Testing and Evaluation Methods for ICT-based Safety Systems

Collaborative Project

Grant Agreement Number 215607

Deliverable D1.2

"CONCEPTS DEFINITION"

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Executive Summary

eVALUE will address the real function of ICT-based safety systems and their capability to perform the function through two courses of action: defining and quantifying the function output to be achieved by the safety system and developing the testing and evaluation methods for the ICT-based safety systems.

D1.2 rounds off the work being done under eVALUE's first WP establishing the basis of the project work by defining concepts for testing and evaluation of ICT-based safety systems. The document leans on the previous eVALUE deliverable D1.1, where the eight safety systems to be considered under the research of eVALUE can be found.

As a starting point, for the definition of the concepts, two approaches are analysed: system and scenario approaches. The system approach is intended to analyse a specific system under specific conditions. The scenario approach is selected and approved among the partners, as within this approach several safety systems can be considered working together in a certain situation (scenario). Then, the scenarios representing common road traffic accidents are defined and safety indicators for describing the safety performance are proposed.

The document also describes concepts for design review and laboratory testing and proposes templates for the test procedures to be developed in the next WP2.

D1.2 constitutes the starting point for launching the research work to be done in the WP2. The main contribution of this deliverable is the definition of the scenarios for the physical vehicle testing and the selected approach, since it establishes the basis for the rest of the work

Document Name

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Version Chart

Version	Date	Comment
0.1	07/11/08	TECNALIA-RBTK draft version delivered to consortium
0.2	28/11/08	TECNALIA-RBTK draft version delivered to IDIADA for internal revision
1.0	19/12/08	Final version as submitted to the EC
1.1	08/05/09	TECNALIA-RBTK draft version with addendum addressing 1st Review report comments delivered to consortium
2.0	20/05/09	Final updated version as submitted to the EC

Authors

The following participants contributed to this deliverable:

Name	Company	Chapters
I. Camuffo, R. Cicilloni	CRF	2, 3, 4, 6
K. Fürstenberg, D. Westhoff	IBEO	2, 3, 4, 6
A. Aparicio	IDIADA	2, 3, 4, 6
M. Benmimoun, J. Lützow, M. Lesemann, A. Zlocki,	IKA	2, 3, 4, 6
H. Eriksson, J. Hérard, J. Jacobson	SP	2, 3, 4, 6
N. Bilbao, I. Iglesias, L. Isasi, J. Sanchez	TECNALIA-RBTK	all
S. Leanderson, K. Heinig	VTEC	2, 3, 4, 6
H. Andersson, F. Bruzelius, J. Jansson,	VTI	2, 3, 4, 6

Coordinator

Dipl.-Ing. Micha Lesemann
Institut für Kraftfahrzeuge - RWTH Aachen University
Steinbachstraße 7, 52074 Aachen, Germany

Phone: +49-241-8027535
Fax: +49-241-8022147
E-Mail: lesemann@ika.rwth-aachen.de

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Table of Contents

1 INTRODUCTION

The content of this document "*D1.2: Concepts definition*" rounds off the work being done under eVALUE's first WP, establishing the basis of the project work by defining concepts for testing and evaluation of ICT-based safety systems.

As a starting point, D1.2 leans on the previous eVALUE deliverable D1.1 (refer to [DOC 2]) where a description on the eight safety systems agreed by the consortium to be considered under the research of eVALUE can be found.

The safety systems considered - with the aim to prevent or mitigate accidents – are listed below:

- CLUSTER 1 safety systems: ACC, FCW, CMbB, for longitudinal control
- CLUSTER 2 safety systems: BSD, LDW, LKA, for lateral control
- CLUSTER 3 safety systems: ABS, ESC, for stability control

This document therefore defines concepts for different possibilities of testing and evaluating the eight primary safety systems. The types of test taken into account in the eVALUE methodology can be split into design review, laboratory testing and physical vehicle testing. Each one of this type of tests are defined on the following chapters. It is worth mentioning that the progress achieved on the concept definitions have been exploited by WP2 Task 1.2, in order to draw up the definition of the testing matrix (refer to [DOC 3]), specially referred to the scenarios definition under the physical vehicle testing.

This deliverable will finalise the concept definition phase under WP1, carried out in tasks T1.1 to T1.4. The next phase, testing strategies on design review, physical vehicle and laboratory tests are to be developed under WP2 Task 2.2 to Task 2.4, respectively.

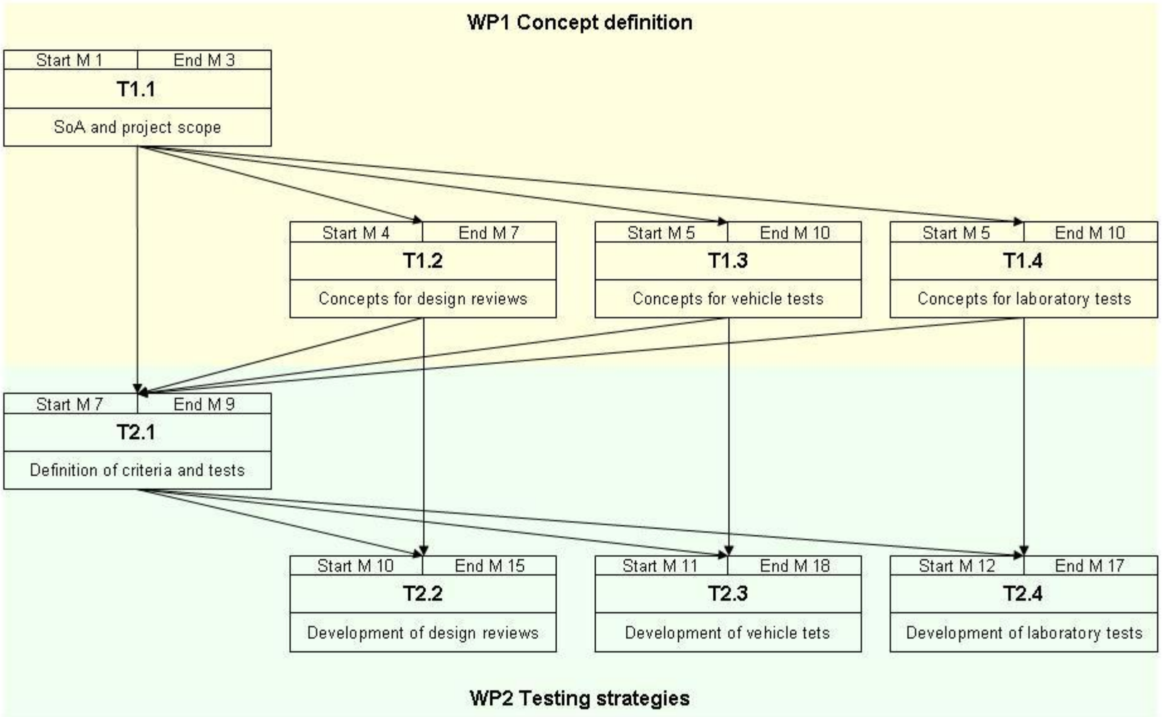


Fig. 1-1: Pert diagram of eVALUE tasks involved in deliverable D12.

The structure of this document is based on the three type of test considered under eVALUE, for this reason there is a specific chapter for each type of test (chapters 2, 3 and 4). Each chapter has a different structure depending on the need and potential outcomes of each type of test. In any case, every categorization for each type of test will be explained in the corresponding chapter. At the end of the document an additional chapter has been added (chapter 8 – Addendum) addressing the recommendations given on the Technical Review Report of the 1st review of the EC held on 18 March 2009 in Brussels. There it can be found eVALUE's approach using a V-model (refer to page 63 for further details)

It is important to note that the document uses different tables describing possible test procedures as examples for each type of test. These tables are given as possible description of the tests procedures. The precise content of these tables is still to be defined in the future work packages.

2 CONCEPTS FOR DESIGN REVIEW

Design review is the first type of test to be carried out under the eVALUE test methodology. The definition of design review assumed in the project is a systematic, comprehensive, and documented analysis of a design to determine its capability and adequacy to meet its requirements. It is also suitable to identify present and potential problems. Therefore, the purpose of the design review is the verification of the design itself, i.e., to test whether the design fulfils its requirements.

Based on the classification of the tests and standards stated in D1.1 (refer to [DOC 2]), which described testing based on systems and testing based on accident statistics, two approaches for design review have been analyzed under eVALUE:

1. Design review system approach.
   In this case, design review targets on specific systems, i.e., the objective is to test the ICT-based system. Under eVALUE scope this approach is focused on the eight ICT-based safety systems, hence, eight design review tests will be defined (one design review per system considered).

2. Design review scenario approach.
   This approach targets not specific safety systems, but the complete vehicle driving in specific traffic scenarios, derived from an analysis of accident data statistics together with the relevance of the considered ICT-based safety systems. The main difference with the system approach is that within this approach several, and combination of systems are considered when working together in a certain situation.

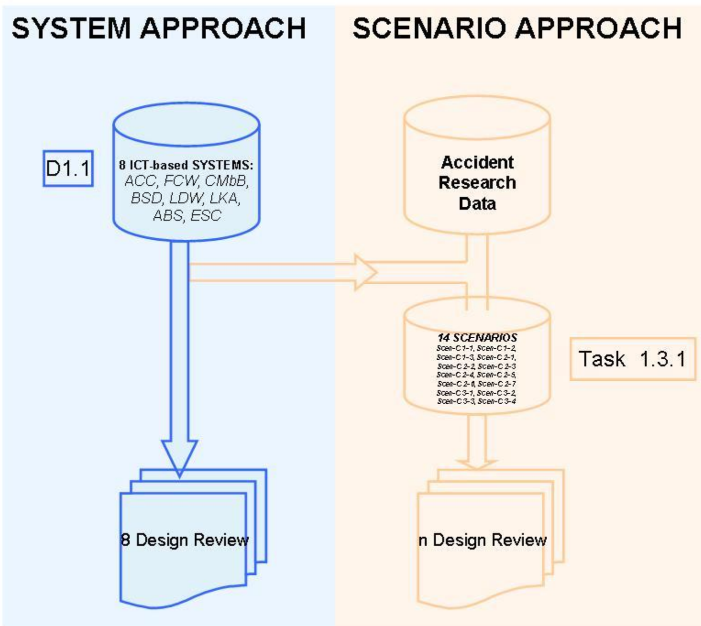


Fig. 2-1: Analysed design review approaches

2.1 Design review system approach

Following this approach, the design review verifies the ICT-based system performance, by checking the presence or not of the system components and their required specifications, i.e. sensors are able to measure the required variables, actuators are able to provide the required function output and ECU's fulfil the required high level functions (refer to the ICT-based safety system description [DOC 2]).

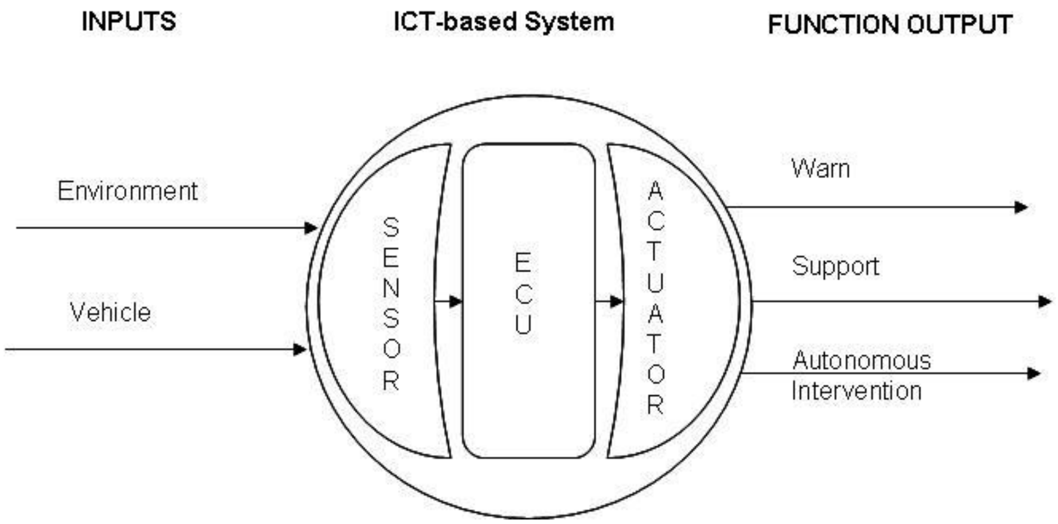


Fig. 2-2: Components of an ICT-based system

The design review, on a system approach, will look like a checklist and will include the following information:

- System information: general information in order to identify the system, i.e. name and cluster addressed
- Vehicle information (for instance vehicle type) related with the name of the car manufacturer and VIN (Vehicle Identification Number)
- System evaluation criteria, eVALUE criteria on global conditions for a positive evaluation of the system, based on D11, (refer to [DOC 2]).
- Component evaluation criteria. Verification at component level, i.e. match system component's specification of the car manufacturer vs. suppliers.
- Test resources, compulsory in order to execute the design review
- Design review result, overall result of the test.

Following these considerations, the checklist, i.e. design review for the BSD will look as follows.

