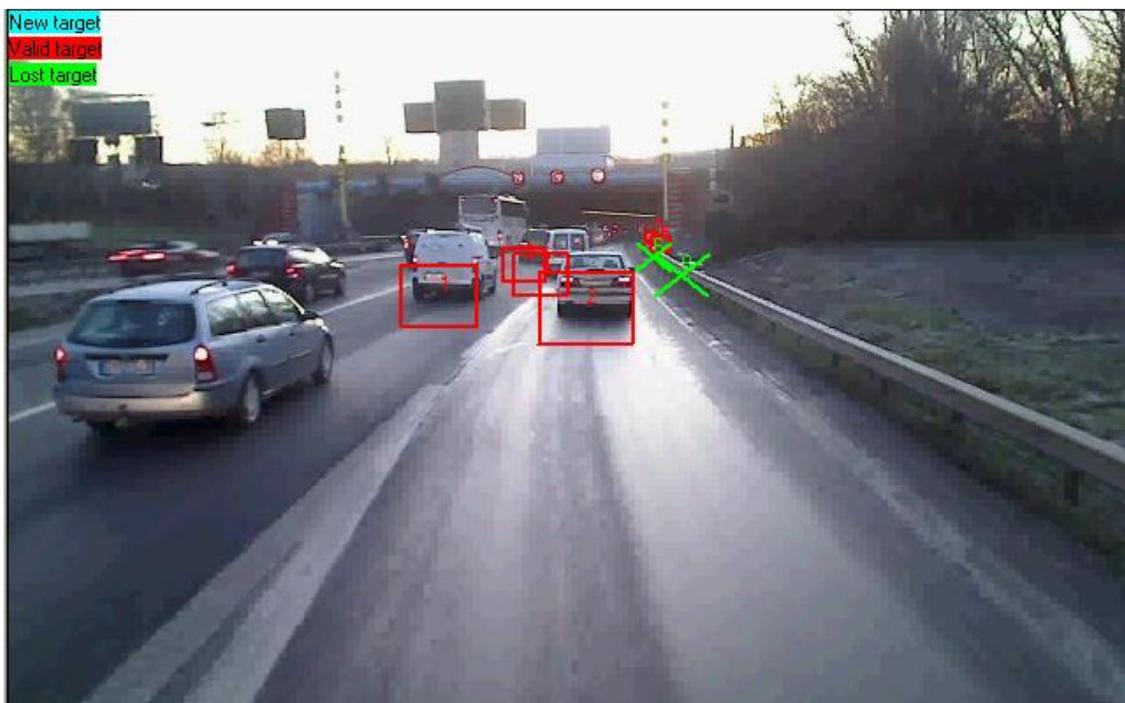




Low Cost Sensor Concept for Collision Mitigation



Author: Anna Theander, Volvo Group Trucks Technology

Date: 2012-01-23

Project within Fordons och trafiksäkerhet



Content

1. Executive summary	3
2. Background	4
3. Objective	5
4. Project realization	5
5. Results and deliverables	6
5.1 Delivery to FFI-goals	6
6. Dissemination and publications	7
6.1 Knowledge and results dissemination	7
6.2 Publications.....	7
7. Conclusions and future research	7
7.1 Conclusions.....	7
7.2 Future research.....	8
8. Participating parties and contact person	8
9. References	9

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



1. Executive summary

The project “Low Cost Sensor Concept for Collision Mitigation” is partly funded by the “Fordonstrategisk forskning och innovation (FFI)” program with Volvo as the only partner. This report presents an overview of the findings of the FFI project.

The legal demand of Advanced Emergency Braking System (AEBS) will affect the sensor technology development within commercial vehicles since AEBS will become mandatory.

AEBS or Collision Mitigation (CM) system intervene by braking if a rear-end collision accident is imminent and not avoidable and thus mitigate the accidents impact. The goal of this project is to investigate possible sensor concepts within a reasonable cost that can fulfill the legal demand.

The implementation of the UN/ECE AEBS regulation in EU-EFTA for commercial vehicles will be done in two steps:

- November 1st 2013 for New Types (NT) /November 1st 2015 for New Registrations (NR)
- November 1st 2016 for New Types (NT) /November 1st 2018 for New Registrations (NR)

where certain vehicle types/applications will be exempted from the regulation.

Therefore it has been important to investigate sensor technologies that meet the legislation but still within a reasonable cost.

