International Journal on Emerging Technologies **6**(1): 61-68(2015)

ISSN No. (Print) : 0975-8364
ISSN No. (Online) : 2249-3255

Automatic Collision Warning and Electro-Mechanical Braking System

Raj Reddy
Asst. Prof. Department of Mechanical Engineering,
BKIT Bhalki, Karnataka, INDIA

(Corresponding author: Raj Reddy)
(Received 12 March, 2015 Accepted 06 April, 2015)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Automotive safety has gained an increasing amount of interest from the general public, governments and the car industry. This is more than justified by traffic accident statistics, as each year around 1.2 million people die due to road traffic accidents. For these reasons safety remains a core value of Volvo Cars. This paper presents some of the latest active safety developments within Volvo Cars. Rear-end collisions are common accident scenarios and a common cause of these accidents is driver distraction and thus not reacting in time. No vehicle system is a substitute for the most important safety feature in any vehicle the driver. However, Volvo is harnessing innovative technologies to help alert drivers to avoid potential collisions and reduce the potential impact speed when a collision cannot be avoided. One of those systems is Collision Warning with Auto Brake where the area in front of the vehicle is continuously monitored with the help of long range radar and a forward-sensing wide-angle camera fitted in front of the interior rear-view mirror. A warning and brake support will be provided for collisions with other vehicles, both moving and stationary. Additionally, if the driver does not intervene in spite of the warning and the possible collision is judged to be unavoidable; intervention braking is automatically applied to slow down the car. This aims at reducing impact speeds and thus the risk for consequences. This system has been verified using innovative CAE methods and practical tests. Finally, it is discussed how the benefit of such systems can be judged from real-life safety perspective using traffic accident statistics.

Keywords: CAE, Belt Drives, Motors, Shaft, Breaking System

I. INTRODUCTION

Automatic collision warning and electro mechanical braking system is a cocktail of several technologies The automatic collision warning and electro mechanical braking system braking system is a answer to the automated material handling problems In advance by using photo-electric sensor Stop indication using flashing LED or hooter. Braking –using Disk brake to ensure optimal braking force and minimum braking distance. Electro mechanical actuation using mechanical actuator making the operation extremely fast thereby safety ensured Braking (Nature similar to the anti-lock braking) I e, intermittent and gradual braking. Power regulation of the prime mover (in our case of model Single phase variable speed motor) to avoid power loss and excessive brake wear. Simultaneous power regulation to avoid power wastage and break wear

II. LITERATURE SURVEY

Automatic Collision Warning and Electro-Mechanical Braking System in a four wheeler is a cocktail of several technological marvels which are discussed as below.

Emergency Brake Assist (EBA): In an emergency, many people do not depress the brake pedal hard enough. EBA senses an emergency braking situation and helps the driver to reduce speed in the shortest distance possible.

Blind Spot Information System (BSIS): Using cameras set just below the outer rear view mirrors the BSDS tell you if there is any vehicle in your blind spot.

Night Vision: Driving during the night becomes safe than ever with the night vision where one can see clearly on the control display even in pitch black. Thanks to infra-red technology.

Dynamic Stability and Traction Control (DSTC): DSTC makes driving on twisty and slippery road conditions safer, by using sensors to detect whether any of the wheels is losing traction. DSTC has the ability to cut power in a flash, helping the car to regain its grip. If in any case the car shows a tendency to skid the system automatically slows the particular wheels to help maintain control.

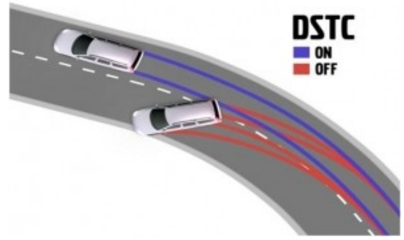

Fig. 1. Dynamic Stability and Traction Control.

Electronic Brake Distribution (EBD): EBD makes sure that the braking forces of the car are distributed between the front and the rear brakes in order to optimize braking efficiency.

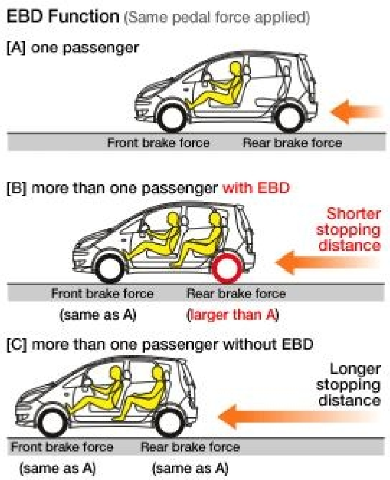

Fig. 2. Electronic Brake Distribution functioning.