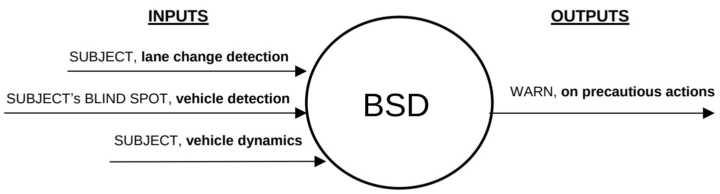
<table>
<tr><td>Type of test
Design review (DR)</td><td>Test identifier
DR-C2 -01-01</td><td colspan="2">System name
Blind Spot Detection (BSD)</td><td>Cluster name
CLUSTER 2: Lateral control</td></tr>
<tr><td>OEM / VIN
VOLVO
VIN number
Type of vehicle</td><td colspan="4">Sketch

</td></tr>
<tr><td>eVALUE criteria</td><td colspan="4">System level:</td></tr>
<tr><td rowspan="12"></td><td colspan="4">The eVALUE evaluation criteria of the BSD, at system level, identifies the following parameters as critical / minimum to be fulfilled by the system in order to obtain a positive evaluation:
☒Y ☐ N BSD system is be able to run at a relative speed between the target and the subject vehicle
☒Y ☐ N BSD system is able to detect a target on the blind spot area of the subject vehicle under certain dimensions
☒Y ☐ N BSD system is able to warn the driver visually
☒Y ☐ N BSD system is able to warn the driver acoustically
☒Y ☐ N BSD system is able to warn the driver haptically</td></tr>
<tr><td colspan="4">Component level:</td></tr>
<tr><td>Component</td><td>Existence</td><td colspan="2">Car manufacturer– suppliers</td></tr>
<tr><td>Steering sensor</td><td>☒ Yes ☐ No</td><td>☒ Matches</td><td>☐ No matches</td></tr>
<tr><td>Blinking sensor</td><td>☒ Yes ☐ No</td><td>☒ Matches</td><td>☐ No matches</td></tr>
<tr><td>Obstacle sensor</td><td>☒ Yes ☐ No</td><td>☒ Matches</td><td>☐ No matches</td></tr>
<tr><td>Speed sensor</td><td>☒ Yes ☐ No</td><td>☒ Matches</td><td>☐ No matches</td></tr>
<tr><td>Visual warning</td><td>☒ Yes ☐ No</td><td>☒ Matches</td><td>☐ No matches</td></tr>
<tr><td>Acoustic warning</td><td>☒ Yes ☐ No</td><td>☒ Matches</td><td>☐ No matches</td></tr>
<tr><td>Haptic warning</td><td>☒ Yes ☐ No</td><td>☒ Matches</td><td>☐ No matches</td></tr>
<tr><td>……</td><td>☐ Yes ☐ No</td><td>☐ Matches</td><td>☐ No matches</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Test resources:</td><td colspan="4">Vehicle: VOLVO VIN number
Blind Spot Detection System</td></tr>
<tr><td>Design review result:</td><td colspan="4">Overall result of the test</td></tr>
</table>

Table 2-1: Design review system approach: BSD system example.

2.2 Design review scenario approach

The main objective of the design review scenario approach is to verify, if the vehicle is able to cope with unexpected events and suddenly occurring critical situations. These traffic conditions, compiled by clusters, are distributed in the different scenarios considered on the physical vehicle testing described on chapter 4 (page 20). By checking the ICT-based system description, the test results derived from the design review generates first outcomes that will set the boundaries of the laboratory specific tests to be carried out by the subject vehicle, identifying the subject vehicle test suite from the overall test methodology.

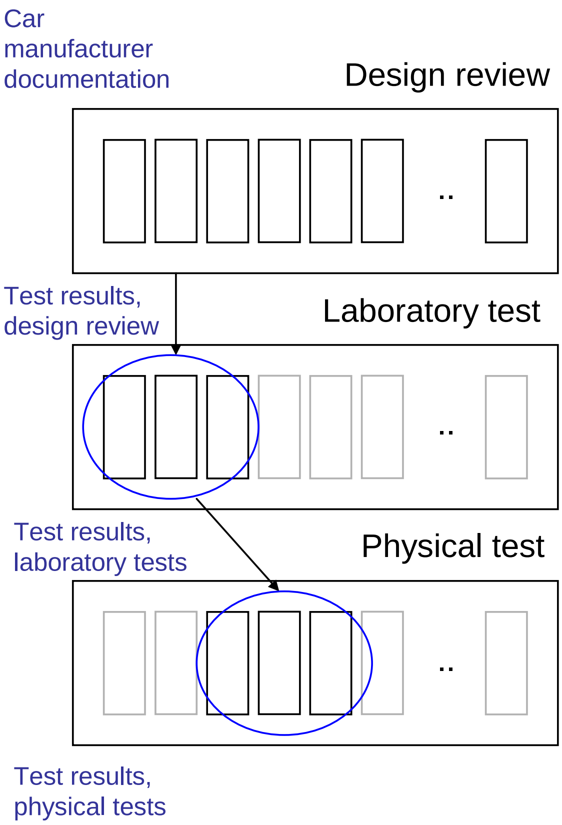


Fig. 2-3: Subject vehicle test suite

The design review, on a scenario approach, will verify that the vehicle is able to cope with:

- Longitudinal control requirements in order to set the boundaries of the laboratory specific tests to be carried out by the subject vehicle on the longitudinal control scenarios (page 25).
- Lateral control requirements in order to set the boundaries of the laboratory specific tests to be carried out by the subject vehicle on the lateral control scenarios (page 32).

- Stability control requirements in order to set the boundaries of the laboratory specific tests to be carried out by the subject vehicle on the stability control scenarios (page 47).

- Function output requirements, covering the overall scenarios, in order to set the boundaries of the laboratory specific tests to be carried out on function output, i.e., warning / support / autonomous intervention.

- Environmental conditions requirements, covering the overall scenarios, in order to set the boundaries of the laboratory specific tests to be carried out taking into account different environmental conditions, such as weather or infrastructure, for instance.

The design review, on a scenario approach, will look like a checklist and will include the following information:

- Test identification: general information in order to identify the test, i.e. type of test, name, identifier, cluster(s), scenario(s) and system(s) addressed.
- Objective and description of the test in order to set the boundaries of the laboratory specific tests to be carried out next.
- Check results on the car manufacturer provided information.
- Test resources, compulsory in order to execute the design review. Vehicle information related with the name of the car manufacturer and VIN will be detailed.
- Design review result, overall result of the test.

Following these considerations, in order to verify that the vehicle is able to cope with the longitudinal control requirements the design review template could look as follows:

<table>
<tr><td>Test name
Longitudinal control</td><td colspan="2">Type of test
Design Review</td><td>Test identifier
DR-Longitudinal control-xx</td></tr>
<tr><td>Cluster(s) addressed
CLUSTER1 – C1</td><td colspan="2">Scenario(s) addressed
Scen-C1-1 to Scen-C1-3</td><td>System(s) addressed
ACC, FCW, CMbB</td></tr>
<tr><td colspan="4">Objective
Set the boundaries of the laboratory specific tests to be carried out by the subject vehicle on the longitudinal control scenarios.</td></tr>
<tr><td colspan="4">Description
Check the subject vehicle and the car manufacturer provided documentation referred to longitudinal control. Generate the test suite of the subject vehicle from the overall test programme.</td></tr>
<tr><td>Car manufacturer provided documentation
Reference list of the docs provided</td><td colspan="3">Requirements to be checked
☒Y ☐ N subject vehicle is able to detect leading target vehicle in the same lane
☒Y ☐ N subject vehicle is able to detect moving target (for instance, pedestrian, motorbikes)
…</td></tr>
<tr><td rowspan="2">Test resources</td><td colspan="3"></td></tr>
<tr><td>Equipment
Vehicle
VIN: xxxxxxxx</td><td>Infrastructure
Workshop</td><td>Human resources
Technician</td></tr>
<tr><td colspan="4">Test result
Overall result of the test</td></tr>
<tr><td colspan="4">References</td></tr>
</table>

Fig. 2-4: Design review scenario approach: Longitudinal control.

2.3 Advantages and disadvantages of system and scenario approach

In this section the main advantages and disadvantages using the previously described different approaches are outlined. The aim is not to evaluate any of the approaches but to set concepts for undertaking the development of test procedures in the subsequent work.

Using the system approach the following advantages have been observed:

- There is one design review test per safety system, the system is tested independently vehicle or scenario.

Disadvantages under this approach include the following:

- The introduction of a new safety system into the testing methodology is not immediate, since the corresponding design review test procedure must be developed for each case.
- The system based method does not support evaluation of several systems and combination of systems.
- Following the system approach it is possible to end up defining system based test procedures, which might improve a specific system, which has no benefit. As a last objective of eVALUE it is needed to define test methodologies to improve safety.

On the other hand, the following advantages have been noted using the scenario approach:

- Better way of meeting end-user expectations. The end-user is searching for the best vehicle not for the best safety system mounted on any vehicle, i.e. vehicle “A” is safer than vehicle “B” whatever systems are onboard.
- This constitutes a general approach achieving an easy introduction of a new safety system into the design review test procedures. The scenario approach is based on safety functions more than on safety system itself, a more general scope is completed.
- In addition, the scenario approach simultaneously tests the effect of several safety systems on the outcome of one specific test.
- Finally, the scenario approach is totally novel due to the fact that the approximation currently being developed by the car manufacturer, suppliers or standardization community is the system approach.

The main disadvantages under this approach were found to be:

- The definition of scenarios can become laborious when trying to take into account a large number of parameters and variables in order to cover as much safety aspects as possible.
- Data from accident research, which constitutes the main source of the approach, is not always accessible and up to date.

3 CONCEPTS FOR LABORATORY TESTS

Under the eVALUE scope, laboratory tests are considered the second type of test and the agreed approach among the partners for this type of test is the scenario approach. This type of tests can be divided into system performance and human factors testing in a driving simulator. A laboratory test is carried out on a static environment and is meant to identify and determine the concepts, requirements, specifications and limitations of the safety systems and components in the subject vehicle, in order to create a set of valid test procedures for the physical vehicle tests. Driver in the loop is considered under this type of test on a simulator environment. The test results derived from the laboratory test will set the range input parameters for the physical vehicle test.

Based on the PReVAL methodology proposed within PReVENT, FP6 project, the figure below presents the connection between a system's technical performance, the driver performance and the overall safety impact and the different dimensions in testing eVALUE aims to address: verification and validation. These concepts will be further presented in WP2.

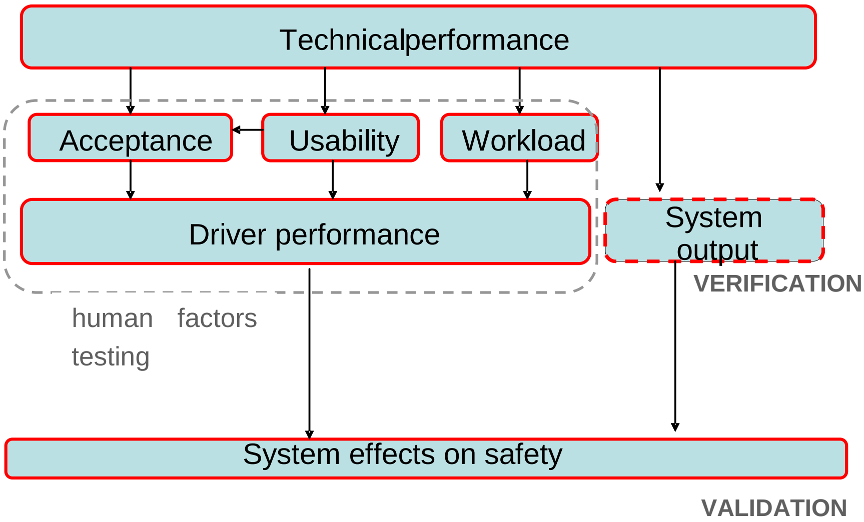


Fig. 3-1: Purpose of the laboratory test: Verification of vehicle performance

The purpose of the laboratory test is to verify the vehicle performance, always taking into account the conditions of the cluster(s) and scenario(s), by carrying out the following tests:

- Subject vehicle laboratory tests verifying the system performance at component level. This laboratory test does not include a driver in the loop and will be carried out in the laboratory or in the workshop. Most of these tests are encouraged to verify the capabilities of the system by itself, under a verification phase. The sensor and component testing can be performed either with the system working on the subject vehicle, or dismounted and tested separately.

- Simulated subject vehicle laboratory tests verifying the human factors by variables such as reaction time, for instance. This laboratory test will not include the subject vehicle and will be carried out in the driving simulator.

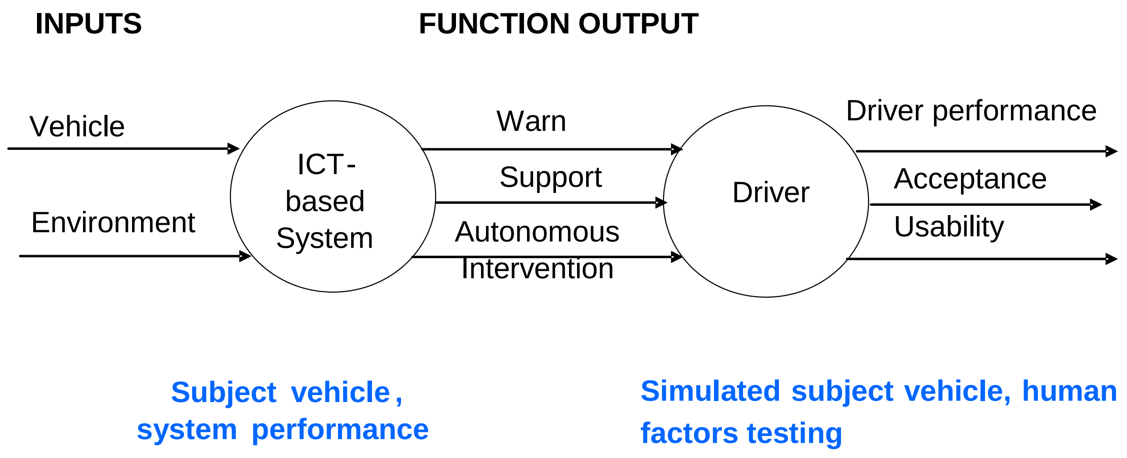


Fig. 3-2: Laboratory test: Verification vehicle performance

3.1 Subject vehicle laboratory test, system performance.

This laboratory test verifies the system performance at component level, without a driver in the loop and carried out in the laboratory. The sensor and component testing can be performed either with the system working on the subject vehicle, or dismounted and tested separately.

