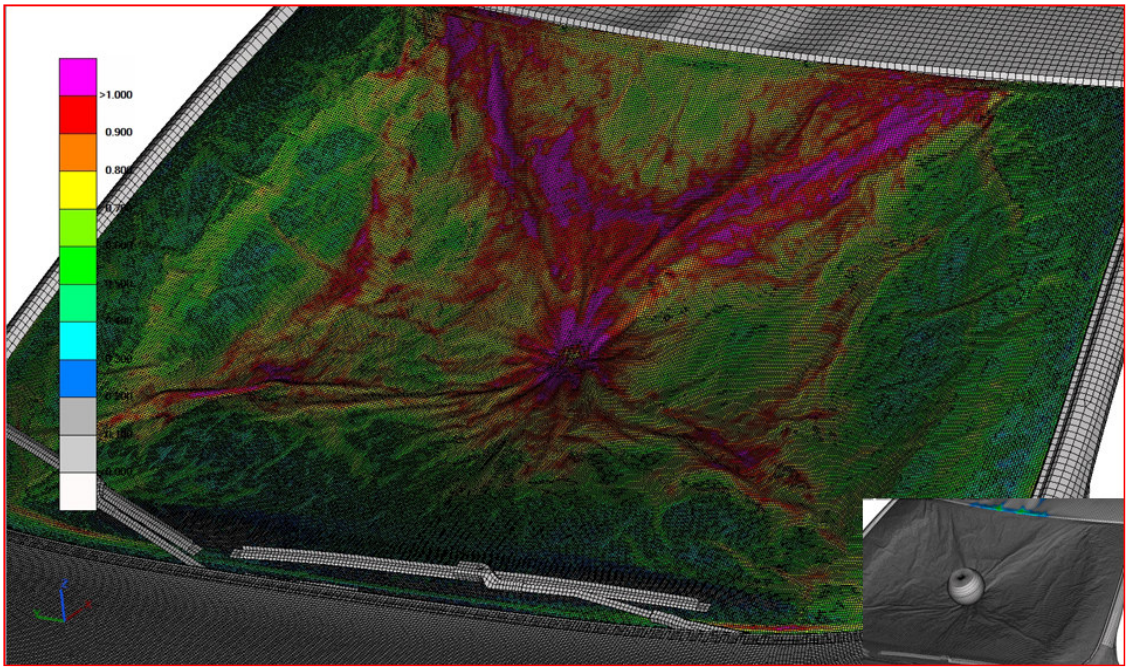
Pedestrian friendly vehicle - Safety activities for vulnerable road-users



Windscreen deformation with new windshield model (max plastic strains)

Project within Fordons – och trafiksäkerhet

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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

1. Executive summary

The sub-projects below (1.1, 1.2a, 1.2b, 1.3) were conducted as separate stand-alone projects, with its own autonomous project teams. The results are confidential within each sub-project. However, partial results may be published in SAE reports and conference reports.

1.1 Field data study:
Pedestrian safety priorities for passenger cars are usually based on data with varying car makes and models. The field data study in this project has resulted in a new database, V_PAD (Volvo Cars Pedestrian Accident Database), with a homogeneous car sample providing a relevant, up-to-date distribution of accident situations as well as pedestrian characteristics and driver information.
A total of 330 pedestrian car accidents are analyzed with the aim to present a first summary of the V_PAD data in terms of accident, injury and impact aspects. The database with cars of the same types gives unique possibilities to design and evaluate effective safety measures for pedestrian safety. The results in this study will form the basis for further improvements, both considering driver support and crash compatibility.

1.2a Development of simulation model for windshields:
The objective of the project was to develop a simulation model of a windshield for simulations of pedestrian accidents, i.e. to simulate the head of a pedestrian impacting the windshield. By improving the modelling technique used for the analysis of head impact against windshield the aim was to get a good correlation both of the crack propagation of the windshield and deceleration signal of the head when comparing CAE with test results. Main focus was to get a good correlation of the deceleration signal.
The first step was to perform a literature survey to make sure the project start with state of art knowledge. Develop accurate simulation models of the windshield is a big challenge while windshield is laminated and is built up of two layers of glass with a plastic PVB layer in between.
Use of a well defined impactor and set up a well defined test method for a component test of the windshield was other important steps to have the prerequisites to improve todays material model of the windshield.
From the component tests a detailed study of the head impact problem into laminated windshield could be done to determine the most important physical aspects which need to be captured. With this knowledge the next step was to implement a new material model for glass and analyse the results. A correlation study was made in CAE with the analysed test results.
To further tune in and understand the behaviour of the windshield a parameter study was performed to set parameters of the new material model. This new material model was then implemented into a Volvo vehicle model and a correlation study was performed to compare the CAE results with test results.

1.2b Design language impact on pedestrian safety:
The task was to find tools to predict pedestrian performance, especially on curved shapes and to find tools to predict performance on styling release instead of NUFO release, this to have a better start when the design phase starts. The results from the pilot project were very good.

