Extended Collision Mitigation

Project within Fordons- och trafiksäkerhet

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FFI

Content

FFI in short

FFI is a partnership between the Swedish government and automotive industry for joint funding of research, innovation and development concentrating on Climate & Environment and Safety. FFI has R&D activities worth approx. €100 million per year, of which half is governmental funding. The background to the investment is that development within road transportation and Swedish automotive industry has big impact for growth. FFI will contribute to the following main goals: Reducing the environmental impact of transport, reducing the number killed and injured in traffic and Strengthening international competitiveness. Currently there are five collaboration programs: **Vehicle Development, Transport Efficiency, Vehicle and Traffic Safety, Energy & Environment and Sustainable Production Technology.**

For more information: www.vinnova.se/ffi

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1. Executive summary

The project "extended collision mitigation" is partly funded by the *Fordonsstrategisk forskning och innovation (FFI) program* with Volvo as the only partner. This report presents an overview of the findings of the FFI project.

A collision mitigation (CM) system intervenes if an accident is imminent and not avoidable by braking or steering (or a combination thereof) and thus mitigates accident impacts. The goal of this project is to investigate possibilities to cover more accident scenarios than today's CM system. A prototype system with only auto braking has been developed and evaluated in a driving simulator, focusing on one serious accident: head-on collision.

The project work consists of 3 work packages:

1. Pre study.
   A limited number of use cases were derived, based on analysis of accident statistics, building a base for elaborating requirements on sensors and defining functions.
2. Concept and function development
   A prototype system has been defined and built using desktop simulation and a driving simulator, both with realistic sensor properties. Data were logged to be analyzed for prototype development.
3. Verification and Evaluation
   The prototype system was tested and verified in a driving simulator, based on pre-study requirements. Results and recommendation for continuing work were documented.

This report gives an overview of each work package as well as the results obtained.

2. Background

Collision mitigation (CM) systems have been introduced on the market, mostly in passenger cars in the premium segment. Contemporary systems of this for heavy trucks only attempt to mitigate rear-end collisions. However, accident statistics show that other types of accidents stand for a considerable part of all serious or fatal accidents involving heavy trucks, especially if the counterparts are cars or vulnerable road users (hereafter: VRUs).

In order to decrease the number of fatalities and the severity of accidents, the CM systems in heavy trucks need to be further developed to cover more complex types of accidents than the rear-end type. New technology and new sensors provide possibilities for such extended CM systems.

3. Objective

The purpose of this project is to investigate how the current CM functionality can be further extended to cover more accident scenarios than today's systems for commercial vehicles. The prioritized severe accident scenarios include oncoming traffic, intersections and VRUs. The project was aimed to show what is possible today, what the difficulties are, and what further work is needed in order to achieve a safe and reliable CM system. Thus, the project promoted and eased the development and introduction of a real product which will reduce the number of fatalities and seriously injured in traffic.

4. Project realization

The project started with a study of the traffic environment where analysis of current accident statistics was made. Then, further analysis was carried out in which basic systems and sensor requirements were elaborated. The conclusion from the pre-study was that project should focus on an algorithm for an extended CM function that covers head-on collisions.

Use cases and requirements of the extended CM function were defined in the beginning of the concept and function development phase. The mitigation solution was aimed to not only provide preventive measures such as warnings when a collision with an oncoming vehicle is likely, but also to activate auto braking when the collision is unavoidable.

A prototype system was developed using time-to-collision threat assessment. It is adapted from a rear-end CM system model developed. Sensor models, which provide input to the prototype system, were based on data logged from real sensors but enhanced to simulate future sensor capabilities. Key head-on collision scenarios were generated to run the use case simulations. Human-machine interface (HMI) functionality was also developed using audio and visual warnings.

The prototype system was further verified and evaluated in a driving simulator where both the algorithm and the HMI hardware design with a warning sound and head-up display (HUD) were implemented. Professional truck drivers have tested the system in the driving simulator. More improvements were realized iteratively in the interaction with the drivers.

5. Results and deliverables

5.1 Background

According to the report Vägverket Djupstudieanalys av olyckor med tunga lastbilar [5], around 100 people were killed in accidents involving heavy duty trucks in Sweden in 2007. Both the number of fatalities and the seriousness of injuries show that accidents with heavy duty trucks are more severe than other types of accidents. Several actions are suggested in order to decrease the number of accidents or the seriousness of the outcome of these accidents. One suggestion is to equip trucks with automatic emergency brake. This is expected to be especially effective when combined with improved impact absorbing crumple zones. These two actions are estimated to decrease the number of fatalities in frontal collisions with 50 percent, provided that the oncoming vehicle is a modern car with a high safety level.

The COMPAT report [4] states that in terms of passenger car underrun of heavy duty trucks in frontal collisions, the deformation of the passenger compartment of the car is dominated by slight to moderate deformations in relative speeds up to 100 km/h. Deformations that reaches between A- and B-pillar of the passenger car are very serious for the car occupants. The report also states that “the risk of being killed in a frontal impact between a car and a truck increases drastically beginning from a closing speed of 80km/h”.

5.2 Results

The results from the simulator study show that the CM system contributes to a bigger speed reduction than compared with baseline group equipped with no CM system (37.5 km/h vs. 30.5 km/h). The difference is statistically significant.