The project work consists of three work packages:

1. The requirement phase (WP1)

The project has during the requirement phase performed an analysis of the draft proposals of [1] ISO 22839 (Forward Vehicle Collision Mitigation Systems) and [2]-[5] UN/ECE regulation AEBS (Advanced Emergency Braking System). From the analysis, a number of requirements on a low cost sensor concept have been derived.

2. Sensor test and concept phase (WP2)

A sensor market survey on currently existing and possible future sensors was performed where a number of suitable sensor concepts and different sensor technologies were investigated. Sensor evaluation was done with regards to performance, cost, environment, packaging, interface and calibration.

3. Implementation tests and evaluation (WP3)



The selected samples were mounted and integrated in a Volvo truck. Data analysis of the AEBS functionality was made by testing the selected sensors on Volvo test track. 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

Accidents statistics show that so called rear-end collisions are responsible for a large share of injuries and fatalities in traffic, especially when commercial vehicles are involved. Thus systems to prevent these kinds of accidents or at least mitigate the effects if they cannot be avoided, so called Collision Mitigation (CM) systems, have been subject of research in the last decade but also recently find their way into the market for passenger car (mostly upper class) and commercial vehicles (few manufacturers) but still in very low volumes.

The overall number of Collision Mitigation systems on the market is still quite low due to high component and development cost. To overcome this situation there is a strategy from the European Commission to introduce several advanced vehicle safety systems into a regulation which shall make Collision Mitigation systems (in the proposal referred to as Advanced Emergency Braking systems, AEBS) mandatory for commercial vehicles.

Before such a mandatory introduction of Collision Mitigation systems, an agreement on technical performance requirements must be achieved. Thus discussions on UN/ECE level have been ongoing to achieve a wide harmonization of standards. The standard shall define the general concept of operation, a minimum functionality, the system requirements, system interfaces and test methods.

The legal demand is called Advanced Emergency Braking System (AEBS) and will become mandatory for commercial vehicles:

- 1st of November 2013 - New Types (NT) with some exceptions
- 1st of November 2015 - New Registrations (NR) with some exceptions

Since the AEBS system will be introduced at a high number of commercial vehicles, sensor system and concept that provide the required functionality to a reasonable cost need to be investigated.



3. Objective

The goal of this project is to investigate possible sensor concept within a reasonable cost that can fulfill the AEBS legal regulation.

The project shall provide different sensor concepts, test and evaluate the achievable functionality with at least one of such sensor concept. To achieve this, the corresponding draft UN/ECE AEBS regulation shall be examined and several levels of performance shall be derived from this.

For selected levels, environmental perception concepts and requirements need to be elaborated with focus on achieving the required functionality to a best possible estimated cost. Those concept and requirements shall then be bench-marked, tested and evaluated with regard to sensor performance and overall Collision Mitigation system performance based on those sensors.

To meet the above UN/ECE regulation to integrate a Collision Mitigation system into all vehicles a new approach is needed, to reduce complexity and costs of sensors concepts on one side and to increase flexibility and feasibility on the other side.

4. Project realization

Work package	2009												2010												2011																							
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12												
WP1 - Requirements												M1																																				
WP2 - Sensor Test and Concepts												D1																																				
WP3 - Implementation test and Evaluation																																																

The requirement phase (WP1) was closed in the end of 2009. The project has during the requirement phase done an analysis of the draft proposals of ISO 22839 (Forward Vehicle Collision Mitigation Systems) and UN/ECE regulation AEBS (Advanced Emergency Braking System). From the analysis, a number of requirements on a low-cost sensor concept have been derived. The project has established contact with the Volvo representatives of the forums in which the above proposals are discussed.

End of 2009 the sensor test and concept phase (WP2) started by evaluating a number of sensor concepts with regard to UN/ECE regulation AEBS and ISO 22839 requirements. A sensor market survey on current existing and possible future sensors was performed where a number of suitable sensor concepts and different sensor technologies were investigated. An initial evaluation of the sensors was done based on specifications. The



result was compiled into a functionality performance matrix. The matrix was used as a base for evaluating different sensor technologies and selecting what sensors and suppliers to proceed with. The results were analysed in a workshop where the evaluation matrix was updated. The cost was analysed together with purchasing and included in the matrix. Sensor evaluation was done with regards to performance, cost, environmental, packaging, interface and calibration.

Potential suppliers were contacted and their sensor systems were evaluated on Volvo test track and in real traffic. The test plan used for evaluation included both use and misuse cases. It was created based on AEBS requirement and other important sensor characteristics. Six sensor systems were evaluated and data analysis was performed with corresponding test reports written. Based on the analysis, three sensors were selected for further evaluation. AEBS legislation discussions were also followed during WP2 and suggestions were provided.