Anti-Lock Braking System (ABS): With ABS you can brake as hard as you can and steer yourself to safety without the fear of wheels locking up and skidding.

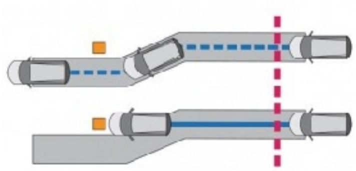

Fig. 3. Anti-Lock Braking System.

Requirements & need: Automatic collision warning and electro mechanical braking system .The above systems as applied to automobiles are extremely costly as they compulsorily need a computer for their implementation .More over all these systems are singular problem oriented, hence there is a need of a cost effective low end technology or device that can perform the function of over-speed indication –alarm-and brake control with minimal use of high end technology, suitable for low budget commercial vehicles.

Problem Definition: The above systems as applied to automobiles are extremely costly as they compulsorily need a computer for their implementation More over all these systems are singular problem oriented, hence there is a need of a cost effective low end technology or device that can perform the function of over-speed indication –alarm-and brake control with minimal use of high end technology, suitable for low budget commercial vehicles.

Solution: The Automatic collision warning and electro-mechanical braking system is a answer to the above problems where in the following features have been incorporated;

(i) In advance Collision warning by using photo-electric sensor.
(ii) Collision indication using flashing LED or hooter.
(iii) Braking –using Disk brake to ensure optimal braking force and minimum braking distance.
(iv) Electro mechanical actuation using solenoid actuator making the operation extremely fast thereby safety ensured.
(v) Braking (Nature similar to the anti-lock braking) i.e., intermittent and gradual braking.
(vi) Power regulation of the prime mover (in our case of model, Single phase variable speed motor) to avoid power loss and excessive brake wear.

Problem solution: The Automatic collision warning and electro-mechanical braking system is a solution to the above problems where in the following features have been incorporated;

(i) In advance Collision warning by using photo-electric sensor.
(ii) Collision indication using flashing LED or hooter.
(iii) Power regulation of the prime mover (in our case of model, Single phase variable speed motor) to avoid power loss and excessive brake wear.
(iv) Electro mechanical actuation using solenoid actuator making the operation extremely fast thereby safety ensured.
(v) Braking (Nature similar to the anti-lock braking) i.e., intermittent and gradual braking.
(vi) Braking –using Disk brake to ensure optimal braking force and minimum braking distance

III. CONSTRUCTION

The construction of an Automatic Collision Warning and Electro-Mechanical Braking System is explained in the section below.

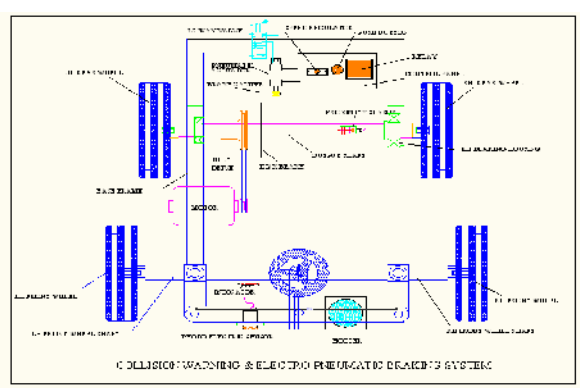

Fig. 4. Construction of automatic collision warning and electro-mechanical braking system.

The Automatic Collision Warning and Electro-Mechanical Braking System comprises of the following:

Chassis or Frame: The chassis or frame is fabricated structure that carries the entire system, rear wheel shaft is the driver shaft that carries the reduction pulley driven by motor using an open belt drive. The end carries the steering mechanism in form of Ackermann steering with the central steering wheel controls the steering angle using the slotted lever arrangement.

Motor: Motor is the prime mover, it is single phase AC motor 50 watt, 0 to 6000 rpm variable speed. Motor speed is regulated using electronic speed regulator.

Collision Sensing mechanism: The over speed sensing mechanism is in the form of an Photo electric sensor with variable sensing range.

Photo-electric sensor: The photo electric sensor is mounted on the sheet metal panel on the base frame by means of a Z shaped clamp. The photo-sensor as the name suggests senses the proximity of the obstruction which acts as stops, such that when they come in front of the photo sensor the Relay is operated to stop the vehicle motion. The photo- sensor is connected to the electronic relay and the power source.

