wheel while driving. The introduction of modern and general road safety devices such as: air bags, seat belts, speedometers, advanced driver assistance system (ADAS), adaptive cruise control (ACS), advanced emergency braking system (AEBS), brake collision system, lane departure warning system and all other invented devices shouldn`t be seen as an ‘‘amusement devices" but rather as devices that are solely meant for the saving of our dear lives and properties on the road. There must be very strict traffic laws/regulations regarding the automobile road usage and the causes of accidents, the deploying of traffic police officers to be monitoring the swift flow of traffic including: drivers, pedestrians and cyclist, on a daily basis and also traffic talk shows and awareness campaigns on our communication mediums should be thoroughly encouraged.

The vast number or majority of vehicle road accidents are caused by human errors. It has been proven by many research institutes and individual researches that about or more than 57% of our daily accidents or crashes are all due to human errors. There are prevalence's where accidents are also caused as a result of mechanical and environmental factors but that should not be taken asan excuse(s)s and cause more human errors to commit dangerous accidents. The human behavior is seen as a devastating factor of lost of many lives and properties on our roads. Those human related factors such as**:** use of mobile phones, drink and driving, undertaking, road raging**,** tailgating, over speeding, driver fatigue, human information processing behaviors and other factors are seen as major causes of accidents and results to the vast number of loses in both uncountable economic values and lives annually. If both our governments and her people have come up with traffic regulations where all would be bound and forced to respect, obey and implement to fight against these above dilemmas, will be a stepping stone to simply reduced road accidents if not totally eliminated as a way of minimizing the lost of valuable lives and properties .Bad driving behavior can be totally discouraged and put to a stop by placing hefty fines, seizure of drivers licenses or on serious cases imposing prison charges on drivers who are found wanting or guilty of committing bad and serious traffic accidents. In most sincere cases, over speeding, drink and driving and use of mobile phones while driving is seen as a bad behavior which is related to mostly teenagers who are amused by the comfort ability of our road conditions, the comfortable inner vehicle devices/entertainment facilities that leads to their improper usage of our roads and the committing of fatal accidents. Proper attention must be paid to strictly observe and regulate such ill behaviors which always claim hundreds of thousands of lives and resources annually. Excessive speeding is responsible for the high proportion of mortality and morbidity rate that results from automobile road accidents. Controlling the use of mobile phones and over speeding while driving can be a great deal but it will immensely reduce the impact of crashes, lessening the severity of injuries sustained by the victims, loss of lives and save many resources that are lost due to road accidents. Finally, until when we are determined to change our bad behaviors on the roads for good, the world would have been a better and safer place to be .But our failures to adopt to the changes in traffic regulations that are geared to save our lives and properties will not only result to mayhem, but surely send us to our early graves and left our families and loved ones in tears and agony. On a more and final note, I would like to suggest thus: ‘’A well behaved driver is always a step away from committing road accidents and also has a better tendency of living a very prosperous long life and building a driving career and as well as having a longer vehicle life span as well”.

One of the problems related to the causes of accidents is due to our own behaviors such as our failures to apply safety measure for the prevention of our selves.

The abuse ofavailable facilities such as cars stereo system, in built DVD`s and other amusements tends to distract most drivers and eventually fall into an accidents by using them. Most drivers are fond of not adhering to the warnings by the modern car safety alerts and thus turns deaf ears to it.

5.3 Recommendation

After a thorough and a very intensive studying and analysis of the current road safety devices, usage of these devices by both drivers and non drivers alike, I would like to personally recommend to the suitable automobile vehicle producers or manufacturers to come up with a more and well equipped vehicles with all the modern and a state of earth facilities to quickly deal with high death toll of people on road usage and related road accidents by drivers and other road users.

Designing and developing computer programmed vehicles that can easily predict any sort of driver behavior or action minutes before it even happens, regulates and provide an immediate response solutions to the human related problems of drivers, the pedestrians and other road users that should be immediately and quickly adhered to by both vehicle manufacturers. The law making and law reinforcement agencies should also be very much aware of the immediate dangers of people's lives and properties that are always perished in road accidents. The vast number of road accidents are caused by human errors. It has been proven by many research institutes and individual researches that about or more than 57% of our daily accidents or crashes are all due to human errors. There are prevalence's where accidents are also caused as a result of **mechanical and environmental factors** but that should not be taken as an excuse(s)s and cause more human errors to commit dangerous accidents. The human behavior is seen as a devastating factor of lost of many lives and properties on our roads. Those human related factors such as**: use of mobile phones, drink and driving, undertaking, road raging, tailgating, over speeding, driver fatigue, human information processing behaviors** and other factors are seen as major causes of accidents and results to the vast number of loses in both uncountable economic values and lives annually.