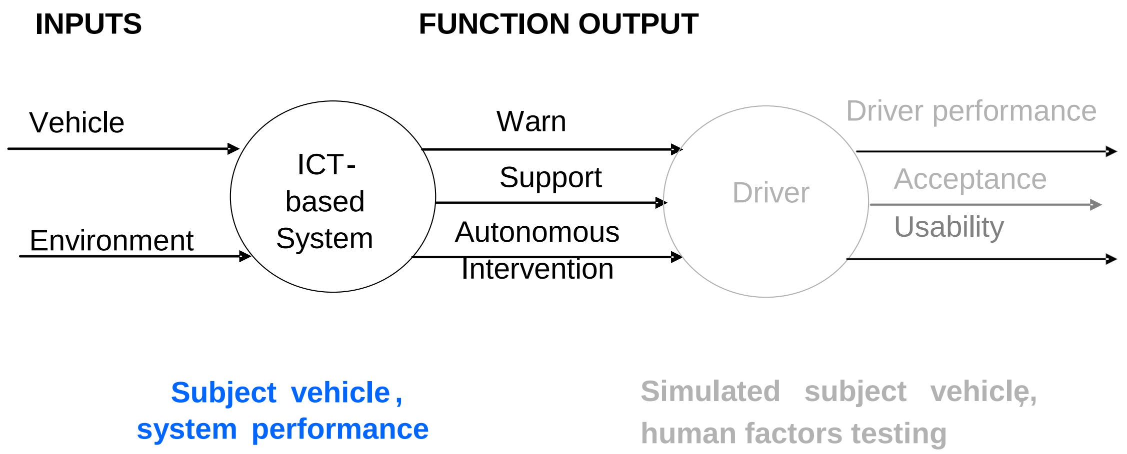


Fig. 3-3: Laboratory test: Verification system performance

In order to verify the system performance, the laboratory tests are structured by component level test, i.e., sensor, ECU and actuator respectively. The results of the following system performance are an input to the driver performance laboratory test:

- At sensor level
  - Detection area test. Verify the detection range areas of CLUSTER1 and CLUSTER2 vehicle systems, in order to create a virtual detection map around the subject vehicle.
  - Discrimination test. Verify that CLUSTER1 and CLUSTER2 vehicle's systems are able to discriminate detected objects. This type of test can include different type of obstacles, target vehicle and pedestrian, and static or moving objects.
  - Resolution test. Verify CLUSTER1 and CLUSTER2 safety systems resolution. In CLUSTER1, for instance, one target is used and the longitudinal distance between the subject and the target vehicle is varied to determine the resolution.
  - Susceptibility test. Verify CLUSTER1 to CLUSTER3 safety systems susceptibility, i.e. possible performance loss, due to adverse environmental conditions.
- At ECU level
  - System response time test. Verify the response time of all clusters ICT-based safety systems determined by ideal and adverse event stimuli.
  - Fault insertion test Verify the fault tolerance of all clusters ICT-based safety systems. Faults according to the fault models (e.g. loose contacts or EMI) are inserted and behaviour of the safety systems is studied.
- At actuator level:
  - Function output relevance test. Verify that the function output of all clusters ICT-based safety systems meet the relevance requirements, i.e. warning, support or autonomous intervention, for the scenarios tested.
  - Function output type test. Verify that the function output of all clusters ICT-based safety systems meet the type requirements, i.e. visual, acoustic or haptic, for the scenarios tested. Physical function output for autonomous intervention, i.e. engine, braking, steering or transmission response, will also be verified under this test.

- Function output location test. Verify that the function output of all clusters ICT-based safety systems meet the location requirements, i.e. height and lateral position relative to the driver.

3.2 Simulated subject vehicle laboratory test, human factors testing.

This laboratory test aims at testing the human factors related aspects of a certain system (or combination of systems) using a driving simulator. Human factors testing includes tests on driver acceptance, perceived usability and overall driver performance. Other factors such as workload and distraction will also affect the final results and has to be taken into consideration. These tests will also contribute in defining test procedures considering the driver in the loop (when needed).

The definition of, and a procedure for, human factors testing was proposed within the EU FP6 project PReVAL. This work will be of importance in eVALUE for identifying human factor related tests needed in the selected scenarios and when defining in what way human factors testing can be taken into account in eVALUE.

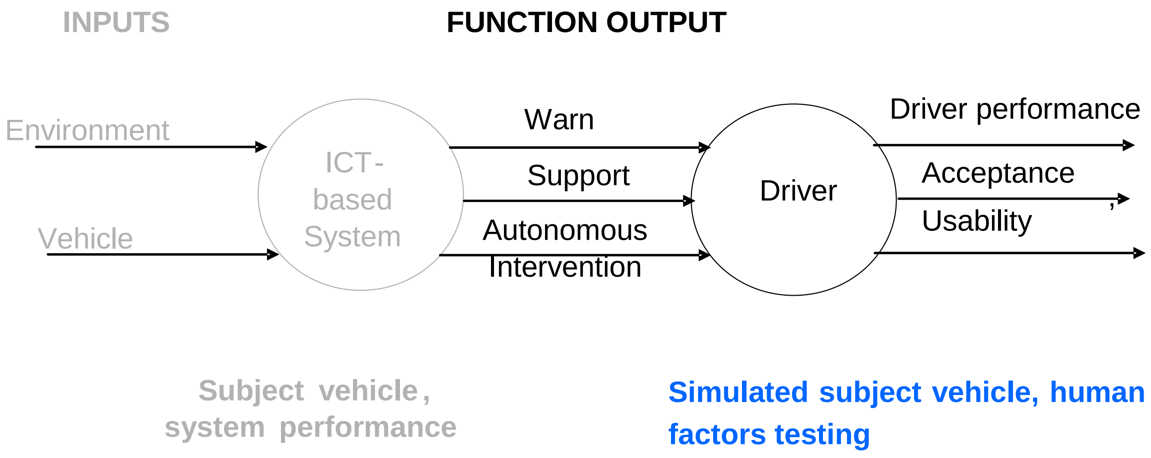


Fig. 3-4: Laboratory test: Human factors testing

The human factors testing in the driving simulator is based on the scenarios derived in eVALUE from available reports on accident statistics. These scenarios are similar to the ones tested in physical environments. The virtual scenarios on the simulator will take into account the system performance laboratory tests results. For instance, the simulated subject vehicle detection area will be set according to results of the system performance laboratory test, at sensor level, “Detection area test”.

The objective with human factors testing in the driving simulator is to verify the function with respect to how the function interacts with the driver. The method is to use a simulated subject vehicle and environment and to collect data for analysis of human factor related issues.

The data collection includes both subjective data on how the driver apprehends the function and objective data from the simulator for evaluating the actual driver performance when driving with the safety system.

Several important areas, at this stage of the concept definition, for human factors testing are presented below.

- Driver acceptance test. Driver acceptance of a system is affected by both the technical performance of the system and the usability. System acceptance refers to driver's subjective evaluation of the safety systems, taking into account for instance system usefulness and system satisfaction. The laboratory test will verify the driver's acceptance of all clusters ICT-based safety systems, valid to the scenarios defined as the scope of eVALUE. The tool for his test will be a questionnaire or survey for gathering the driver's opinion.

  Projects such as the European projects AIDE and PReVAL and the International NHTSA project IVBSS "Integrated Vehicle-Based Safety Systems" will be of great help in order to develop the test templates

- Driver usability test. Usability under eVALUE can be understood as the extent to which a safety system can be used by individual drivers to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use of the subject vehicle. In an ADAS function one important issue is weather or not the warning is comprehended in the intended way by the driver. Usability could be described by the match between the driver's mental model of how the system works and the actual operation of system. This laboratory test will verify the driver's usability of all clusters ICT-based safety systems, valid to all the scenarios defined as the scope of eVALUE. As with the driver acceptance tests the tools for usability testing will be a questionnaire or survey for gathering the driver's opinion.

  Projects such as the European projects AIDE and PReVAL and the International NHTSA project IVBSS "Integrated Vehicle-Based Safety Systems" will be of great help in order to develop the test templates.

- Driver performance. In addition to evaluation of subjective data on acceptance and usability collection of objective data is of great importance for quantitative analysis and assessment of the actual driver performance. Objective data collections is retrieved from the simulator environment by logging certain vehicle parameters during the test drives. This data provides result on the performance indicators selected as representative for reflecting changes in driver performance. These indicators can be for example driver reaction time or time to line crossing (TLC).

A separate section later in this report summarizes a set of common safety indicators (page 22). This serves as a basis for the future eVALUE work, for defining both the driving simulator test setups and the physical test setups. The intention is to, from these proposed indicators select the most representative ones for the eVALUE scenarios.

- Workload and distraction. While tests on driver usability, acceptance and driver performance can be referred to as tests for investigating desired or intended effects of a preventive safety system, tests on workload and distraction can be referred to as tests for investigation unwanted or unintended effects of such systems. While preventive safety system hopefully will support drivers on different levels, it might at the same time bring some negative aspects as distracting or increasing the workload on the driver. Traditionally workload and distraction has been of great importance when assessing in vehicle information systems. Undesired effects such as high workload and driver distraction have been addressed in some European projects when evaluating human factors aspects of preventive safety systems, but the focus has mainly been on intended effects.

The way these areas will be addressed within eVALUE will be further investigated in WP2 when analysing the test objectives and developing the test procedures. A survey of tools for evaluating the above mentioned dimensions of preventive safety system tests is presented in deliverable D1.1 (refer to [DOC 2]).

In D1.1 also the methodology on human factors testing from the PReVAL project is briefly presented. In the PReVAL project some concerns and issues are raised with respect to human factors. A discussion is held on the potential for achieving a complete test basis for analysis of human factors in a simulator environment at a comparison with performing physical testing with similar objectives. These raised issues are important to consider in eVALUE.

4 CONCEPTS FOR PHYSICAL VEHICLE TESTS

Physical vehicle tests constitute the third type of tests considered under the eVALUE scope. The general approach of eVALUE is based in real accident scenarios. This approach is emphasized in physical testing, where there is a clear implementation of real traffic scenarios. It is approved among the partners that the approach for the physical tests is the scenario approach. The purpose of this type of test is to validate the complete vehicle's performance, following the scenario approach. In other words, the approach is not to test one particular ICT-based safety system, but to validate the whole vehicle's functional safety under different scenarios, i.e. specific real driving situations, which are relevant regarding the functionality of the considered ICT-based safety systems.

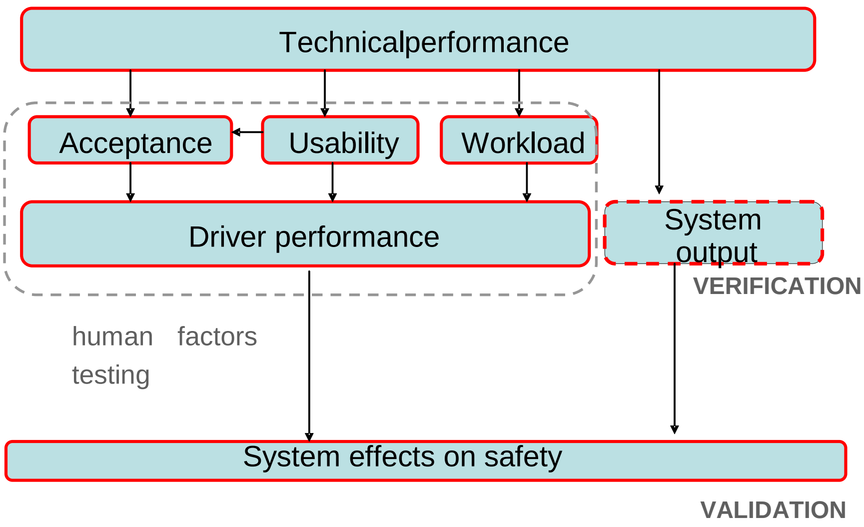


Fig. 4-1: Purpose of the physical vehicle test: Verify and validate vehicle performance.

It is weighed up that the use of a strict system definition, i.e. system approach, will discriminate upcoming ICT-based safety systems that do not fall within any of the existing system description. Furthermore, the scenario approach will simultaneously test the effect of several safety systems on the outcome of one specific test. In addition, the scenario test approach is totally novel due to the fact that the approximation currently being developed by the car manufacturer, suppliers or standardization community is the system approach.

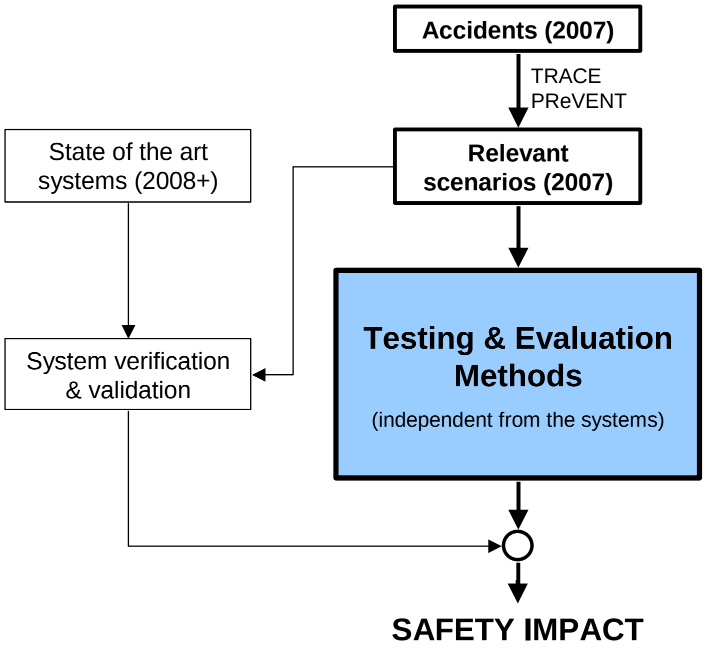


Fig. 4-2: eVALUE approach

Among all the scenarios proposed, 14 were selected, compiled by clusters, to be the ones to be tested under physical vehicle test basically founded on the following four factors: existing accidents statistics (available from National Statistics and from up to date European projects, such as TRACE and PREVENT), the state of the art, i.e. knowledge on current ICT-based safety systems, international standards (such as NHTSA and EURONCAP) and the experience of the consortium. The rest of scenarios discussed have been collected on a separate document (refer to [DOC 4]).