1.3 Development of simulation model for active pedestrian systems:
Research on technical solutions with active pedestrian protection systems have been implemented, however, no correlated calculation models are available today. Validated CAE models are a necessity to implement and optimize system solutions in vehicle projects in an effective way.
The planned activity in this sub-project was the development of CAE models for active pedestrian system, including activation and energy absorption, and its impact on adjacent components. The planned results were correlated CAE models matched to the physical tests.
Due to strategic changes in the planned active pedestrian system has only physical tests and simplified calculation models been developed. The project has therefore not used up the whole planned budget or received all planned results. Cooperation with the intended partner was limited and the work has mostly been performed at Volvo Cars.

2. Background

A major problem in the world is injuries to the vulnerable road users. 1.1 million are killed annually in traffic, of which 65% are vulnerable road users (ref. World Bank 2001). 8000 vulnerable road users are killed annually in Europe, and 300 000 are injured. Global pedestrian legal requirements and Consumer Institute operates in the automotive industry to develop new innovative technologies.

The fundamental first step in sustainable development cycle always includes a relevant survey of the problem. VCC's field data-based approach, Figure 1, is used since the early 70's with successful results. This project aims to provide a basic understanding of how requirements of cars and systems should be designed with regard to vulnerable road users.

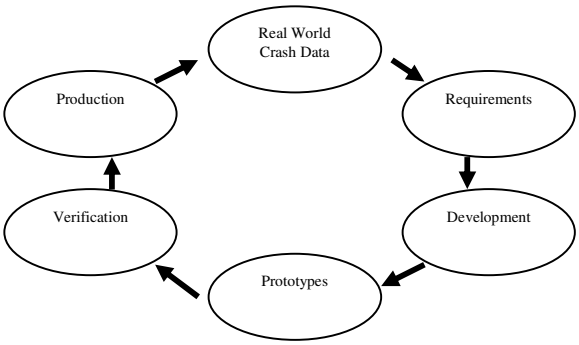

Figure 1. VCC's field data-based process

From a car manufacturer's perspective, in order to contribute to the reduction of injuries or accidents and set the right priorities, it is important to have knowledge about the character of real world accidents with cars relevant for the manufacturer. Also, as results from legal and consumer testing show significant differentiation between different car models, it is important to have a sufficiently large and homogenous data set in terms of the cars involved from which to work.
For car-to-pedestrian accidents, such knowledge has not readily been available. The databases on hand usually contain a heterogeneous vehicle population. Further, in many studies the analysis is limited to a specific pedestrian injury severity level, age group, or excludes certain types of driving locations.
For a car manufacturer, who ideally would prefer to work with a modern and homogenous car-make sample that includes all types of pedestrian accidents, these limitations pose a difficult challenge. The database is intended to provide a basis for further developments within the pedestrian-car accident research area, aiming at priorities for active, integrated and passive safety measures, as well as comparative analyses with other pedestrian car accident databases.

To reduce the harmful effects of accidents the car industry can help to make vehicles more energy-absorbing in the front-end for pedestrians and thereby reduce the severity. This drives the development of new technologies of both static and active pedestrian systems. An active pedestrian system means that the car is placed on the increased energy-absorption in a collision. This allows for a lower car and thus reduced fuel consumption.
Previously conducted research has so far been directed towards solving the first generation of pedestrian safety. Example is the energy-absorbing hood, which was introduced in the early 2000s. Basic research of active pedestrian systems has previously been performed by IVSS projects through 2008.
Today it is very time consuming and costly to implement an active pedestrian system in the project, due to lack of simulation methods. Development of material models and correlated simulation methods is a necessity. This includes the active pedestrian system itself, but also interoperable systems and components manufactured by several different types of materials.

The aim with this project and previous experience is to take a leading position in pedestrian safety, promoting our brand value and competitive force.

3. Objective

The overall objective of the project was to analyse field data for the specification of the problem scenario for pedestrian accidents, development of simulation models for windshields and active pedestrian systems and finally understanding of design language's impact on pedestrian safety.

The project consists of the following parts:

Field data study: with the objective to

- Analyse available field data - approximately 450 accidents from the years 1998-2008 to gain increased knowledge of accident scenarios and failure mechanisms.

Development of simulation model for windshields: with the objective to

- Simulate pedestrian head impact tests in the windscreen area to be able to predict the windscreen contribution in crash simulations.
- Use correlated CAE models matched to the physical tests in the future development process.

Design language impact on pedestrian safety: with the purpose to

- To understand different hood design shape effect on energy absorption. Design is a very important and trends change rapidly. Increased competition and increased safety requirements from the market, requires us to further develop a design language that also delivers the highest safety performance.
- Find out how to control the pedestrian results and be able to give design guidelines to designers and to styling department. Especially the curved shapes "the cat walk step" was to be considered.

Development of simulation model for active pedestrian systems: with the objective to

- Be able to use correlated CAE models in the development process.
- Simulate activation and energy absorption, and its impact on adjacent components.