Fig. 5. Photo electric sensor Size M18.

Sensor type: Photo electric sensor and cylindrical sensors with built-in amplifiers (Size: M18)

• Threaded with built-in amplifier
• PVC cable sheath
• Compact and space-saving
• Watertight construction exceeds IP67 ratings
• DC switching types available with connector connection
• Housing materials: ABS plastic and nickel-plated brass (NPB) models stocked; 303 stainless steel models available
• Through-beam models include emitter and receiver pair
• Retro-reflective models include reflector
• Selectable Light-ON/Dark-ON operation on DC 3-wire models
• DC models with full metal plug-in connector for easy maintenance Specifications
• Voltage range: AC models: 24-240 VAC ±10%, 50/60 Hz; DC models: 10-30 VDC
• Load rating:
• DC models: NPN or PNP open collector, 100 mA max.
• AC models: SCR, 200 mA; 5 V max. Residual voltage
• Current consumption:
• 50 mA max. (Through-beam)
• 30 mA max. (Polarized retro-reflective, diffuse and background suppression)
• 25 mA max. (Wide beam diffuse)
• Directional angle: 3 to 20 deg. (through-beam, retro-reflective);
• Differential travel: 20% max. (Diffuse reflective); 5% max. (Background suppression)
• Response time: AC models: 30 ms max.; DC models 2.5 ms max.
• Circuit protection:
• Power source reverse polarity (DC)
• Output short-circuit (DC)
• Operating ambient: -25 to 55 C, 35% to 85% RH

We have Selected M18 Sensor with the following specifications:

1. Mounting size hole: 18.5 mm
2. Voltage: 230 Volt AC
3. Sensing distance:

Minimum: 50 mm
Maximum: 500mm

This sensor is selected mainly for the three reasons described below:

(i) In order to prevent the collision minimum distance should be 50 mm

(ii) DC sensors with higher range are very costly (5000+)

(iii) Because we do not have engine for demonstration model it is easy to use a 230 volt AC motor with variable speed. So the sensor used is also 230 Volt AC

Electronic Speed Regulator: Motor is a commutator motor i.e. the current to motor is supplied to motor by means of carbon brushes. The power input to motor is varied by changing the current supply to these brushes by the electronic speed aviator, thereby the speed also changes.

Collision warning indicator lamp and or Hooter: This is the indication or alarm system, the lamp is a red LED lamp that flashes when over speed occurs, similarly the hooter is a horn or buzzer arrangement that goes on after over-speed occurs there by alarming the driver.

Electronic Relay: Electronic relay is used for the sequencing of the actuation mechanism .It helps to operate the and work in a sequence in order to bring the required results of the system.

Fig. 6. Electronic relay.

Braking Mechanism: The braking mechanism uses a disk brake and brake caliper arrangement. The Disk brake is used with the view to maximize the braking and ensure safety.

Fig. 7. Disc Brake.

Solenoid: The function of solenoid is to actuate the brake caliper to apply the brake with electro magnetic operation, when electric current is passed to it.

Fig. 8. Solenoid.

Brake Caliper:

Fig. 9. BrakeCaliper.

IV. WORKING OPERATION

System starts with the starting of motor. The motor speed is controlled by electronic speed regulator. As the vehicle moves forward, the resultant gap between the obstruction and the proximity sensor exceeds the permissible limit which makes the relay to operate and consequently the following actions takes place:

(a) Visual collision warning in the form of indicator lamp lights

(b) Audio collision warning in the form of hooter goes ON

(c) Braking mechanism is actuated to operate the shoe brake cam Linear actuator mechanism

In operation, as the electric current passes to the solenoid, a magnetic field is developed which pulls the ram of the solenoid behind and thus the ram which in turn is connected to the brake lever is pulled back to apply the brake.

V. DESIGN

Design consists of application of scientific principles, technical information and imagination for development of new or improvised machine or mechanism to perform a specific function with maximum economy & efficiency. Hence a careful design approach has to be adopted. The total design work, has been split up into two parts:

System design. System design mainly concerns the various physical constraints and ergonomics, space requirements, arrangement of various components on main frame at system, man + machine interactions, No. of controls, position of controls, working environment of machine, chances of failure, safety measures to be provided, servicing aids, ease of maintenance, scope of improvement, weight of machine from ground level, total weight of machine and a lot more.