I also recommend that all modern vehicle should be equipped with a safety device that will automatically read and analyze the drivers blood pressure and determines whether the driver is in a stable state of mind or condition to drive .On the other hand, third world country drivers who are educated and does not know how to use this modern and sophisticated should be well trained as how to use such future cars through a national registered and recognized drivers training institute with a certified government license of training and must work under the code of conduct and operation of the international standard organization (ISO) traffic rules and acts. The use of vehicle safety features such as the lane departure warning, ABS, collision detection system and an inbuilt safety camera/s in automobile vehicles should be immensely encouraged and improved by both sundry. Despite the imminent prevalence of road accidents caused by drivers, there are other related accidents that are as a result of poor road construction and infrastructure management by individual countries. This can be tackled by constructing newer and reliable roads with wider lane dimensions to avoid crashes and knocks that are common forms of accidents. Governments and vehicle manufacturers should emulate and adopt regulations such as theEuropean Union member states traffic acts regarding the use of speed and the speedometer. A recommended approval speed for vehicles meeting similar EU standards in which they specify that:

The indicated speed must never be less than the actual speed, i.e. it should not be possible to inadvertently speed because of an incorrect speedometer reading.

The indicated speed must not be more than 110 percent of the true speed plus 4 km/h at specified test speeds. For example, at 80 km/h, the indicated speed must be no more than 92 km/h.

Another important short coming from most drivers and vehicle users are the failure to use seat belts while the vehicle is moving. It will be good for all countries to amend their traffic acts and lay down rules regarding the use of seat belts. I will recommend and use a similar case study of my country The Gambia where drivers and front passengers are fine with an estimated amount of about $30 upon failure to use seat belts. Since this has been introduce in Gambia in around 2005/6 the casualty rate regarding drivers and passenger`s head knocks during accidents and vehicle collision has dramatically reduce and it creates awareness in people about the use of seat belts. Researchers have shown that most of accidents related to over speeding happened in the rural areas where drivers are bound to take on longer journeys and hurriedly drive to reach their destination earlier, there must be regular/intermittent traffic check points man by traffic police at least every 20 to 25 kilometers so that the issue of over speeding and drivers falling asleep can be overcome.

On a final note, the most important things that needs to be done to reduce such accidents should be a concern for both and there can traffic talk shows on both print and be electronic medium to teach and sensitize the populace about the needs of road safety for the preservation of both human lives and properties.

References:

1. Marcus, C. L., & Loughlin, G. M. (1996). Effect of sleep deprivation on driving safety in house staff. *Sleep*, *19*(10), 763-766.

2. P.Fischhoff, B., & Lichtenstein, S. (1978). Accident probabilities and seat belt usage: A psychological perspective. *Accident Analysis & Prevention*, *10*(4), 281-285.

3. ANDERSON, P. A., Rivera, F. P., Maier, R. V., & DRAKE, C. (1991). The epidemiology of Seatbelt-associated injuries. *The Journal of Trauma and Acute Care Surgery*, *31*(1), 60-67.

4. RAGHUNANDHANAN, V., & KOLAY, R. (2009). VEHICLE NAVIGATING SYSTEM.

5. GerónimoGomez, D. (2010). A global approach to vision-based pedestrian detection for advanced driver assistance systems.

6.Bailey, B. J., Wong, S., Wipasuramonton, P. P., Tobian, R., Reuter, J., & Jost, S. (2000). *U.S. Patent No. 6,073,961*. Washington, DC: U.S. Patent and Trademark Office.

7. Beir ness, D., Simpson H., Mayhew, D., and Desmond, K. (2005) The Road Safety Monitor: Drinking and Driving. The Traffic Injury Research Foundation. Ottawa, Canada.

8. Cacciabue, P. C. and Saad, F. (2008). Behavioural adaptations to driver support systems: a modelling and road safety perspective. Cognition, Technology &Work. Vol 10: 31-39.