This chapter will describe a total of 14 scenarios, structured by clusters, approved for eVALUE as listed below:

- Scenarios for Cluster1. A total of three scenarios will validate the vehicle from a longitudinal point of view, such as scenarios on a straight road, on a curve and with a transversally moving target.

- Scenarios for Cluster2. In this case seven scenarios will validate the vehicle from a lateral point of view, when the vehicle is changing lane or there is an unintentional road or lane departure, for instance.

- And finally, scenarios for Cluster 3 will validate the vehicle's stability in four scenarios, for instance emergency braking, fast driving into a curve driver collision avoidance and roll stability situations.

The necessary information to be detailed for each of the scenarios is the following:

- Name and identifier (indexed per cluster) for the scenario. For clearness reasons, an intuitive sketch on the scenario operation is also provided.

- Objective and relevance of the scenario. Short literature on the sketch and relevance of the scenario according to statistics, technical feasibility, system relevance and to what extend the driver will be in the loop at the test. This indicator was used when selecting the scenarios to be covered under eVALUE scope, i.e., scenarios with higher relevance were selected.

- Description and references. General overview description of the scenario and relevant citations referred on the scenario description.

- Scenario examples. Additional information that will clearly position the scenario scope.

Wrapping up with the physical vehicle test, performance testing will describe how well a vehicle and its driver will cope in a real traffic scenario. The scenarios selected under eVALUE represent common road traffic accidents and it is clear that the overall objective is to avoid accidents or at least to reduce the injuries caused by vehicle impacts.

Next, the safety indicator or the variables to describe the effects of the preventive safety system as for instance accident avoidance and injury reduction must be selected. A set of safety indicators are listed bellow, keeping in mind that at this stage of the project, a safety indicator is seen as a measurable quantity candidate to be used on a definition for the complete vehicle's safety performance measurement.

Some of these indicators have an overall application to all scenarios such as the collision speed and the driver acceptability and usability, i.e., a low collision speed will mean low risk of injuries to the driver and the passengers, whereas a high collision speed will mean high risk of fatal accidents. In addition, there are safety indicators particularly applicable to specific scenario(s), for instance headway time, applicable on longitudinal control traffic situations.

4.1 Considered safety indicators

The variables describing safety performance, i.e. safety indicators, will be different for each of the cluster foreseen under the eVALUE scope, CLUSTER1 - Longitudinal control, CLUSTER2- Lateral control and CLUSTER3 - Stability control.

Next table provides a proposal on potential safety indicators for validating the performance. Collision speed and driver's acceptance and usability are considered as overall safety indicators (applicable to every cluster) as well as particular indicators applicable to the different clusters.

The indicators proposed are based on the variables collected from the common experience among the eVALUE partners and should be seen as potential indicators that can be applied to the eVALUE Clusters. The indicators that are finally selected will be derived in WP2. The collection of the safety variables gathered from the eVALUE partners have been compiled on a separate document (refer to [DOC 4]).

SAFETY INDICATOR / CLUSTER	CLUSTER1	CLUSTER2	CLUSTER3
Collision speed	X	X	X
Driver's acceptance and usability	X	X	X
Headway time	X		
TLC		X	
Path deviation		X	X
Target detection, dimension and classification	X	X	
Function output type and relevance	X	X	X
Driver's intention	X	X	X
Braking distance			X
Vehicle's control			X

Table 4-1: Safety indicators, classified by clusters.

The safety indicators outlined on the previous table can be defined as follows:

- Collision speed can be chosen as the overall performance indicator. A low collision speed will mean low risk of injuries to the driver and the passengers. A high collision speed will mean high risk of fatal accidents. For run-off road accidents, the collision speed may be interpreted to the speed at which the vehicle exits the road.
- Driver's acceptance and usability. This indicator is also an overall performance indicator and refers to driver's subjective evaluation of the safety systems, taking into account for instance system usefulness and system satisfaction. Thus, these indi-

cators will be subjective measures that are directly affected by the technical performance; the way the function works.

- Headway time. It is the time gap to the target vehicle. This variable describes at what time gap the subject vehicle acts for longitudinal control.

- Target detection, dimension and classification. These variables describe maximum range at which an object can be detected, size and identification of the objects that will be detected in longitudinal and lateral control.

- Function output's type and relevance, i.e., interaction with the driver. This indicator will describe how does the ICT-based safety system interacts with the driver in avoiding or mitigating an impact. This can be done by warning the driver, assisting the driver by different chassis control system or autonomously intervene the vehicle.

- TLC (Time to Line Crossing). This variable describes the time remaining before the driver's subject vehicle will reach a lane boundary assuming the current steering wheel angle remains constant and the driver fails to intercede.

- Driver's intention. Depending on his intention the ICT-based safety system will be working one mode or another. For instance, if the lane crossing is intentional, i.e., the driver wishes to overtake a target vehicle, the LKA should not be activated.

- Braking distance, this indicator describes the distance from where the vehicle starts braking until full stop.

- Path deviation, this indicator is an error measure, showing the difference between the desired trajectory of the vehicle and the real trajectory.

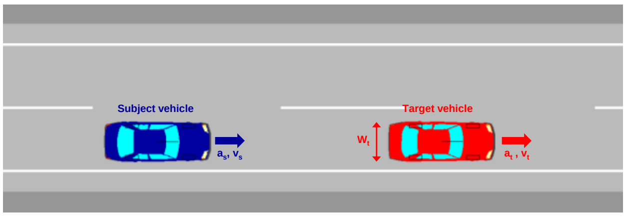
- Vehicle's control, this indicator describes how easy is for the driver to keep the desired trajectory of the car.

The explained variables are potential variables to be used, in the next WP2, as inputs for defining and selecting the safety indicators. The table 4-1 (pg 22) should be taking into account as an example not as a definitive choice.

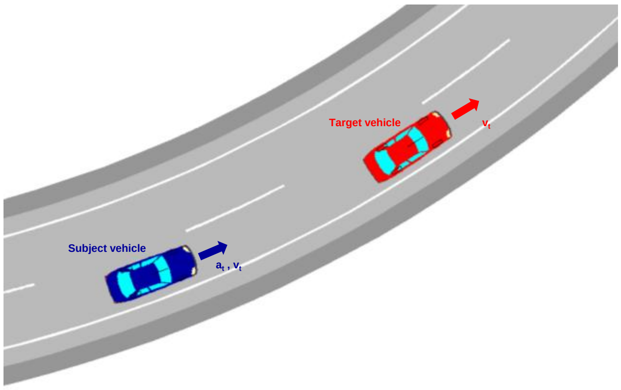
4.2 Scenarios CLUSTER 1

This chapter includes the following scenarios addressed under Cluster 1 as well as the safety indicators that will one way or another measure the functional safety of the subject vehicle on a longitudinal control basis.

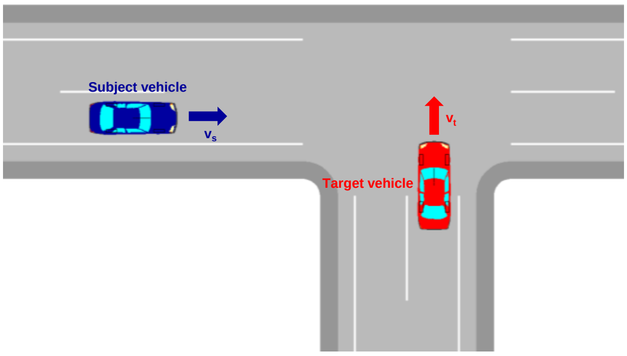
- Scen-C1-1: Straight road. Validate that the subject vehicle can detect and handle (warn, support, and/or intervene) a target vehicle in the same lane on a straight road



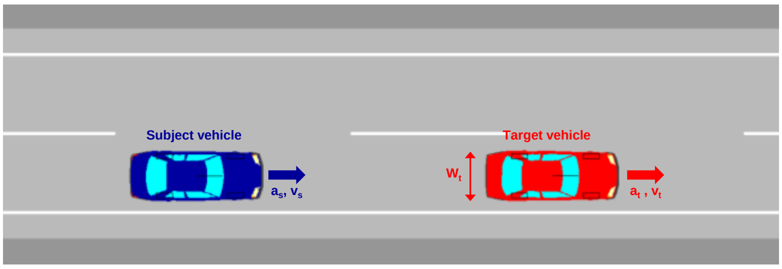
- Scen-C1-2: Curved road. Validate that the subject vehicle can detect and handle (warn, support, and/or intervene) a target vehicle in the same lane on a curved road.



- Scen-C1-3: Transversally moving target. Validate that the subject vehicle can detect and handle (warn, support, and/or intervene) a target vehicle, which moves transversally to the subject vehicle.



Scenario name: Straight road	**Scenario identifier:** Scen-C1-1



Objective:

The objective of this scenario is to validate that the subject vehicle can detect and handle (warn, support, and/or intervene) a target vehicle in the same lane on a straight road.

Scenario relevance:

Rear-end or catching up collisions represent 15%, 18%, 14%, and 15% of the total accidents in Germany, Italy, Spain, and Sweden, respectively. Furthermore, frontal collisions represent 8%, 7%, 5%, and 4% of the total accidents in Germany, Italy, Spain, and Sweden, respectively. Finally, collisions with stationary objects (e.g. parked vehicles) represent 7%, 8%, and 3% of the total accidents in Germany, Italy, and Spain, respectively. (Based on accident statistics from year 2006 or 2007)

The scenario needs a long straight road on a proving ground to facilitate different speeds. The scenario also needs target vehicles of at least two sizes: one representing a medium-sized car and one representing a motorcycle or bicycle. The acceleration, speed, and direction of travel (toward of from the subject vehicle) of the target vehicles must be able to be changed. The scenario will evaluate ICT-based safety systems such as FCW, ACC, and CM.

Description:

This scenario contains a subject vehicle which is moving at speed V_S. The subject vehicle will:

- at constant distance and speed follow a target vehicle which starts to decelerate
- encounter a slower moving target vehicle
- encounter a stationary target vehicle
- encounter a target vehicle travelling in the same lane but in opposite direction

The scenario shall be conducted at a number of different but representative speeds and accelerations (V_T and A_T). At least two sizes (W_T) of target vehicles shall be used: one size representing a medium-sized car and one smaller representing a motorcycle or bicycle. The scenarios can be conducted at different weather, road, and visibility conditions. The subject and target vehicles can be driven by professional test drivers or driving robots.

References:

ISO/DIS 22179 Intelligent transport systems – Full speed range adaptive cruise control (FSRA) systems – Performance requirements and test procedures (Automatic “Stop” capability test)

SAE J2400 “*Human Factors in Forward Collision Warning Systems: Operating Characteristics and User Interface Recommendations*”, 2003. (Tests 1, 5, 6, 7)

Integrated Vehicle-Based Safety Systems (IVBSS), First Annual Report, Publication DOT 810 842, U.S. Department of Transportation, National Highway Traffic Safety Administration. (Rear-end scenarios 1, 2, 3, 4, 5, 12)

Development of Crash Imminent Test Scenarios for Integrated Vehicle-Based Safety Systems (IVBSS), Publication DOT 810 757, U.S. Department of Transportation, National Highway Traffic Safety Administration. (Rear-end crash imminent test scenarios 2, 3, 4)

Pre-Crash Scenario Typology for Crash Avoidance Research, Publication DOT HS 810 767, U.S. Department of Transportation, National Highway Traffic Safety Administration (Crash number 20, 21, 22, 23, 24, 25, 26).

Scenario name: Straight road	**Scenario identifier:** Scen-C1-1

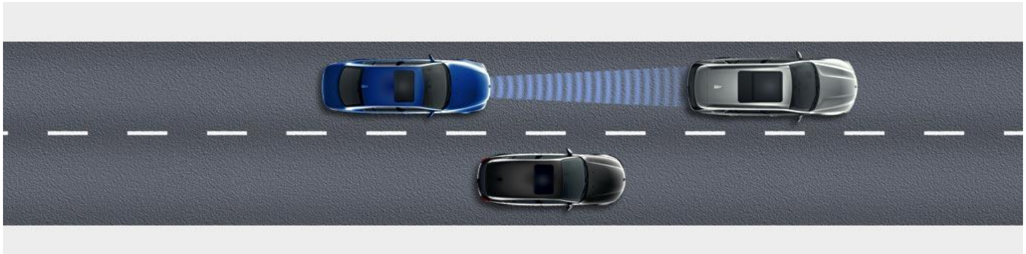
Scenario examples:

Depending on how direction, speed and acceleration values are chosen for the subject and target vehicles, different real traffic scenarios can be emulated. If the subject vehicle is travelling at speed V_S the following table shows how the other parameters can be selected to create different test cases:

Direction: same (+) opposite (-). Acceleration: accelerating (+) braking (-).