5.3 Delivery to FFI-goals

The Swedish Parliament has decided that the amount of fatalities in traffic in Sweden shall be reduced by 50% and the number of seriously injured reduced by one fourth by 2020. The goal for the FFI subarea Vehicle and traffic safety is to contribute to a reduction of one third of the 50% reduction of fatalities. As stated in Section 5.1, one of the traffic types that contribute to a serious amount of the total fatalities on Swedish roads every year is collision between passenger cars and heavy duty trucks. To focus on these types of accidents and be able to reduce or mitigate the outcome of these accidents could give significant reduction in the number of fatalities and seriously injured. Especially when focusing on oncoming collisions between cars and heavy duty trucks. At the same time it is very challenging to develop safety systems for heavy duty trucks due to their limited manoeuvre capabilities, and regulations for e.g. dimensions (bigger crumple zones). In these particularly types of accidents, the possibilities for mitigating interventions is also very tough due to the short periods of time from the moment the situation appears to the time of impact. The speed reduction of the truck at impact could be one partial solution and even if each step in development may be small, every step could be crucial for the outcome of the accidents. As also stated in Section 5.1, a speed reduction in combination with improved impact absorbing crumple zones could give significant contribution to a reduction of fatalities and seriously injured in oncoming collision between cars and heavy duty trucks. According to the COMPAT report [3] if relative speeds in oncoming collision could be reduced to 100 km/h or even 80 km/h, the positive outcome regarding reduction of fatalities and also seriously injured could be significant. These relative speeds could work as milestones on the way to reach the FFI Vehicle and traffic safety goal. The result from the Extended Collision Mitigation work does show that it contributes to reduce the impact speed in oncoming collisions. Though the reduction is not enough to reach the 100 km/h and 80 km/h milestones, provided that both vehicles are travelling in each direction on a 70 km/h or 80 km/h road, this could work as a partial solution together with additional passive safety systems. It shall also be seen as a first step towards even higher impact speed reduction when development work continues. Considering the heavy weight of the truck compared with the oncoming vehicle, every speed reduction of the truck would give a significant contribution to the reduction to the energy of movement of the truck.

6. Dissemination and publications

Internal dissemination at Volvo has been carried out by several seminars and meetings.

Externally one workshop with traffic safety analyst of TRV (Johan Strandroth) has been held to discuss the possibilities and challenges with autobraking for heavy vehicles.

7. Conclusions and future research

The prototype CM system developed in this project provides warnings to the driver and executes auto brake to mitigate head-on collision. The system including HMI hardware has been developed and evaluated in the driving simulator,

The effect of the emergency braking has been analyzed. The accident statistics show that in a car-truck head-on collision, it is usually the car at fault, which results in a passive position for the truck to take action to avoid the collision. Moreover, a truck has a lower capability to steer away than a car. Thus, only a late decision can be made for the truck. However, due to the big mass difference, the emergency braking of a truck can still reduce quite much of the crash energy, and thus decrease the risk of fatalities.

A sensor with good lateral positioning for oncoming object is crucial. A camera could be an option in the future. The range of the sensor has to be sufficiently long in order to achieve a proper warning time, considering the high relative speed and the driver reaction time. The sensor should also provide good lane assignment information for the system to clearly distinguish objects in the host vehicle lane. Sensor data filtering is needed to handle sensor output noise so as to ensure a stable risk assessment. The sensor requirements concluded from the project can be continued in a future project between Volvo and sensor suppliers.

The simulator study shows that an Extended CM system with a sound and HUD HMI helps to reduce the impact speed in a type of head on collision situation. It is difficult to judge how much the autonomous braking and the sound and HUD warnings contributed to the speed reduction. However, most likely it is the autonomous braking had the biggest effect.

The analysis of the qualitative data also shows that the overall perception of the system was perceived as good for system equipped with sound and HUD HMI and acceptable for system equipped with sound only. This result shows that what the respondents like also corresponds with what gives the best performance.

Since there isn't any significant difference in braking pattern for the respondents that receives a warning consisting of sound and HUD compared to baseline, it is possible that there is more room for developing an HMI that gives a better and stronger intervention from the driver in head on collisions. When it comes to warn already alert drivers, who are aware of the seriousness of the situation, this design of HMI may not be optimal. Though, in situations with a distracted driver it is likely that this kind of HMI design would help to alert the driver. The fact that it is the oncoming vehicle that is at fault may also affect the late strong braking from the respondents.

The recommendation is to continue the development concerning the autonomous braking since this study shows that it reduces the speed at time of impact for this kind of head on collision scenario. An HMI solution as used in this second round simulator study may not have a major positive impact on the driver behaviour but certainly not a negative one. Though, in a situation with a distracted driver it is very likely that it would help to get the drivers attention. In order to improve the driver reaction and countermeasure the HMI needs to be further developed and perhaps also re-designed. To get proper knowledge on how to continue that development, more work needs to be done on driver behaviour in head on collision situations.

The study accident mitigation and avoidance for extended scenarios will be carried on to the ongoing FFI project Non-Hit Car and Truck (NHC&T) , where AB Volvo is one of the partners.

8. Participating parties and contact person

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