Mechanical Design. In mechanical design the components are listed down and stored on the basis of their procurement, design in two categories namely,

Designed Parts. For designed parts detached design is done & distinctions thus obtained are compared to next highest dimensions which is readily available in market. This amplifies the assembly as well as postproduction servicing work. The various tolerances on the works are specified. The process charts are prepared and passed on to the manufacturing stage.

Parts to be purchased: The parts which are to be purchased directly are selected from various catalogues & specified so that anybody can purchase the same from the retail shop with given specifications.

A. System Design. In system design we mainly concentrated on the following parameters: -

System Selection Based on Physical Constraints: While selecting any machine it must be checked whether it is going to be used in a large-scale industry or a small-scale industry. In our case it is to be used by a small-scale industry. So space is a major constrain. The system is to be very compact so that it can be adjusted to corner of a room. The mechanical design has direct norms with the system design. Hence the foremost job is to control the physical parameters, so that the distinctions obtained after mechanical design can be well fitted into that.

Arrangement of Various Components: Keeping into view the space restrictions the components should be laid such that their easy removal or servicing is possible.

More over every component should be easily seen none should be hidden. Every possible space is utilized in component arrangements.

Components of System: As already stated the system should be compact enough so that it can be accommodated at a corner of a room. All the moving parts should be well closed & compact. A compact system design gives a high weighted structure which is desired.

Man Machine Interaction: The friendliness of a machine with the operator that is operating is an important criteria of design. It is the application of anatomical & psychological principles to solve problems arising from Man – Machine relationship. Following are some of the topics included in this section. *(i) Design of foot lever (ii) Energy expenditure in foot & hand operation (iii) Lighting condition of machine* **Chances of Failure:** The losses incurred by owner in case of any failure is an important criteria of design. Factor safety while doing mechanical design is kept high so that there are less chances of failure. Moreover periodic maintenance is required to keep unit healthy.

Servicing Facility: The layout of components should be such that easy servicing is possible. Especially those components which require frequents servicing can be easily disassembled.

Scope of Future Improvement: Arrangement should be provided to expand the scope of work in future. Such as to convert the machine motor operated; the system can be easily configured to required one. The die & punch can be changed if required for other shapes of notches etc.

Height of Machine from Ground: For ease and comfort of operator the height of machine should be properly decided so that he may not get tired during operation. The machine should be slightly higher than the waist level, also enough clearance should be provided from the ground for cleaning purpose.

Weight of Machine: The total weight depends upon the selection of material components as well as the dimension of components. A higher weighted machine is difficult in transportation & in case of major breakdown, it is difficult to take it to workshop because of more weight.

Prime Mover Selection: Motor is a Single phase AC motor, Power 50 watt, Speed is continuously variable from 0 to 6000 rpm. The speed of motor is validated by means of an electronic speed variator. Motor is a commutator motor i.e., the current to motor is supplied to motor by means of carbon brushes. The power input to motor is varied by changing the current supply to these brushes by the electronic speed variator, thereby the speed is also is changes. Motor is foot mounted and is bolted to the motor base plate welded to the base frame of the indexer table.

B. Working of Disk Brake

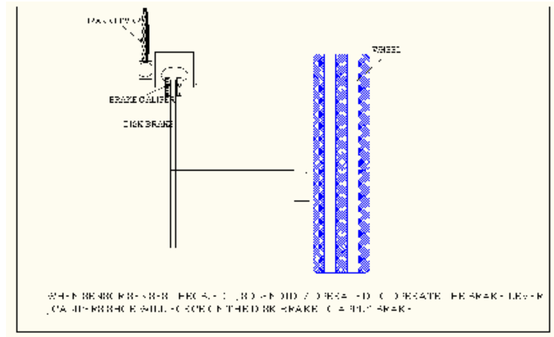

Fig. 10.

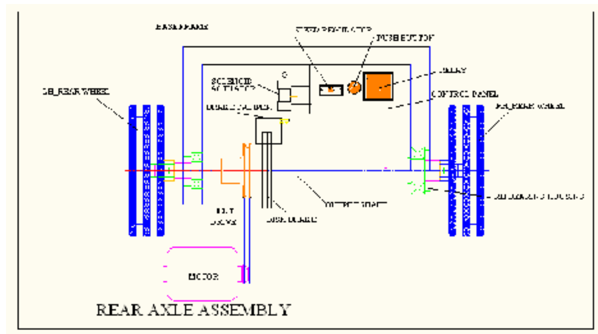

Fig. 11.