4. Project realization

Field data study:
The field data study was performed by Volvia (IF P&C Insurances) and VCC with support from Y-Med. The information about pedestrian accidents in Sweden involving Volvo Cars was provided by Volvia (IF P&C Insurances) to Volvo's Traffic Accident Research Team and stored in the V_PAD database. All new Volvo passenger cars in Sweden are insured with Volvia for at least three years. Thus all pedestrian accidents were identified and sampled both for the newest vehicles as well as for a large portion of the older vehicles. The database contained information about the pre-crash scenario, the crash, the car, the driver and the pedestrian, in a total of 126 variables. Each case was anonymised before being stored in the database.

Development of simulation model for windshields:
Dynamore Nordic (former ERAB):

- Carried out the literature survey.
- Compared head form models between the used one at Volvo and the latest head form from ARUP.
- Studied the head impact problem into laminated windshield and determined the most important physical aspects which need to be captured.
- Made a material implementation of a new material model for glass and analyzed the results.
- Analyzed test results.
- Performed a parameter study to set parameters of new material model.

Volvo Cars:

- Carried out component tests of windshields.
- Carried out pedestrian head form impacts to windshields in vehicles.
- Implemented new material model into Volvo vehicle models and performed correlation study to test results.

Design language impact on pedestrian safety:
The over all plan was to find out how to control the pedestrian results and be able to give design guidelines to designers and to styling department.
Especially the curved shapes "the cat walk step" was to be considered, where we had poor knowledge of which parameters was important either as single parameter or in cooperation with others. When the formula was found we where able to make a model that could give simple and fast indication of what result a specific design will give.
From these results we can also create restrictions for deformation or change the design of the car. The model also made it possible to optimize the hood itself with glue and inner hood parameters.

Development of simulation model for active pedestrian systems:
The sub-project was initiated by needs identified by previous IVSS project "Pedestrian Protection airbag" reported 2008. The new and the old project were planned with the cooperation partners Autoliv, XDIN and VCC.
The planning phase was made in 2010 as previously reported.
A strategic system solution change was discussed and decided 2010Q4-2011Q1, which meant that the project was paused for reassessment.
It was decided to carry out the project in a more limited scale than in the original plan, and it was also decided that the project mainly should be done within Volvo Cars.

5. Results and deliverables

5.1 Delivery to FFI-goals

The project contributes to increased safety for pedestrians and thus protects it on Volvo's core values of safety and increased competitiveness.

The project contributes in general to the following of the FFI goals:

- increase industry's ability to competitively engage in knowledge-based production in Sweden.
- contribute to a continued competitive automotive industry in Sweden.
- carry out industrially relevant development schemes.
- lead to industrial technology and skills.
- contribute to security of employment, growth and strengthened R & D activities.

- support innovation and collaboration environments.
- work to ensure that new knowledge is generated and implemented, and that existing knowledge is implemented in industrial applications.
- work to ensure that the national human resource management are secured and that the R & D with international competitiveness is established.

By state of the art Field data study and CAE modell of the windshield together with the knowledge of the need of further improvements of static and active pedestrian protection systems will give Swedish vehicle industry important tools to keep the strength of pedestrian safety.

6. Dissemination and publications

6.1 Knowledge and results dissemination

The increased focus of the protection of pedestrians through the rating institutes and regulatory requirements will accelerate the spread of results from this project. The field data study and the simulation model for windshield will in future also be used in the development of ADAS systems.

6.2 Publications

Ircobi Conference 2011
IRC-11-61
Pedestrians interacting with a passenger car; a study of real world accidents
Magdalena Lindman, Lotta Jakobsson, Sofia Jonsson

7. Conclusions and future research

Field data study:
A homogenous car-make database providing relevant and up-to-date distributions of accident situations, pedestrian characteristics and driver information is a prerequisite for design of effective active, integrated and passive safety measures. In this study, an overview of the first known homogenous car-make pedestrian traffic accident database, the Volvo Pedestrian Accident Database (V_PAD), was presented and comparisons made with related data sets in order to assess V_PAD's potential as such data set. As the set covers all car moving directions, accident locations, injured as well as uninjured pedestrians for all age groups within a homogenous car-make sample it very likely can fulfil that role, i.e. provide the basis for a holistic analysis of how to further enhance pedestrian safety. Future research in the area of VRU (Vulnerable Road Users) will also include bicyclist data.

Development of simulation model for windshields:
The new material model brought forward in this project can be used for studies of the crack propagation in case of a pedestrian head form impacting the windshield. In total the new material model of the windshield need further improvements to be fully useful in analysing the pedestrian head form impacting the windshield.
The recommendation must be to continue improving the material model of the windshield with the aim to get a better correlation of the deceleration of the head form. This is necessary to be a fully useful tool for use in the work to continue to improve the safety of pedestrians.

Design language impact on pedestrian safety:
Conclusions was that each type of car shape needs a specified model, but similar cars can be handled in the same model

Development of simulation model for active pedestrian systems:
Results have been obtained in terms of progress in activation phase of the bag, tests correlated with the simplified calculation models.
Testing of the bags ability to absorb energy in different areas and different interactions with the surrounding components have been made, but not completely correlated with calculation models. Developments of simulation models for active pedestrian systems needs to be continued too make it possible to implement and optimize system solutions in vehicle projects in a more efficient manner.

8. Participating parties and contact person

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