During implementation tests and evaluation (WP3), the sensors were be mounted and integrated in a Volvo truck. A gateway was created to adapt the sensor to a Collision Mitigation functionality interface. The test plan was updated and extended with more use and misuse cases.

The sensors were tested on a Volvo test track together with a data interface to the Collision Mitigation functionality. Data analysis was performed to evaluate best possible sensor with regard to sensor performance and overall Collision Mitigation system performance.

Finally requirements as sensor performance, cost, environment, packaging, interface and calibration were elaborated with focus on achieving the required functionality to a best possible estimated cost.

5. Results and deliverables

5.1 Delivery to FFI-goals

The project will contribute to the overall targets of the program as indicated in the following summarizing list:

- Main purpose and contribution of the project is to reduce the number of seriously or fatally injured in traffic. This can be achieved by providing evaluated and ready to implement sensor concepts for Collision Mitigation system at a competitive cost level.
- The work will contribute to maintain and improve Volvo core values in terms of safety and improve the competitiveness of Volvo against other commercial vehicle manufactures.



- The project allows transferring know-how of earlier European or national projects into new and upcoming series production systems.
- The work will allow maintaining and enhancing the competence within active safety for AB Volvo.
- Relevant and competent personnel can be kept inside the company and thus the project promotes employment.
- The project will enable to set up clear requirements for cost efficient sensor systems for CM systems. These can be used in cooperation with other projects inside the program or dedicated suppliers to perform dedicated development work towards providing such sensor concepts.

6. Dissemination and publications

6.1 Knowledge and results dissemination

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

6.2 Publications

No publication has been published during the project.

7. Conclusions and future research

7.1 Conclusions

Different low cost sensor concepts as radar, stereo-vision system, lidar and Time-of-Flight (TOF) cameras have been evaluated during the project phase.

Stereo-vision and TOF cameras have recently found their way into the market for passenger car, but still under development for commercial vehicles. However, the technologies are very interesting for further evaluation when the sensors have become more adapted for commercial vehicles. Lidar sensors are still expensive compared to radar sensors.



Due to performance and state-of-the art many OEM, both for passenger cars and commercial vehicles, have chosen radar as the base for Collision Mitigation (CM) systems, often combined with mono-camera.

7.2 Future research

Within the project, knowledge and know-how transfer from previously gained experience within national and international research towards a more series production oriented and closer to market perception system concept have been achieved.

Besides the expected direct influence on series production solutions for CM systems, the project has as well strengthen the role of AB Volvo and Volvo Group Trucks Technology within future national and international research projects by building up new projects and cooperation based upon the knowledge and competence gained during the project. Thus further strengthen the important role of overall Swedish automotive industry in Europe and European research.

8. Participating parties and contact person



Anna Theander, Volvo Group Trucks Technology, +46-31-323 35 97,
anna.theander@volvo.com

Hans Deragården, Volvo Group Trucks Technology, +46-31-322 80 54,
hans.deragarden@volvo.com

Hong Yang, Volvo Group Trucks Technology, +46-31-322 75 59,
hong.yang@volvo.com

Hui Zhong, Volvo Group Trucks Technology, +46-31-322 72 09,
hui.zhong@volvo.com

Malte Ahrholdt, Volvo Group Trucks Technology, +46-31-322 67 09,
malte.ahrholdt@volvo.com



9. References

- [1] ISO 22839 (Forward Vehicle Collision Mitigation Systems)
- [2] ECE/TRANS/WP.29/2011/92, Draft Regulation for vehicles equipped with AEBS
- [3] ECE/TRANS/WP.29/2011/93, draft 01 series of amendment to the above and WP.29/GRRF-71 Informal 27, agreed corrections to the above two documents
- [4] Directive 2007/46/EC Point 5 of part A of Annex II- Special purpose vehicles
- [5] Directive 2007/46/EC Points 4.2 and 4.3 of Part A of Annex II- Off- road vehicles
- [6] FFI Extended Collision Mitigation - Technical final report



FORDONSSTRATEGISK
FORSKNING OCH INNOVATION

Adress: FFI/VINNOVA, 101 58 STOCKHOLM
Besöksadress: VINNOVA, Mäster Samuelsgatan 56, 101 58 STOCKHOLM
Telefon: 08 - 473 30 00