

Authors

Renzo Cicilloni: Centro Ricerche Fiat

Stefan Deutsche: IKA

Karen Minna Oltersdorf: Tuev

Title: “Results of vulnerable road user protection system in PROTECTOR”

Abstract

Protector is a three years project funded by the European Commission that has the task to demonstrate the validity of a preventive vulnerable road user protection system in the improvement of the traffic safety. During the project life three demonstrator vehicles has been developed by the consortium with the specific objective to test in experimental conditions the effectiveness of solution envisaged and user acceptance, even if at prototype level. The paper will describe objective and subjective evaluation methodologies and main results.

Protector Aims and Objectives

PROTECTOR is a project with the aims of supporting (by a common definition of system requirements), guiding (by using common EU guidelines for system evaluation and validation) and validating (by test-site operation) the development of the sensorial and communication systems needed to **improve safety for the vulnerable road users** in urban and rural areas, and consequently to support the driver completely in all environmental scenario, improving accident reduction and guaranteeing a positive and remarkable social impact.

The focus of the project has been on the definition of the application in terms of functionality (user needs, scenarios to be covered, limitations and misuses) and architecture (interactions among the different on-board and off-board systems). The development and validation of implementation concepts based on autonomous sensors. The investigation of the road user needs has been relevant both in the definition phase of the PROTECTOR requirements and in the final assessment phase.

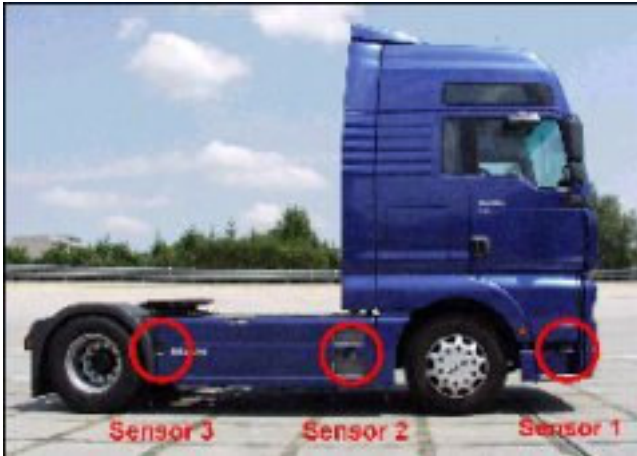
The Consortium developed car demonstrators, based on commercial vehicles and cars, which allowed the involvement of possible end-users since the beginning of the project. Thus it has been possible to work in parallel on system safety, system architecture and users interaction tasks in iterative steps to improve continuously the final product considering the end user requirements.

Since project beginning PROTECTOR involved a group of potential users in order to define their needs. This process has been achieved by the involvement of the users in specific field test in which the PROTECTOR application has been simulated and evaluated by interviewing campaigns.. With reference to the vulnerable road users detection, the verification of the application taken place in a controlled test site (reproduction of the real life situations in an artificial environment) including the scenario identified during the project first phases.

The Consortium involves the following European and extra –European partners: Centro Ricerche Fiat S.C.p.A., Università di Pavia, Centro Studi sui Sistemi di Trasporto, (Italy), DaimlerChrysler AG, MAN, IBEO Lasertechnik Hipp KG, SIEMENS, TÜV Kraftfahrt GmbH, Institut fuer Kraftfahrwesen Aachen, (Germany) Israel Aircraft Industries – TAMAN, RAMOT (Tel Aviv) University Authority for Applied Research and Industrial Development Ltd. (Israel).

Protector demonstrators

The three demonstrator vehicles built inside the project are a MAN truck with SiemensVDO 24 Gz radar, a FIAT passenger car with IBEO laser scanner and a DaimlerChrysler passenger car with DaimlerChrysler stereo-vision



Assist truck driver during right turn at intersection: warn for bicyclists that go straight.

