



Further development of passive safety test and measurement methods for heavy commercial vehicles



Project within Vehicle and Traffic Safety

Stefan Thorn

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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 current project proposal aims to perform a continued work with implementing and refining passive safety test methods for heavy commercial vehicles by a number of validating crash tests. Furthermore, the aim was to perform a continued evaluation of the biofidelic limits with crash test dummies and of improved dummy instrumentation, including validating crash tests.

The project has delivered the following results:

- Crash tests and crash simulations has been performed and evaluated according to the developed test and evaluation procedures for: impact friendly exterior and interior, front and rear under-run protection, cab strength pendulum impacts, rollover, and frontal barrier crash.
- Based on these findings, adjustments of the test and evaluation procedures have been performed. Head impact and barrier crash simulation methods have also been validated by physical tests.
- The findings has been presented within the Volvo Trucks product planning organisation and has been found as a tool easy to interpret for evaluation of the total safety benefit of different safety systems.
- The biomechanical limits with crash test dummies have been further evaluated, including validating pendulum tests on Hybrid III chest with and without extra instrumentation. The extra-instrumented dummy has furthermore been successfully tested in a number of sled test and also in two full-scale tests. The work is continuing in the FFI funded project Chest injury prediction in heavy vehicle collision tests (Dnr 2010-02136), and will lead to doctoral thesis for the PhD student during autumn 2012.
- The results have been presented internally and externally on several SAFER seminars and on international scientific conferences. The results will also be used for continued communication of passive safety within the Volvo organization.

2. Background

Swedish commercial vehicles are among the safest on market. Heavy investments have been made to achieve this position, e.g. by high and detailed safety design targets. Non-experts and customers do however have difficulties to interpret these targets. This problematic lead to a development of passive safety test methods for heavy commercial vehicles (Dnr 2006-01005).



3. Objective

The project aims to perform a continued work with implementing and refining these test and measurement procedures by a number of validating crash tests. Furthermore, a continued evaluation of the biofidelic limits with crash test dummies and of improved dummy instrumentation, including validating crash tests, will be performed.

4. Project realization

The following project activities have been performed:

- Crash tests according to the developed test procedures from previous project (Dnr 2006-01005)
- Evaluation of results
- Communication and implementation of the test procedures in the Volvo internal product development and product planning organisation
- Continued PhD research on improved chest injury criteria for heavy commercial vehicles; definition of criteria levels, instrumentation of crash test dummy, crash tests and validations
- Dissemination activities through scientific papers, conferences and seminars.

5. Results and deliverables

- The test protocols has been refined and used by input from physical testing, simulation activities and new scientific findings. The methods and results has been communicated and implemented in the daily project development work.
- Comparative studies of pedestrian and FMH head form impactors have been performed for interior and exterior head impact tests. With same impact velocity used for both head forms, the adult head form tends to result in higher peak accelerations and higher HIC(d) values. The difference was approximately 100 – 200 in HIC(d).
- The head impact simulations have been validated to real physical tests. The head form rubber may be modelled too stiff when the interior trim bottoms out.
- A re-instrumentation of the Hybrid III dummy, measuring multi-point chest deflection by a RibEye™ equipment, has been implemented and evaluated in pendulum tests, sled tests and full-scale truck collision tests. Tests validating the dummy simulations have been performed. A suggested method to measure the Hybrid III chest deflection and evaluate injury risks at impact point has been developed.

5.1 Delivery to FFI-goals

The work has contributed to increased knowledge of how different parts of the passive safety systems contribute to the total safety level for the heavy commercial vehicle. This will be an important tool to reach the goals to *perform relevant development activities* and to *strive for that new knowledge is developed and implemented and that existing knowledge is implemented in industrial applications*. The work is also aiming to develop knowledge and strategic tools that are needed to ensure that Swedish manufactured heavy commercial vehicles maintain the position as leading in safety, which is as important contribution to the goal to *contribute to a continued competitive Swedish vehicle industry*.

The work is also contributing to the goal to *strengthen the cooperation between vehicle industry, authorities, universities, and research institutes*. AB Volvo and Chalmers are both partners in the SAFER centre. A significant part of the project has been performed in the SAFER environment at Lindholmen Science Park. By that, the project has benefited for the environment and from other SAFER related projects using similar tools, for instance human body models. The project contributes also back to this environment and thereby also to the goal to *support research and innovation environments*.

Furthermore, the project has contributed to the Vehicle and Traffic Safety program goals by definition and validation of *evaluation methods for passive safety* and by research within *Biomechanics – “human modeling” and method development*. The results are relevant for industrial applications within heavy commercial vehicle transports.

6. Dissemination and publications

6.1 Knowledge and results dissemination

The results have been presented internally and externally at several SAFER seminars, and on two international scientific conferences. The results will also be used internally for continued communication of passive safety within the Volvo organisation.

6.2 Publications

Holmqvist, Kristian; Svensson, Mats Y.; Davidsson, Johan; Brolin, Karin; Thorn, Stefan (2010): Challenges in Steering Wheel Rim to Thorax Impacts Using Finite Element Hybrid III and Human Body Models for Heavy Vehicle Frontal Crash Applications. International IRCOBI Conference on the Biomechanics of Impact, pp. 293-296.

Holmqvist, Kristian; Svensson, Mats Y.; Davidsson, Johan; Thorn, Stefan (2009): Evaluation of Hybrid III Thoracic Injury Criteria in Impacts With a Simulated Truck Steering Wheel Suggestions for Modifications in Instrumentation and Reference Values. International IRCOBI Conference on the Biomechanics of Impact, pp. 201-204.



Holmqvist K, Svensson M, Thorn S, Rundberget P, Törnvall F, Davidsson J (2012). Heavy Vehicle Frontal Sled Crash Test Analysis - Chest Deflection Response in the Hybrid III Dummy. Manuscript.

7. Conclusions and future research

- The project results have given an increased competence and knowledge on how different parts of the passive safety systems contribute to the total safety level for the heavy commercial vehicle, which will be an important tool to perform relevant development activities and to strive for that new knowledge is developed and implemented and that existing knowledge is implemented in industrial applications
- The research on development of injury criteria and criteria levels for chest injury prediction is continuing in the FFI funded project Chest injury prediction in heavy vehicle collision tests (Dnr 2010-02136), and will lead to doctoral thesis for the PhD student during autumn 2012.

8. Participating parties and contact person

CHALMERS



Stefan.thorn@volvo.com