9. DesRosiers, Dennis. (2002). The Need for Dialogue: A Perspective on Vehicle Safety.

10. Koppel, S., Charlton, J., Fildes, B., Fitzharris, M. (2008). How important is safety in the new vehicle purchase process? Accident Analysis and Prevention. Vol. 40: 994-1004.

11. Page, Y., Foret-Bruno, J., and Cuny, S. (2005. Are Expected and Obser ved Effectiveness of Emergency Brake

12. Assist in Preventing Road Injury Accidents Consistent? Proceedings from the 19th ESV Conference; Paper No. 05-0268; June, 2005.

13. Robertson, R., Marcoux, K., Vanlaar, W. and Pontone, A. (2010). The Road Safety Monitor 2010: Distracted Driving. The Traffic Injury Research Foundation. Ottawa, Canada.

14. Rudin-Brown, C., Burns, P., Jenkins, R., Whitehead, T., LeBlond, O. (2011). ESC (Electronic Stability Control) Public and Driver Surveys. Transport Canada: TP 14848E.

15.Rudin-Brown, C. and Noy, I. (2002). Investigation of Behavioral Adaptation to Lane Departure Warnings. Transport Canada: Paper no. 02-2454.

16. Singhal, D., Simpson, H., Vanlaar, W., and Mayhew, D. (2006). The Road Safety Monitor: Public A wareness and Concerns about Road Safety. The Traffic Injury Research Foundation. Ottawa, Canada.

17. Transport Canada. (2007). Seat Belt Sense: What you need to know about seat belts, air bags, and child restraints. Transport Canada: TP 14646E.

18. Transport Canada. (2007). Canadian Attitudes towards Excessive Speed and Countermeasures: A Quantitative and Qualitative Study. Prepared by EKOS Research Associates, November 2007. TP-1002461.

19. Vanlaar, W., Simpson, H., Mayhew, D., and Robertson, R. (2006). The Road Safety Monitor 2006: Distracted Driving. Traffic Injury Research Foundation. Ottawa, Ontario.

20. Vanlaar, W., Emery, P., and Simpson, H. (2007). T he Road Safety Monitor 2007: Drinking and Driving. The Traffic Injury Research Foundation. Ottawa, Ontario.

21. Vanlaar, W., Robertson, R., and Marcoux, K. (2007). The Road Safety Monitor 2007: Excessive Speeding. The Traffic Injury Research Foundation, Ottawa, Ontario.

22. Vanlaar, W., Marcoux, K., and Robertson, R. (2008). The Road Safety Monitor 2008: Pedestrians and Bicyclists. The Traffic Injury Research Foundation. Ottawa Ontario.

23. Vanlaar, W., Marcoux, K., and Robertson, R. (2012). The Road Safety Monitor 2011: Distracted Driving. The Traffic Injury Research Foundation. Ottawa, Ontario.

24.Vanlaar, W., and Robertson, R. (2010) The Road Safety Monitor 2010: Drinking and Driving in Canada . The Traffic Injury Research Foundation. Ottawa, Canada.

25. Vanlaar, W., Robertson, R., Marcoux, K., Mayhew, D., Brown, S., and Boase, P. Trends in alcohol-impaired driving in Canada. Accident Analysis and Prevention, 2012.

26. Vanlaar, W., Simpson, H., and Robertson, R. A perceptual map for understanding concern about unsafe driving behaviours. Accident Analysis and Prevention 40 (2008).

27. Vrkljan, B. and Anaby, D. (2011). What vehicles features are considered important when buying an automobile? An examination of driver preferences by age and gender. Journal of Safety Research. Vol. 42: 61-65.

28. Williams, A. F., Kyrychenlo, S. Y., and Retting, R. A. (2006). Characteristics of speeders. Journal of Safety Research, 37(3), 227-232.

29. Wilde, G.J.S. (1982). The Theory of Risk Homeostasis: Implications for Safety and Health. Risk Analysis. Vol. 2, no.4: pp. 209-225.

30. Underwood, G., Jiang, C., and Howarth, C. (1993). Modelling of Safety Measure Effects and Risk Compensation. Accident Analysis and Prevention. Vol. 25, no. 3, pp. 277-288.

31. Briem, V., & Hedman, L. R. (1995). Behavioural effects of mobile telephone use during simulated driving. *Ergonomics*, *38*(12), 2536-2562.