There are two principal feedbacks to the driver:

- Information Situation: (if object was detected by sensor 1 or sensor 2 within range 30-200 cm and the driver has activated blinker for right turn)
- Warning Situation: (if object was detected by sensor 1 or sensor 2 within range 30-200 cm and the driver has turned the steering wheel more than 90° to the right)

Assist driver in the front part of the traffic scenario: warn both the driver and the vulnerable road user.

The driver have a tree level warning with visual feedback on a display and acoustical warning via speech information. The vulnerable road user get an acoustical warning from an array of buzzer placed behind the front bumper.



Assist driver in the front part of the traffic scenario: warn the driver .

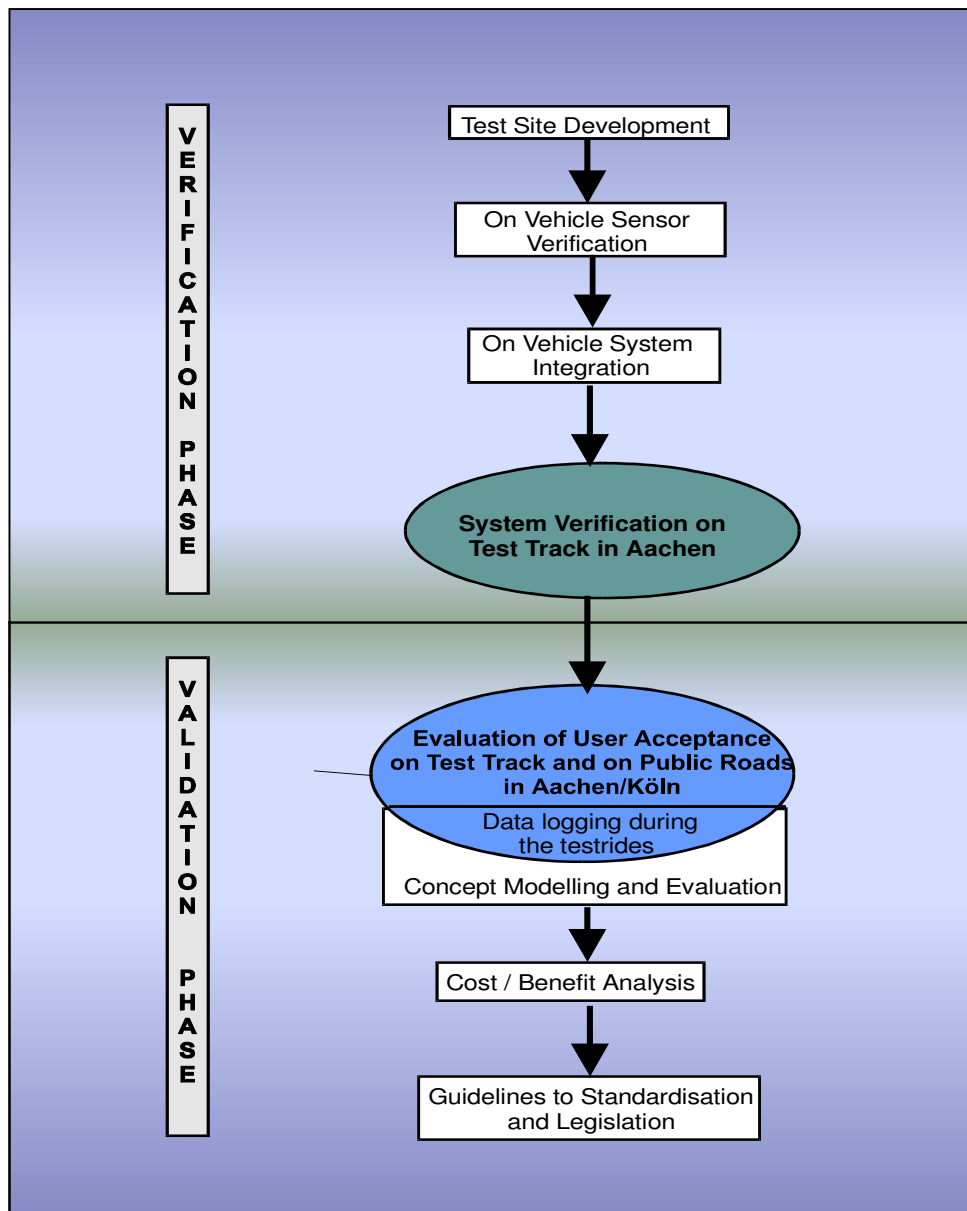
The driver have a one level acoustical warning in danger situation.