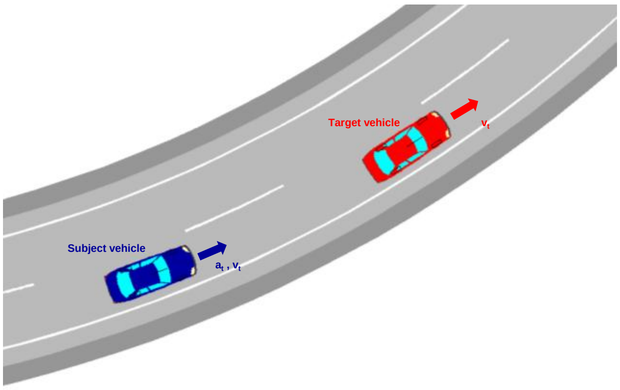
	Target vehicle		
Scenario examples	**Direction**	**Speed**	**Acceleration**
A car is following another car at the same speed. The constant distance is manually controlled or controlled by ACC. Suddenly the forward car brakes due to an obstacle.	+	$V_T = V_S$	-
A car is travelling at constant speed on a highway. The car rapidly approaches a slower moving truck which is e.g. climbing a hill.	+	$V_T < V_S$	0
A car is approaching a parked car.	0	0	0
A car travelling in the opposite direction drifts into our lane. The driver of the other car may be distracted or impaired.	-	$V_T \sim V_S$	0
A car travelling in the opposite direction is overtaking another car.	-	$V_T \sim V_S$	+

Example of FCW (Source: GM)



Example of ACC (Source: BMW)

Scenario name: Curved road	**Scenario identifier:** Scen-C1-2



Objective:

The objective of this scenario is to validate that the subject vehicle can detect and handle (warn, support, and/or intervene) a target vehicle in the same lane on a curved road.

Scenario relevance:

Rear-end or catching up collisions represent 15%, 18%, 14%, and 15% of the total accidents in Germany, Italy, Spain, and Sweden, respectively. In Spain 30% of the rural accidents occur in a curve. However in urban areas the percentage is lower, about 5%. In Germany, a curve represents the third most common place of accident with 16% of the total accidents. Finally, collisions with stationary objects (e.g. parked vehicles) represent 7%, 8%, and 3% of the total accidents in Germany, Italy, and Spain, respectively.

The scenario needs one or several roads with different curvatures (radius, left and right turns) on a proving ground. The scenario also needs a target vehicle representing a medium-sized car. The speed and acceleration of the target vehicle must be able to be changed. The scenario will evaluate ICT-based safety systems such as FCW, ACC, and CM and possibly also ESC and ABS.

Description:

This scenario contains a subject vehicle which is moving at speed V_S. The subject vehicle will be in a curve:

- at constant distance and speed follow a target vehicle which starts to decelerate
- encounter a slower moving target vehicle
- encounter a stationary target vehicle
- encounter a target vehicle travelling in the same lane but in opposite direction

The scenarios shall be conducted at a number of different but representative speeds and accelerations (V_T and A_T). The scenarios can be conducted at different weather, road, and visibility conditions. The subject and target vehicles can be driven by professional test drivers or driving robots.

References:

ISO 15622:2000 Transport Information and Control Systems – Adaptive Cruise Control Systems – Performance Requirements and Test Procedures (Curve capability test)

Integrated Vehicle-Based Safety Systems (IVBSS), First Annual Report, Publication DOT 810 842, U.S. Department of Transportation, National Highway Traffic Safety Administration. (Rear-end scenario 7, 8)

SAE J2400 "Human Factors in Forward Collision Warning Systems: Operating Characteristics and (User Interface Recommendations", 2003. (Test 3)

Development of Crash Imminent Test Scenarios for Integrated Vehicle-Based Safety Systems (IVBSS), Publication DOT 810 757, U.S. Department of Transportation, National Highway Traffic Safety Administration. (Multiple-Threat crash imminent test scenario 5)

Pre-Crash Scenario Typology for Crash Avoidance Research, Publication DOT HS 810 767, U.S. Department of Transportation, National Highway Traffic Safety Administration (Crash number 24, 25, 26).

Scenario name: Curved road	**Scenario identifier:** Scen-C1-2

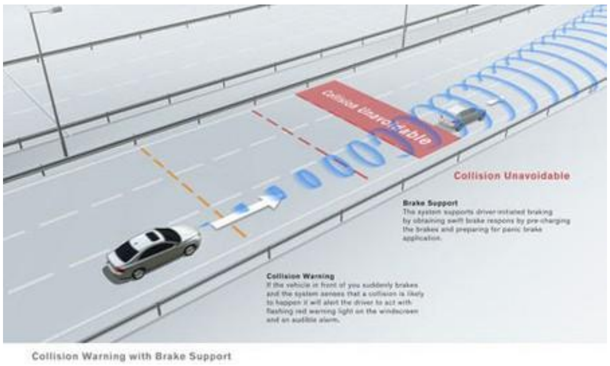
Scenario examples:

Depending on how speed and acceleration values are chosen for the subject and target vehicles, different real traffic scenarios can be emulated. If the subject vehicle is travelling at speed V_S the following table shows how the other parameters can be selected to create different test cases:

Acceleration: accelerating (+) braking (-).

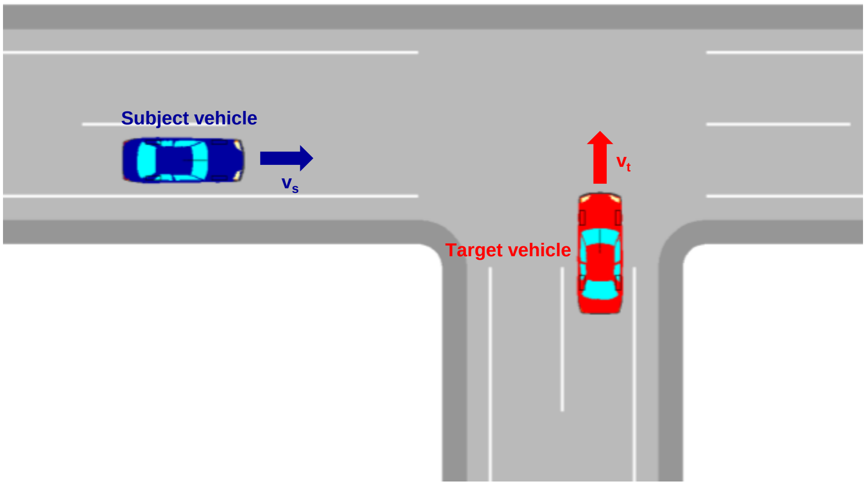
	Target vehicle		
Scenario examples	**Direction**	**Speed**	**Acceleration**
A car is following another car at the same speed into a curve. The constant speed and distance is manually controlled or controlled by ACC. Suddenly the forward car brakes due to too high speed into a tight curve.	+	$V_T = V_S$	-
A car is travelling at constant speed. The car suddenly approaches a slower moving tractor in a curve.	+	$V_T < V_S$	0
A car is approaching another stationary car in a curve. The stationary car might be fixing a puncture.	0	0	0
A car travelling in the opposite direction drifts into our lane. The driver of the other car may be distracted or impaired.	-	$V_T \sim V_S$	0
A car travelling in the opposite direction is overtaking another car.	-	$V_T \sim V_S$	+

Example of ACC (Source: Continental)



Example of CM (Source: Volvo)

Scenario name: Transversally moving target	**Scenario identifier:** Scen-C1-3



Objective:

The objective of this scenario is to validate that the subject vehicle can detect and handle (warn, support, and/or intervene) a target (e.g., other vehicle, pedestrian,…) which moves lateral to the subject vehicle.

Scenario relevance:

Frontal-lateral collisions represent 36% and 27% of the total accidents in Italy and Spain, respectively. Furthermore, collisions with pedestrians represent 9%, 8%, 11%, and 9% of the total accidents in Germany, Italy, Spain, and Sweden, respectively. Finally, collisions with animals represent 0.5% and 2% of the total accidents in Spain and Sweden, respectively.

The scenario needs an area on a proving ground where a subject vehicle and a target can move at different speeds lateral to each other. The scenario also needs targets of different sizes, e.g. representing a medium-sized car or pedestrians. The speed of the target must be changeable.

The scenario will evaluate ICT-based safety systems such as CMbB and FCW. Additionally, the scenario will evaluate novel ICT-based safety systems such as Pedestrian Protection. The eVALUE project expects these systems to be an upcoming technology in the next vehicle generations.

Description:

This scenario contains a subject vehicle which is moving at speed V_S. The subject vehicle will suddenly encounter a lateral moving target.

The scenarios shall be conducted at a number of different but representative speeds (V_T). At least three sizes (L_T, H_T) of target objects shall be used: one size representing a medium-sized car, one size representing game, and one size representing a human. The scenarios can be conducted at different weather, road, and visibility conditions. The subject can be driven by professional test drivers or driving robots.

References:

Pre-Crash Scenario Typology for Crash Avoidance Research, Publication DOT HS 810 767, U.S. Department of Transportation, National Highway Traffic Safety Administration (Crash number 9, 10, 11, 12, 30, 31).

PReVENT Deliverable D51.11 Compose Final Report, Contract Number FP6-507075, http://www.prevent-ip.org

Detection of road users in fused sensor data streams for collision mitigation . L. Walchshausl, R. Lindl , K. Vogel, T. Taschke:AM. 10th International Forum on Advanced Microsystems for Automotive Applications, Berlin, Germany, April 2006.

Reliable Pedestrian Protection based on Laserscanners. K.C. Fuerstenberg: Proceedings of ITS 2005, 12th World Congress on Intelligent Transport Systems, November 2005, San Francisco, USA.

Scenario name: Transversally moving target	**Scenario identifier:** Scen-C1-3

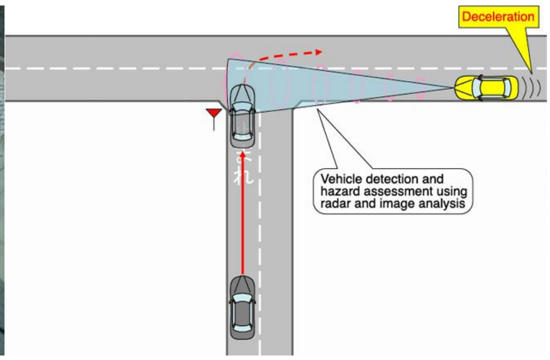
Scenario examples:

Depending on how speed for the subject vehicle and speed and size for the target object are chosen, different real traffic scenarios can be emulated. If the subject vehicle is travelling at speed V_S the following table shows how the other parameters can be selected to create different scenarios:

Depending on how speed for the subject vehicle and speed and size for a target vehicle and pedestrian (running or walking) are chosen, different real traffic scenarios can be emulated. Two situations are most relevant for pedestrian detection: one where the pedestrian is visible while the subject vehicle is approaching and another where the pedestrian is hidden behind an obstacle, e.g. a car, before she crosses the street. Note, that the target speeds are relative to the targets capabilities. If the subject vehicle is travelling at speed V_S the following table shows how the other parameters can be selected to create different test cases:

	Target vehicle	
Scenario examples	**Speed**	**Size**
A car is approaching an intersection where a car coming from the right ignores a red light or a stop sign.	$V_T < V_S$	Large
A car is approaching an intersection where a powered two-wheeler coming from the right ignores a red light or a stop sign.	$V_T < V_S$	Medium
A car is approaching while a pedestrian is crossing the street from the right.	V_T = Low	Small
A car is approaching when suddenly a pedestrian runs out in the street from behind an obstacle.	V_T = High	Small

Example of CMbB (Source: IBEO)

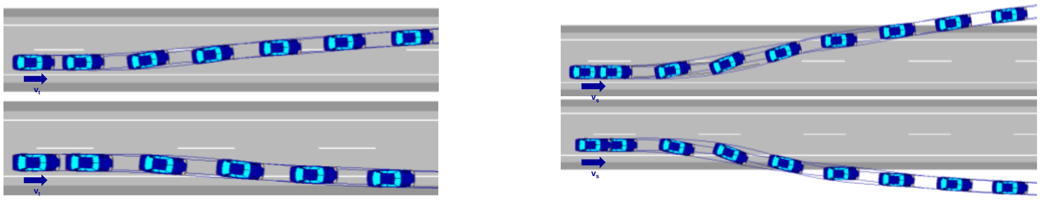


Example of CMbB (Source: Honda)

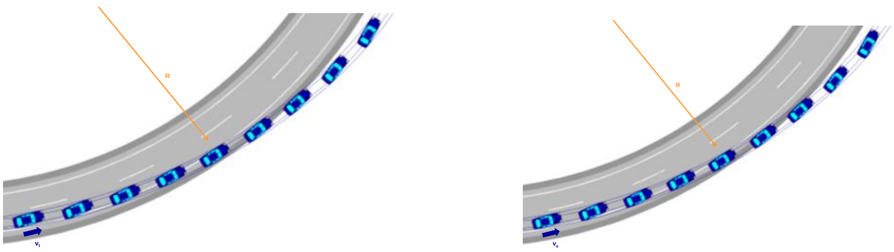
4.3 Scenarios CLUSTER 2

This chapter includes the different scenarios addressed under Cluster 2 as well as the safety indicators that will measure the functional safety of the subject vehicle on a lateral control basis.

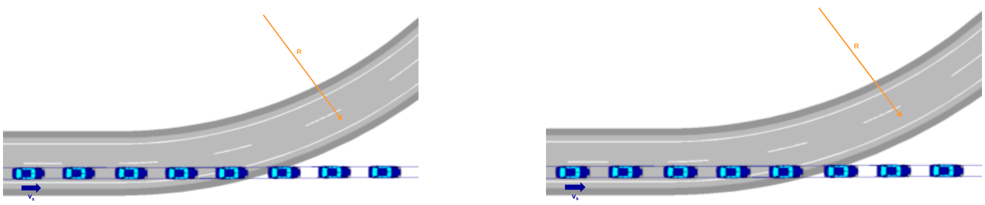
- Scen-C2-1 and Scen-C2-2: Lane and road departure on a straight road. Validate the subject vehicle capability to avoid involuntary (left / right) lane and road departure driving on a straight road.