VI. PRIME MOVER SELECTION

Motor is an Single phase AC motor, Power 50 watt , Speed is continuously variable from 0 to 6000 rpm. The speed of motor is varied by means of an electronic speed regulator Motor is an commutator motor i e, the current to motor is supplied to motor by means of carbon brushes. The power input to motor is varied by changing the current supply to these brushes by the electronic speed regulator there by the speed is also is changes. Motor is foot mounted and is bolted to the motor base plate welded to the base frame of the indexer table.

Mechanical Design:

Design of Belt Drive:
Selection of an open belt drive using V-belt;
Reduction ratio = 5
Planning a 1 stage reduction;
A) Motor pulley (ϕ D1) =20mm
B) Main shaft pulley (ϕ D2) =100mm
Input data:
Input power = 0.05kW
Input speed =1000 rpm
Center distance = 210 mm
Max belt speed = 1600 m/min = 26.67 m/sec
Groove angle (2β) = 40^0
Coefficient of friction = 0.25
Between belt and pulley
Allowable tensile stress = 8 n/mm^2
Section of belt section
Ref Manufacturers Catalogue

C/S Symbol	Usual Load Of Drive (Kw)	Nominal Top Width (Mm)	Nominal Thickness T Mm	Weight Der Meter Kgf
FZ	0.03 - 0.15	6	4	0.05

$$\sin \propto = \frac{0_2M}{0_1 0_2} = \frac{R_2 - R_1}{x} = \frac{D_2 - D_1}{2x}$$

Result Table:

Table: 1

1.	BELT SELECTED	FZ 6 x 600
2.	Tight side Tension	T_1 =124.24 N
3.	Slack side Tension	T_2 = 16 N
4.	Motor pulley did.(ϕ D_1)	D_1 =20 MM
5.	Pulley (a) diameter (ϕD_2)	D_2 =100MM

Design of Input Shaft:

Motor Torque

$$P = \frac{2 \Pi N T}{60}$$

T = 0.095 N-m

Power is transmitted from the motor shaft to the input shaft of drive by means of an open belt drive,

Motor pulley diameter = 20 mm

IP _ shaft pulley diameter = 110 mm

Reduction ratio = 5

IP shaft speed = 6000/5 = 1200 rpm

Torque at IP shaft = 5 x 0.095 = 0.475 Nm

T_{Design} = 2 x T =0.95 Nm, FOS =2

= 0.95x 10^3 N.mm

Selection of input shaft material

Ref: - PSG Design Data.

Pg No: - 1.10 & 1.12.0 1.17

Designation	Ultimate Tensile Strength N/mm^2	Yield strength N/mm^2
EN 24 (40 N; 2 cr 1 Mo 28)	720	600

Using ASME code of design;

Allowable shear stress;

Fs_{all} is given stress;

Fs_{all} = 0.30 syt = 0.30 x 600

=180 N/mm^2

Fs_{all} = 0.18 x Sult = 0.18 x 720

= 130 N/mm^2

Considering minimum of the above values;

fs_{all} = 130 N/mm^2

As we are providing dimples for locking on shaft, reducing above value by 25%.

$\Rightarrow fs_{all}$ = 0.75 x 130

= 97.5 N/mm^2

(a) Considering pure torsional load;

$$T_{design} = \frac{\Pi}{16} fs_{all} d^3$$

$$\Rightarrow d^3 = \frac{16 \times 0.95 \times 10^3}{\Pi \times 97.5}$$

d = 7.0 mm

selecting minimum diameter of spindle = 16 mm from ease of construction because the standard pulley has a pilot bore of 12.5 mm in as cast condition, and a bore of minimum 16 mm for keyway slotting operation.

Design (Selection of LH Wheel Shaft Bearing): In selection of ball bearing the main governing factor is the system design of the drive i.e.; the size of the ball bearing is of major importance; hence we shall first select an appropriate ball bearing first select an appropriate ball bearing first taking into consideration convenience of mounting the planetary pins and then we shall check for the actual life of ball bearing.

Ball bearing selection:

Series 60

ISI NO	Brg Basic Design No (SKF)	d	D1	D	D2	B	Basic capacity	
							C kgf	Co Kgf
15A C02	6002	15	17	32	30	9	2550	4400

P = X Fr + Yfa.
Where;
P=Equivalent dynamic load, (N)
X=Radial load constant
Fr= Radial load (H)
Y = Axial load contact
Fa = Axial load (N)
In our case;
Radial load FR= T1 +T2=
$F_a = 0$
P= 140.4 N
$\Rightarrow$L= $(C/p)^{p}$
Considering 4000 working hours
As required dynamic of bearing is less than the rated dynamic capacity of bearing,
$\Rightarrow$ Bearing is safe.