The evaluation process

In PROTECTOR the evaluation process gives strong emphasis to the verification and validation of the concept of vulnerable road user protection application as far as defined within the project.

The evaluation plan comprises a series of different trials that will be carried out with different objectives and means.

The following figure describes the evaluation process.



Two steps characterise evaluation plan, they are:

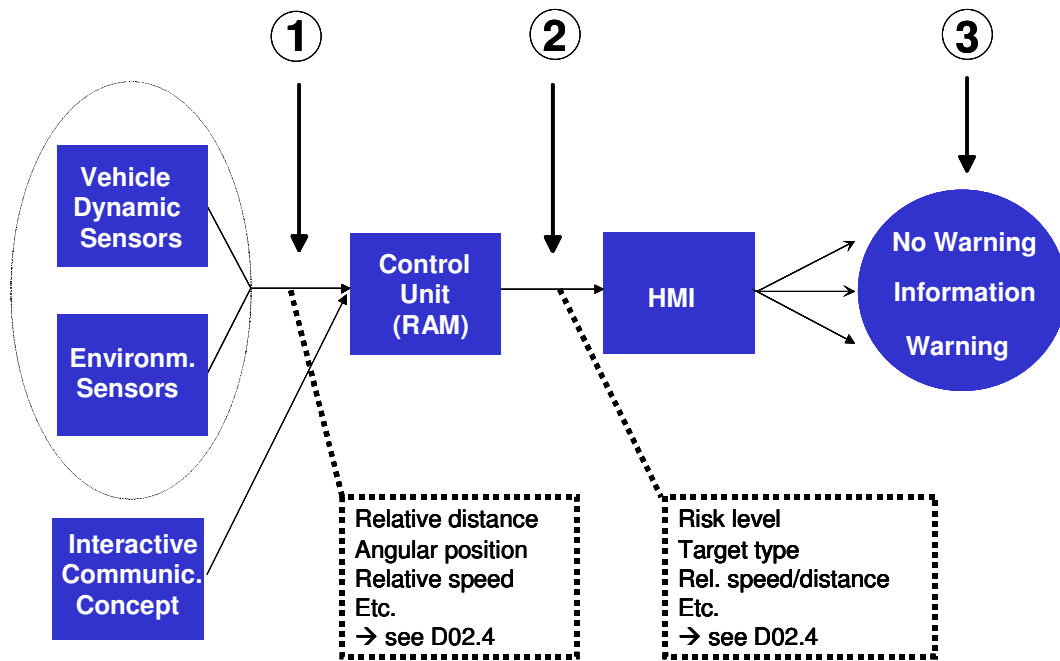
- Verification Phase
- Validation Phase

The paper will describes main outcomes of this two activities

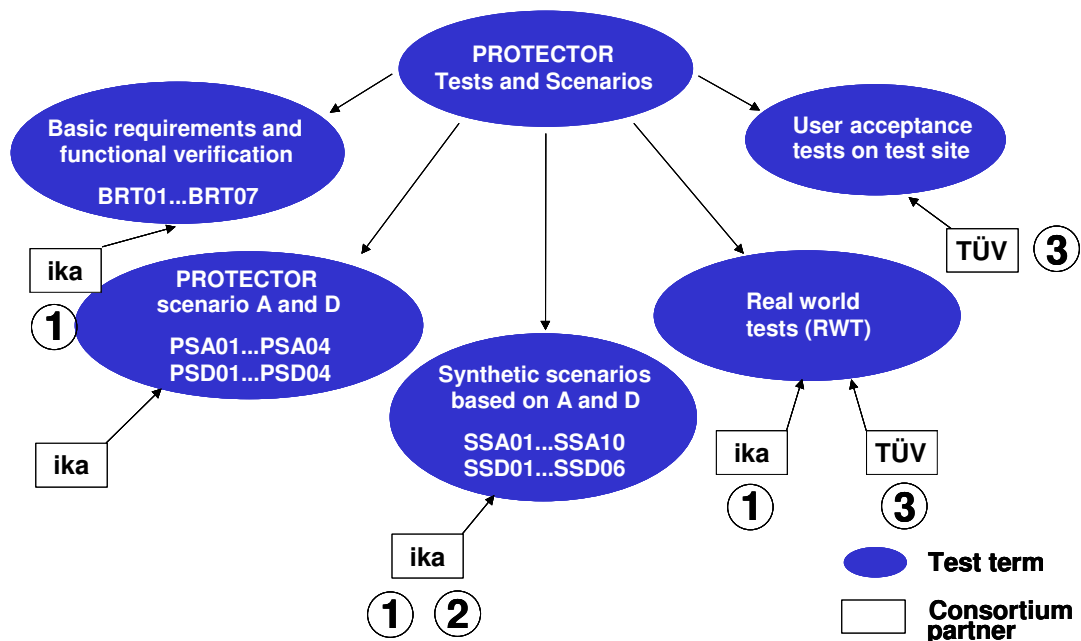
The verification phase

For the verification of the PROTECTOR system performance a test catalog was developed containing both sensor and system tests. These tests were done on a closed test track to avoid irreproducible influences on the system and also on public roads to get information about the system function under real traffic conditions.

As we are dealing with three demonstrators with different architectures the flow of information in the system is shown in a generalized way in the following figure. The figure shows the different modules of the PROTECTOR system and the position *where* to evaluate *which* information.



Based on the architecture of the PROTECTOR systems the tests are divided into a technical part of sensor and system tests to evaluate the function of each module separately and the user acceptance tests (UAT). The Point 1 in the above figure is just related to sensor output information like distance, speed and classification of objects. Point 2 is Risk Assessment Module output and Point 3 is output of the HMI. According to this segmentation the following figure shows the tests of the system with the points of information inspection and the consortium partner interested in the generated results.



The purpose and criteria for the above-presented tests are described in the following section and are related to the position of information inspection. The BRT (Basic Requirement Tests) evaluate the sensor performance like sensor coverage area and accuracy of distance and velocity by comparison to a secondary measuring system. These tests are done for all three demonstrators with dummy targets to guarantee reproducible conditions within the tests.