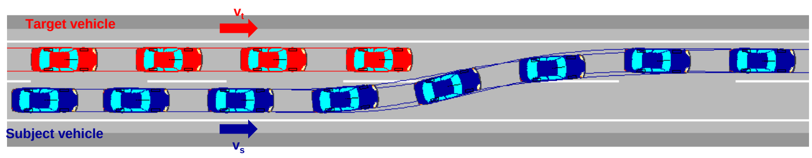
- Scen-C2-3 and Scen-C2-4: Lane and road departure on a curve. Validate the subject vehicle capability to avoid involuntary (left / right) lane and road departure driving on a curve.



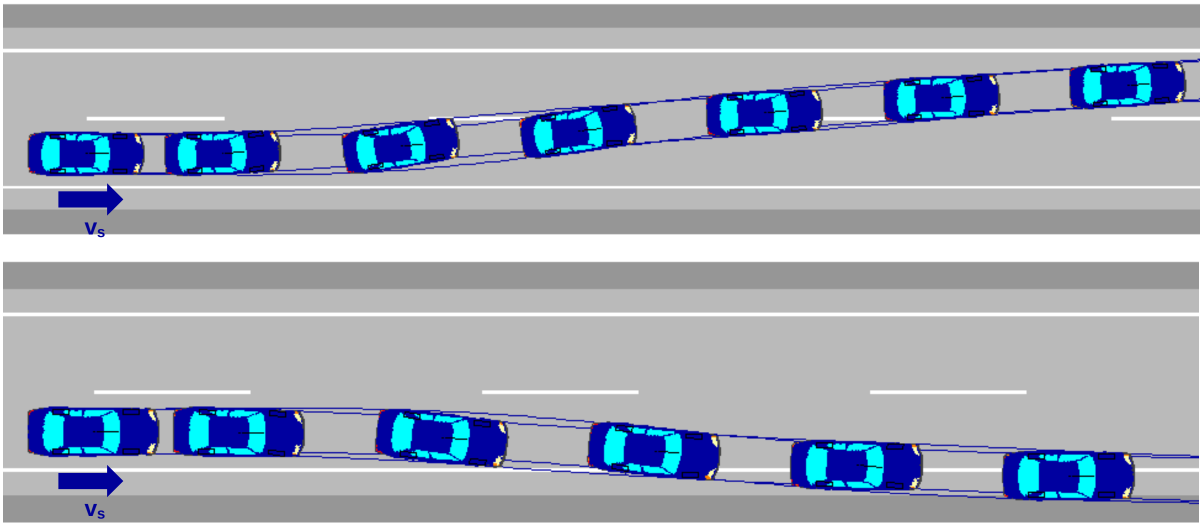
- Scen-C2-5 and Scen-C2-6: Lane and road departure on a straight road just before entering a curve. Validate the subject vehicle capability to avoid involuntary lane and road departure driving on a straight road just before entering an upcoming curve



- Scen-C2-7: Lane change collision avoidance in a straight road. Validate the subject vehicle capability to avoid a lateral collision when changing lane on a straight road and encountering an approaching target vehicle



Scenario name:	Scenario identifier:
Lane departure on a straight road	Scen-C2-1



Objective:

This scenario is meant to validate the subject vehicle capability to avoid involuntary (left / right) lane departure driving on a straight road.

Scenario relevance:

The scope of this scenario will represent 4% of the accidents and 3% of the fatalities, in the case of collision with another vehicle moving laterally in the same direction. The preparation of this scenario is fairly simple, i.e., the main complexity resides in the lane marks positioning.

The scenario will evaluate ICT-based safety systems such as LDW and LKA.

Description:

This is a single vehicle scenario moving on a straight road. The subject vehicle is driving at speed V_S inside the lane boundaries, and suddenly leaves the lane involuntarily. Related to the subject vehicle, the scenario considers all type of vehicles driving at different speed settings. The scenarios can be conducted at different weather, road, and visibility conditions. The subject vehicle can be driven by professional test drivers or driving robots.

References:

German Accident Statistics 2006 report, eVALUE internal documentation, May 2008.

Development of Crash Imminent Test Scenarios for Integrated Vehicle-Based Safety Systems (IVBSS), Publication DOT 810 757, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Integrated Vehicle-Based Safety Systems (IVBSS), First Annual Report, Publication DOT HS 810 842, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Definition of a Pre-Crash Scenario Typology For Vehicle Safety Research, Paper Number 07-0412, Volpe National Transportation Systems Center, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Scenario name: Lane departure on a straight road	**Scenario identifier:** Scen-C2-1

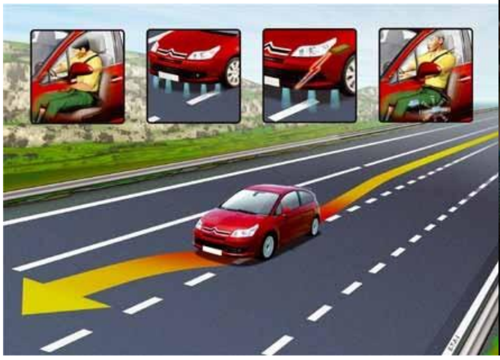
Scenario examples:

Depending on the lateral velocity of the subject vehicle relative to the lane marks, Vs (subject vehicle velocity) the environment conditions and the type of vehicle, different real traffic scenarios can be emulated. If the subject vehicle is travelling at speed Vs the following table shows how the other parameters can be selected to create different test cases:

Scenario examples	SVehicle	LatVs	V_s	Direction*	Environment
Low lateral velocity right	Passenger	$Lat_{Low}V_s$	V_s	Right	Daylight, Dry asphalt
High lateral velocity right	Passenger	$Lat_{HIGH}V_s$	V_s	Right	Daylight, Dry asphalt
Low lateral velocity left	Passenger	$Lat_{Low}V_s$	V_s	Left	Daylight, Dry asphalt
High lateral velocity left	Passenger	$Lat_{HIGH}V_s$	V_s	Left	Daylight, Dry asphalt

* Side of the lane departure

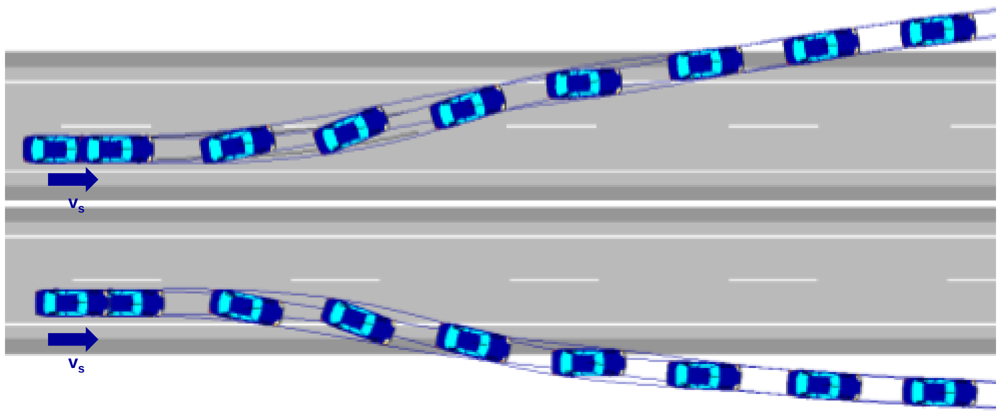
This scenario could be used to validate the safety requirements of ICT-based systems such as LDW or LKA.



Example of LDW (Source: Citroën)

Example of LKA (Source: BMW)

Scenario name: Road departure on a straight road	**Scenario identifier:** Scen-C2-2



Objective:

This scenario is meant to validate the subject vehicle capability to avoid involuntary road departure driving on a straight road.

Scenario relevance:

The scope of this scenario will represent 4% of the accidents and 3% of the fatalities, in the case of collision with another vehicle moving laterally in the same direction. The preparation of this scenario is fairly simple, i.e., the main complexity resides in the lane marks positioning. Finally, the scenario will fully validate the safety requirements for the ICT-based safety systems proposed, i.e. LDW and LKA.

The scenario will evaluate ICT-based safety systems such as LDW and LKA.

Description:

This is a single vehicle scenario moving on a straight road. The subject vehicle is driving at speed V_S inside the lane boundaries, and suddenly leaves the road involuntarily. Related to the subject vehicle, the scenario considers all type of vehicles driving at different speed settings. The scenarios can be conducted at different weather, road, and visibility conditions. The subject vehicle can be driven by professional test drivers or driving robots.

References:

German Accident Statistics 2006 report, eVALUE internal documentation, May 2008.

Development of Crash Imminent Test Scenarios for Integrated Vehicle-Based Safety Systems (IVBSS), Publication DOT 810 757, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Integrated Vehicle-Based Safety Systems (IVBSS), First Annual Report, Publication DOT HS 810 842, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Definition of a Pre-Crash Scenario Typology For Vehicle Safety Research, Paper Number 07-0412, Volpe National Transportation Systems Center, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Scenario name: Road departure on a straight road	Scenario identifier: Scen-C2-2

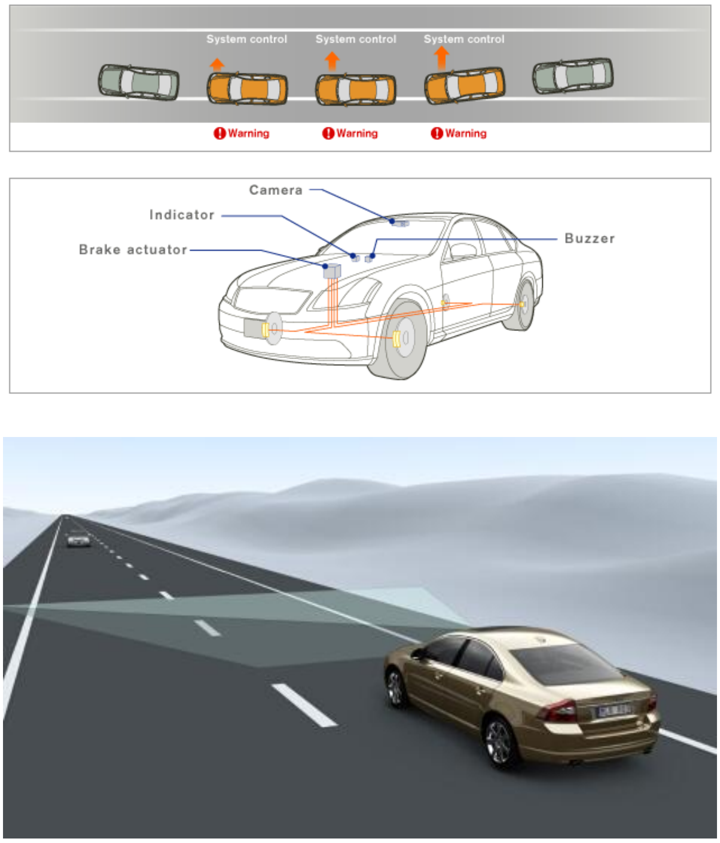
Scenario examples:

Depending on Vs (subject vehicle velocity), the environment conditions and the type of vehicle, different real traffic scenarios can be emulated. If the subject vehicle is travelling at speed Vs the following table shows how the other parameters can be selected to create different test cases:

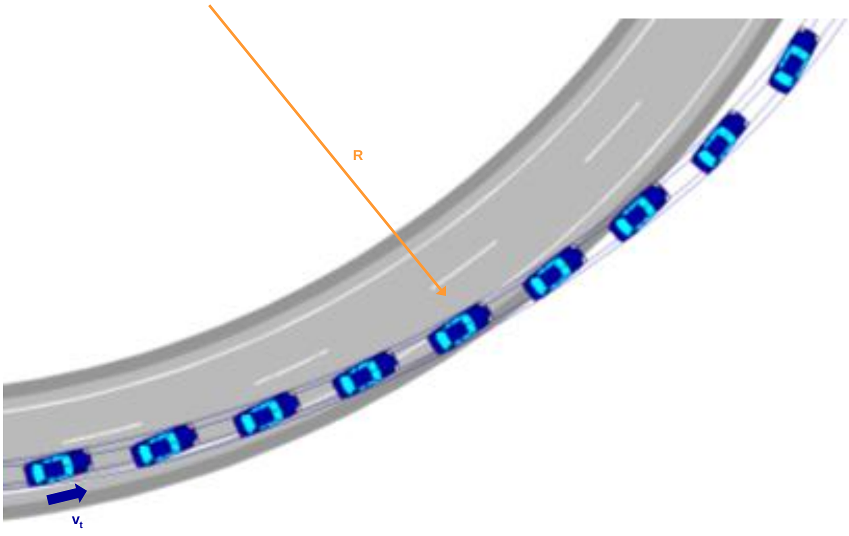
Scenario examples	SVehicle	V_s	Direction*	Environment
Road departure on the right	Passenger	V_s	Right	Daylight, Dry asphalt
Road departure on the right	Passenger	V_s	Right	Night, Icy asphalt
Road departure on the left	Passenger	V_s	Left	Daylight, Dry asphalt
Road departure on the left	Passenger	V_s	Left	Night, Icy asphalt

* Side of the road departure

This scenario could be used to validate the safety requirements of ICT-based systems such as LDW or LKA.



Examples of LDW (Source: Volvo)

Scenario name: Lane departure on a curve	Scenario identifier: Scen-C2-3
	
Objective: This scenario is meant to validate the subject vehicle capability to avoid involuntary (left / right) lane departure driving on a curve.	
Scenario relevance: The scope of this scenario will represent 4% of the accidents and 3% of the fatalities, in the case of collision with another vehicle moving laterally in the same direction. The preparation of this scenario is fairly simple, i.e., the main complexity resides in the lane marks positioning. The scenario will evaluate ICT-based safety systems such as LDW and LKA.	
Description: This is a single vehicle scenario moving inside a curve. The subject vehicle is driving at speed V_S inside the lane boundaries, and suddenly leaves the lane involuntarily. Related to the subject vehicle, the scenario considers all type of vehicles driving at different speed settings. The scenarios can be conducted at different weather, road, and visibility conditions. The subject vehicle can be driven by professional test drivers or driving robots.	
References: *German Accident Statistics 2006 report*, eVALUE internal documentation, May 2008. *Development of Crash Imminent Test Scenarios for Integrated Vehicle-Based Safety Systems (IVBSS)*, Publication DOT 810 757, U.S. Department of Transportation, National Highway Traffic Safety Administration. *Integrated Vehicle-Based Safety Systems (IVBSS)*, First Annual Report, Publication DOT HS 810 842, U.S. Department of Transportation, National Highway Traffic Safety Administration. *Definition of a Pre-Crash Scenario Typology For Vehicle Safety Research*, Paper Number 07-0412, Volpe National Transportation Systems Center, U.S. Department of Transportation, National Highway Traffic Safety Administration.	