Design (Selection of RH Wheel Shaft Bearing): In selection of ball bearing the main governing factor is the system design of the drive i.e.; the size of the ball bearing is of major importance; hence we shall first select an appropriate ball bearing first select an appropriate ball bearing first taking into consideration convenience of mounting the planetary pins and then we shall check for the actual life of ball bearing.

Ball Bearing Selection.
Series 60
P = X Fr + Yfa.
Where;
P=Equivalent dynamic load, (N)
X=Radial load constant
Fr= Radial load (H)
Y = Axial load contact
Fa = Axial load (N)
In our case;
Radial load F_R= T1 +T2=
$F_a = 0$
P= 140.4 N
$\Rightarrow$L= $(C/p)^{p}$
AS; required dynamic of bearing is less than the rated dynamic capacity of bearing;
$\Rightarrow$ Bearing is safe.

ISI NO	Brg (SKF)	D	D1	D	D2	B	Basic capacity	
							C kgf	Co Kgf
15A C02	6002	15	17	32	30	9	2550	4400

VII. DESIGN OF BRAKE DISK HUB

Brake disk hub can be considered to be a hollow shaft subjected to torsional load.

Material selection.

Designation	Ultimate Tensile strength N/mm^2	Yield strength N/mm^2
EN 24	800	680

As Per ASME Code;
$\Rightarrow fs_{max} = 108$ N/mm^2

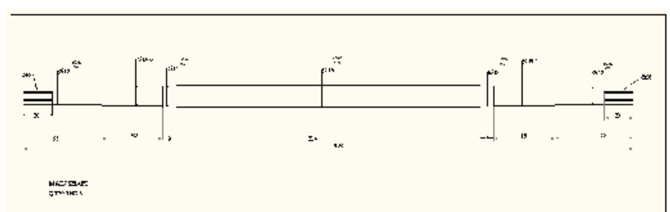

Fig. 5. Main shaft.

VIII. CONCLUSION

Automated Collision Warning and Electro Mechanical Braking Systems brings major transportation benefits in terms of safety, efficiency, affordability and usability, and environment in order to achieve its development goals. A key feature of the control design architecture is the separation of the various control functions into distinct layers with well-defined interfaces. Each layer is then designed with its own model that is suited to the functions for which it is responsible. The models at the various layers are different not only in terms of their formal structure (ranging from differential equations to state machines to static graphs), but also in the entities that have a role in them.

The Automated Collision Warning and Electro Mechanical Braking is a complex large-scale control system, whose design required advances in sensor, actuator, and communication technologies and in techniques of control system synthesis and analysis. It is a measure of the advanced state of the art that these techniques have reached a stage that they could be successfully used in this project.

REFERENCE

[1]. Peden M, Scurfield R, Sleet D, (2004). "World report on road traffic injury prevention", Geneva: World Health Organization, 2004.

[2]. Isaksson-Hellman I and H. Norin. (2005). How thirty years of focused safety development has influenced injury outcome in Volvo cars". 49th AAAM Annual Scientific Conference, Boston, USA.

[3]. NASS Crashworthiness Data System (2004). National Center for Statistics and Analysis of the National Highway Traffic Safety Administration.

[4]. Najm, W.G., S. Basav, J.D. Smith and B.N. Campbell. (2003). Analysis of light vehicle crashes and pre-crash scenarios based on the 2000 General Estimates System, NHTSA Technical report DOT HS 809573.

[5]. Jakobsson, L., B. Lundell, H. Norin and I. Isaksson-Hellman. (2000). WHIPS – Volvo’s Whiplash Protection Study Accident Analysis and Prevention 32: 307-319

[6]. Neale, V.L., T.A. Dingus, S.G. Klauer, J. Sudweeks and M. Goodman. (2005). An overview of the 100 car naturalistic study and findings, ESV.

[7]. Coelingh, E., H. Lind, W. Birk and D. Wetterberg. (2006). Collision Warning with Auto Brake, FISITA World Congress, F2006V130, Yokohama Japan.

[8]. Kiefer et al. "Forward Collision Warning Requirements Project Final Report", NHTSA DOT HS **809** 574, 2003.