The scenario tests PSA and PSD are used for the Milestone to show the sensor function. They were done by the demonstrator builders. The synthetic scenarios SSA and SSD are enlargements of the defined PROTECTOR scenarios PSA and PSD with more than one VRU and roadside objects as noise for the sensors. The synthetic scenarios evaluate the function of the RAM module and also the sensor performance. These tests use real pedestrians and cyclists as targets.

The last step of the technical tests is the RWT (Real World Tests), which are designed to show the sensor function in real traffic under realistic conditions with the number of correct/false/missing detections as a result.

The validation phase

Main part of the Validation Phase was the User Acceptance Test, which mainly focuses on the user perspective, that can be divided into three levels: the cognitive, the emotional and the product acceptance level.

The following concepts have been kept in mind during this phase:

- User acceptance / perceptibility
- User comprehensibility / understanding
- User learnability
- Usability and Usefulness
- Monetary value (Willingness to pay)

With a total of 52 drivers the three demonstrators had been tested. Every test trial comprised a pre-questionnaire to explore the subjects' experience and attitudes, an introduction to one of the systems, a one-hour test ride on a selected route in urban area and through defined test scenarios on the test track and an extensive questionnaire after the test.

The results of the User Acceptance Test deliver the information needed for the further development and HMI-design of the PROTECTOR-System, that is the system's perception and understanding, i.e. which kind of warning (visual/acoustical) seems advisable, the distraction effect of the system and the perceived safety as well as the congruence between driver's perception and system performance. Besides that the attitudes towards the system and the willingness to pay are explored.