Scenario name: Lane departure on a curve	**Scenario identifier:** Scen-C2-3

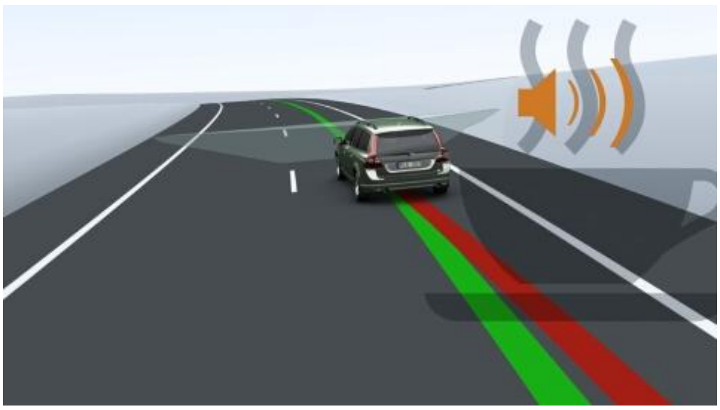
Scenario examples:

Depending on the lateral velocity of the subject vehicle relative to the lane marks, Vs (subject vehicle velocity) the environment conditions and the type of vehicle, different real traffic scenarios can be emulated. If the subject vehicle is travelling at speed Vs the following table shows how the other parameters can be selected to create different test cases:

Scenario examples	SVehicle	LatVs	V_s	Direction*	Environment
Low lateral velocity right	Passenger	$Lat_{Low}V_s$	V_s	Right	Daylight, Dry asphalt
High lateral velocity right	Passenger	$Lat_{HIGH}V_s$	V_s	Right	Daylight, Dry asphalt
Low lateral velocity left	Passenger	$Lat_{Low}V_s$	V_s	Left	Daylight, Dry asphalt
High lateral velocity left	Passenger	$Lat_{HIGH}V_s$	V_s	Left	Daylight, Dry asphalt

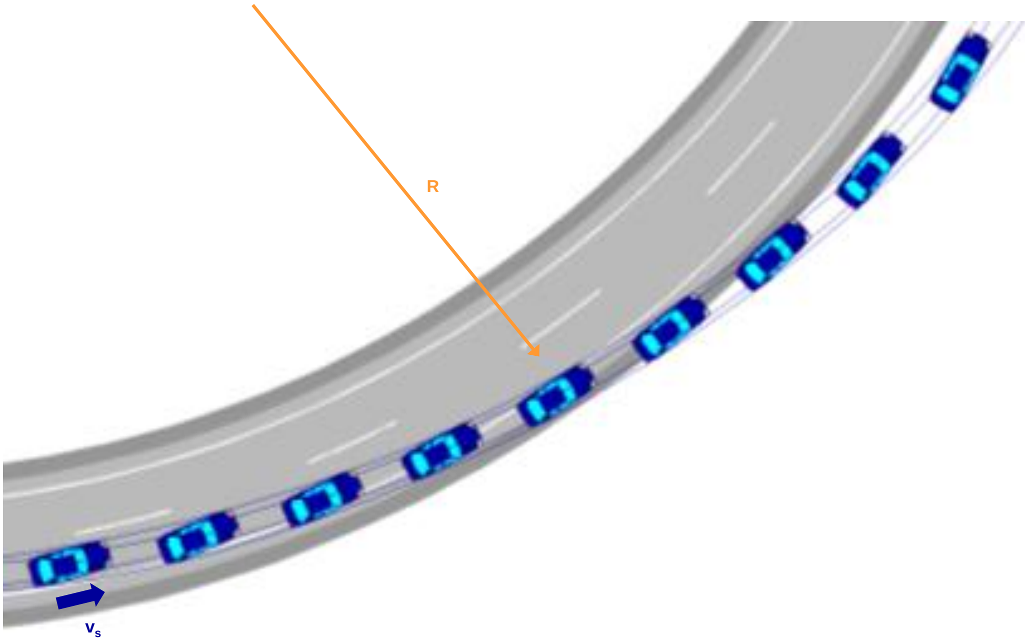
* Side of the lane departure

This scenario could be used to validate the safety requirements of ICT-based systems such as LDW or LKA.



Examples of LDW (Source: Volvo)

Scenario name: Road departure on a curved road	Scenario identifier: Scen-C2-4



Objective:

This scenario is meant to validate the subject vehicle capability to avoid involuntary road departure driving on a curve.

Scenario relevance:

The scope of this scenario will represent 4% of the accidents and 3% of the fatalities, in the case of collision with another vehicle moving laterally in the same direction. The preparation of this scenario is fairly simple, i.e., the main complexity resides in the lane marks positioning.

The scenario will evaluate ICT-based safety systems such as LDW and LKA.

Description:

This is a single vehicle scenario moving inside a curve. The subject vehicle is driving at speed V_S inside the lane boundaries, and suddenly leaves the road involuntarily. Related to the subject vehicle, the scenario considers all type of vehicles driving at different speed settings. The scenarios can be conducted at different weather, road, and visibility conditions. The subject vehicle can be driven by professional test drivers or driving robots.

References:

German Accident Statistics 2006 report, eVALUE internal documentation, May 2008.

Development of Crash Imminent Test Scenarios for Integrated Vehicle-Based Safety Systems (IVBSS), Publication DOT 810 757, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Integrated Vehicle-Based Safety Systems (IVBSS), First Annual Report, Publication DOT HS 810 842, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Definition of a Pre-Crash Scenario Typology For Vehicle Safety Research, Paper Number 07-0412, Volpe National Transportation Systems Center, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Scenario name: Road departure on a curved road	Scenario identifier: Scen-C2-4

Scenario examples:

Depending on the lateral velocity of the subject vehicle relative to the lane marks, Vs (subject vehicle velocity) the environment conditions and the type of vehicle, different real traffic scenarios can be emulated. If the subject vehicle is travelling at speed Vs the following table shows how the other parameters can be selected to create different test cases:

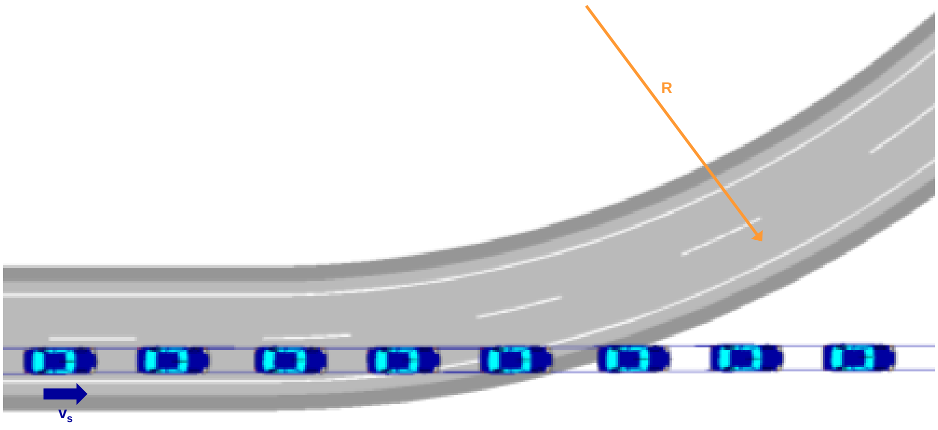
Scenario examples	SVehicle	V_s	Direction*	Environment
Road departure on the right	Passenger	V_s	Right	Daylight, Dry asphalt
Road departure on the right	Passenger	V_s	Right	Night, Icy asphalt
Road departure on the left	Passenger	V_s	Left	Daylight, Dry asphalt
Road departure on the left	Passenger	V_s	Left	Night, Icy asphalt

* Side of the road departure

This scenario could be used to validate the safety requirements of ICT-based systems such as LDW or LKA.

Examples of LDW (Source: Nissan)

Scenario name: Lane departure on a straight road just before entering a curve	Scenario identifier: Scen-C2-5



Objective:
This scenario is meant to validate the subject vehicle capability to avoid involuntary lane departure driving on a straight road just before entering an upcoming curve.

Scenario relevance:
The scope of this scenario will represent 4% of the accidents and 3% of the fatalities, in the case of collision with another vehicle moving laterally in the same direction. The complexity on the preparation of this scenario resides when setting up the curve and the merging of the straight road and the curve. Rather than that, the preparation is fairly simple, i.e., the main complexity resides in the lane marks positioning.

The scenario will evaluate ICT-based safety systems such as LDW and LKA.

Description:
This is a single vehicle scenario moving on a straight road just before entering an upcoming curve. The subject vehicle is driving at speed V_S inside the lane boundaries, and suddenly leaves the lane involuntarily just before entering the upcoming curve. Related to the subject vehicle, the scenario considers all type of vehicles driving at different speed settings. The scenarios can be conducted at different weather, road, and visibility conditions. The subject vehicle can be driven by professional test drivers or driving robots.

References:
German Accident Statistics 2006 report, eVALUE internal documentation, May 2008.

Development of Crash Imminent Test Scenarios for Integrated Vehicle-Based Safety Systems (IVBSS), Publication DOT 810 757, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Integrated Vehicle-Based Safety Systems (IVBSS), First Annual Report, Publication DOT HS 810 842, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Definition of a Pre-Crash Scenario Typology For Vehicle Safety Research, Paper Number 07-0412, Volpe National Transportation Systems Center, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Scenario name: Lane departure on a straight road just before entering a curve	**Scenario identifier:** Scen-C2-5

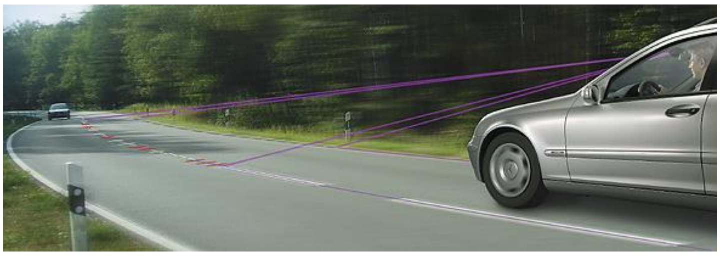
Scenario examples:

Depending on V_s (subject vehicle velocity) the environment conditions and the type of vehicle, different real traffic scenarios can be emulated. If the subject vehicle is travelling at speed V_S the following table shows how the other parameters can be selected to create different test cases:

Scenario examples	SVehicle	V_s	Direction*	Environment
Lane departure on the right	Passenger	V_s	Right	Daylight, Dry asphalt
Lane departure on the right	Passenger	V_s	Right	Night, Icy asphalt
Lane departure on the left	Passenger	V_s	Left	Daylight, Dry asphalt
Lane departure on the left	Passenger	V_s	Left	Night, Icy asphalt

* Side of the lane departure

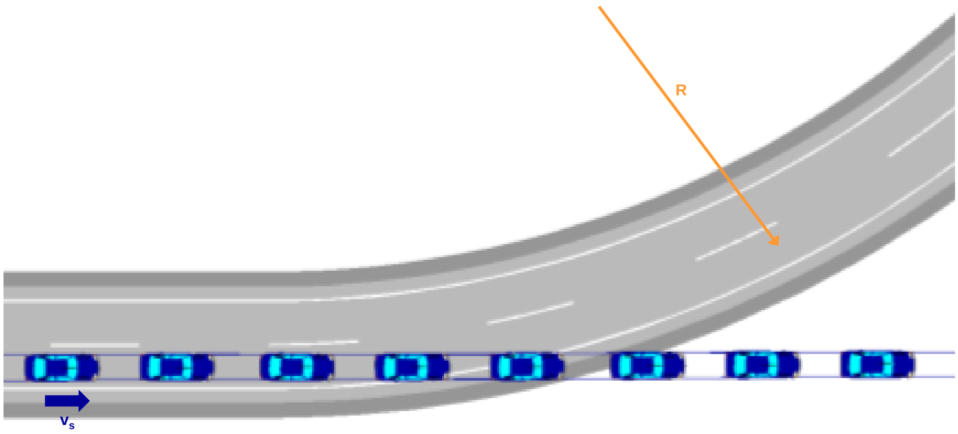
This scenario could be used to validate the safety requirements of ICT-based systems such as LDW or LKA.



Example of LKA/LDW (Source: Mercedes Benz)

Example of LDW (Source: BMW)

Scenario name: Road departure on a straight road just before entering a curve	**Scenario identifier:** Scen-C2-6



Objective:
This scenario is meant to validate the subject vehicle capability to avoid involuntary road departure driving on a straight road just before entering an upcoming curve.

Scenario relevance:
The scope of this scenario will represent 4% of the accidents and 3% of the fatalities, in the case of collision with another vehicle moving laterally in the same direction. The complexity on the preparation of this scenario resides when setting up the curve and the merging of the straight road and the curve. Rather than that, the preparation is fairly simple, i.e., the main complexity resides in the lane marks positioning.

The scenario will evaluate ICT-based safety systems such as LDW and LKA.

Description:
This is a single vehicle scenario moving on a straight road just before entering an upcoming curve. The subject vehicle is driving at speed V_S inside the lane boundaries, and suddenly leaves the road involuntarily just before entering the upcoming curve. Related to the subject vehicle, the scenario considers all type of vehicles driving at different speed settings. The scenarios can be conducted at different weather, road, and visibility conditions. The subject vehicle can be driven by professional test drivers or driving robots.

References:
German Accident Statistics 2006 report, eVALUE internal documentation, May 2008.

Development of Crash Imminent Test Scenarios for Integrated Vehicle-Based Safety Systems (IVBSS), Publication DOT 810 757, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Integrated Vehicle-Based Safety Systems (IVBSS), First Annual Report, Publication DOT HS 810 842, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Definition of a Pre-Crash Scenario Typology For Vehicle Safety Research, Paper Number 07-0412, Volpe National Transportation Systems Center, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Scenario name:	Scenario identifier:
Road departure on a straight road just before entering a curve	Scen-C2-6

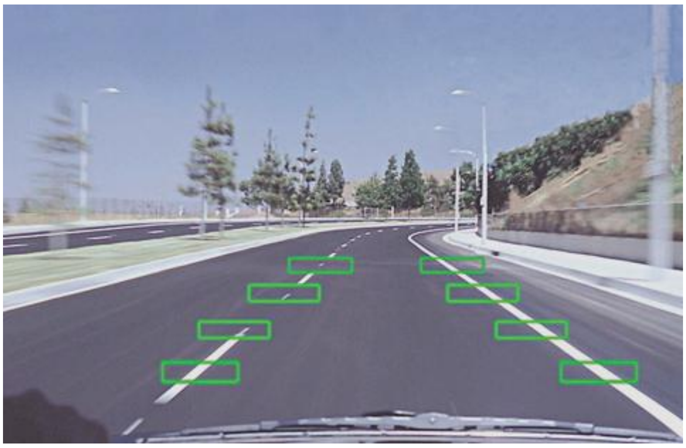
Scenario examples:

Depending on V_s (subject vehicle velocity) the environment conditions and the type of vehicle, different real traffic scenarios can be emulated. If the subject vehicle is travelling at speed Vs the following table shows how the other parameters can be selected to create different test cases:

Scenario examples	SVehicle	V_s	Direction*	R	Environment
Road departure on the right	Passenger	V_s	Right	Curve Radius	Daylight, Dry asphalt
Road departure on the right	Passenger	V_s	Right	Curve Radius	Night, Icy asphalt
Road departure on the left	Passenger	V_s	Left	Curve Radius	Daylight, Dry asphalt
Road departure on the left	Passenger	V_s	Left	Curve Radius	Night, Icy asphalt

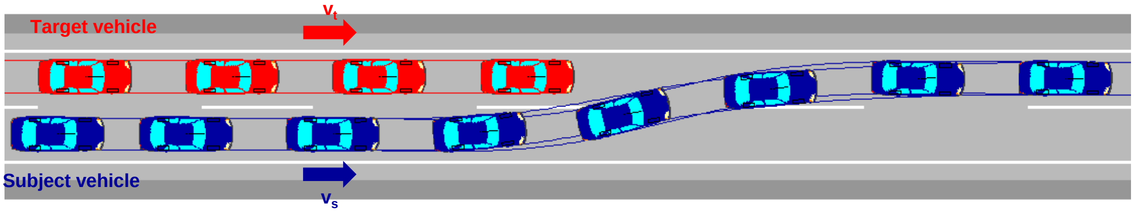
* Side of the road departure

This scenario could be used to validate the safety requirements of ICT-based systems such as LDW or LKA.



Example of LKA/LDW (Source: Nissan)

Scenario name: Lane change collision avoidance on a straight road	Scenario identifier: Scen-C2-7



Objective:

This scenario is meant to validate the subject vehicle capability to avoid a lateral collision when changing lane on a straight road and encountering an approaching target vehicle.

Scenario relevance:

The scope of this scenario will represent 15% of the accidents, in the case of collision when leaving the carriage way to the left or the right. The preparation of this scenario is fairly simple, i.e., the main complexity resides in the lane marks positioning. Finally, the scenario will validate the safety requirements of ICT-based safety system proposed, such as BSD.

Description:

In this scenario a subject as well as a target vehicle are involved. The subject vehicle is driving at speed Vs on a straight road and voluntarily changes the lane, encountering an approaching target vehicle (Vt). The scenario considers that the target vehicle is both outside and inside the blind spot, when reaching or passing the subject vehicle. Related to the subject and the target vehicle, the scenario considers all type of vehicles driving at different speed settings. The scenarios can be conducted at different weather, road and visibility conditions. The subject vehicle can be driven by professional test drivers or driving robots.

References:

German Accident Statistics 2006 report, eVALUE internal documentation, May 2008.

Development of Crash Imminent Test Scenarios for Integrated Vehicle-Based Safety Systems (IVBSS), Publication DOT 810 757, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Integrated Vehicle-Based Safety Systems (IVBSS), First Annual Report, Publication DOT HS 810 842, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Objective Test Scenarios for Integrated Vehicle-Based Safety Systems (IVBSS), Paper Number 07-0183, National Highway Traffic Safety Administration, National Institute of Standards and Technology, Volpe National Transportation Systems Center, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Analysis of Lane Change Crashes, Research and Special Programs Administration, Publication DOT HS 809 571, Volpe National Transportation Systems Center, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Scenario name: Lane change collision avoidance on a straight road	**Scenario identifier:** Scen-C2-7

Scenario examples:

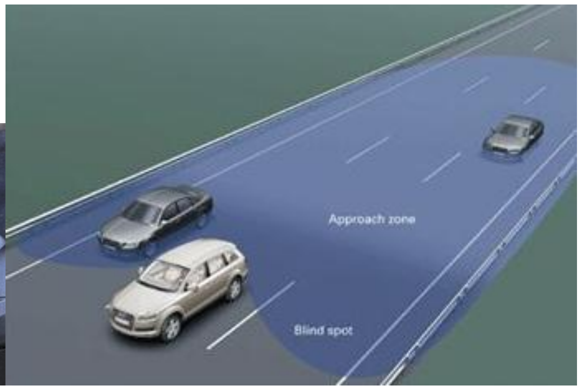
Depending on the lateral velocity of the subject vehicle, Vs (subject vehicle velocity), V_T (target vehicle velocity) ,the environment conditions and the type of vehicle, different real traffic scenarios can be emulated. If the subject vehicle is travelling at speed Vs the following table shows how the other parameters can be selected to create different test cases:

Scenario examples	SVehicle	LatVs	Vs	Direction*	TVehicle	V_T	Environment
Low lateral velocity (Right)	Passenger	Lat-$_{Low}V_S$	V_S	Right	Passenger	V_T	Daylight, Dry asphalt
High lateral velocity (Right)	Passenger	Lat_{HIGH} V_S	V_S	Right	Passenger	V_T	Daylight, Dry asphalt
Low lateral velocity (Left)	Passenger	Lat-$_{Low}V_S$	V_S	Left	Passenger	V_T	Daylight, Dry asphalt
High lateral velocity (Left)	Passenger	Lat_{HIGH} V_S	V_S	Left	Passenger	V_T	Daylight, Dry asphalt

* Side of the intended lane change

This scenario could be used to validate ICT-based safety systems such as the BSD when the target vehicle is both inside and outside the subject's blind spot

Example of BSD (Source: Volvo)

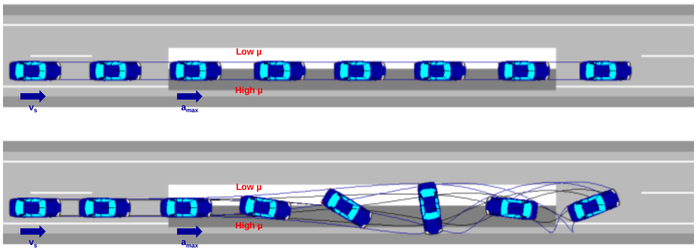


Example of BSD (Source: Audi)

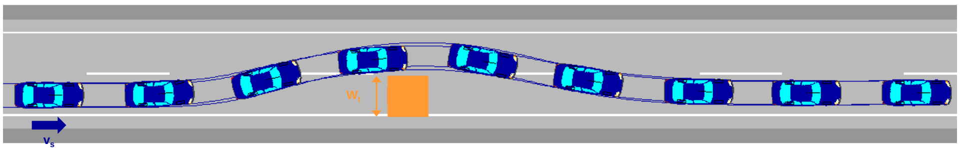
4.4 Scenarios CLUSTER 3

This chapter includes the different scenarios addressed under Cluster 3 as well as the safety indicators that will one way or another measure the functional safety of the subject vehicle on a stability control basis.

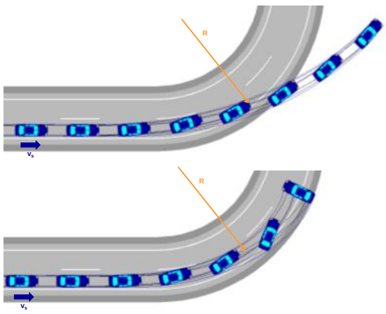
- Scen-C3-1: Emergency braking on a µ-split. Evaluate the subject vehicle capability to stop in a reasonable space keeping the desired driving direction while braking on asymmetric surface.



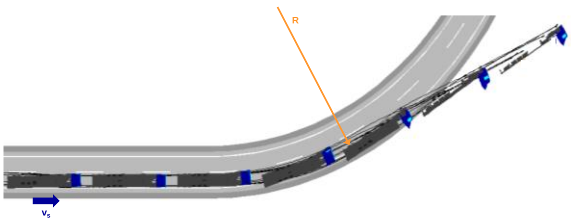
- Scen-C3-2: Driver collision avoidance. Evaluate the subject vehicle capability to avoid the loss of control in case of a sudden obstacle avoidance manoeuvre, followed by a come back to the original lane in order to avoid the collision with an incoming vehicle.



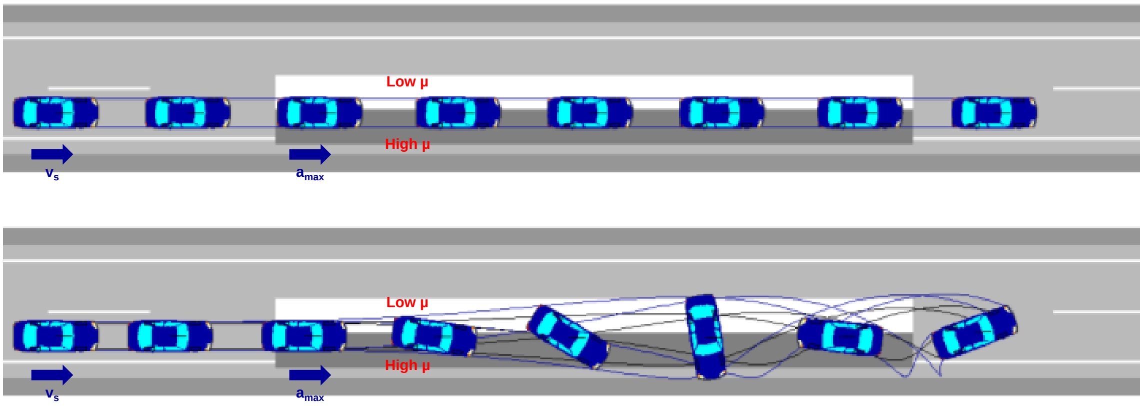
- Scen-C3-3: Fast driving into a curve. Evaluate the subject vehicle capability to avoid a loss of control as well as a lane/road departure in the case of a curve approached too fast.



- Scen-C3-4: Roll stability scenario. Evaluate the subject vehicle capability to avoid a loss of stability which may result in a rollover event while negotiating a long curve, such as highway entrance or exit ramps.



Scenario name:	Scenario identifier:
Emergency braking on a µ-split	Scen-C3-1



Objective:

This scenario is meant to evaluate the subject vehicle capability to stop in a reasonable space keeping the desired driving direction while braking on a µ-split surface.

Scenario relevance:

The scope of this scenario represents about 10000 accidents on rural roads per year. The preparation of this scenario is quite simple: only the availability of a high/low friction surface is required. The scenario will validate the behaviour of ICT-based safety systems, such as ABS and ESC.

Description:

This is a single vehicle scenario. The subject vehicle is moving on a straight road at a V_S speed when it reaches the brake test course with the µ-split surface. On µ-split surfaces the vehicle is braking. Related to the subject vehicle, the scenario can consider all type of vehicles. The scenarios can be conducted at different weather and road conditions. The subject should be driven by professional test drivers.

References:

German Accident Statistics 2006 report, eVALUE internal documentation, May 2008.

ISO 21994 Passenger cars – Stopping distance at straight-line braking with ABS – Open-loop test method

Scenario name: Emergency braking on a µ-split	**Scenario identifier:** Scen-C3-1

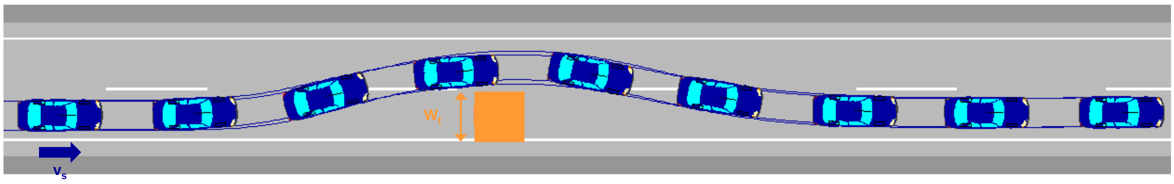
Scenario examples:

This scenario can represent a real situation in which, due to humidity and low temperature, the side of the lane in shadow is frosted or icy while the side in the sun is dry. Depending on Vs (subject vehicle velocity), the braking force, the environment conditions and the type of vehicle, different real traffic scenarios can be emulated. If the subject vehicle is travelling at speed Vs the following table shows how the other parameters can be selected to create different test cases:

Scenario examples	Svehicle	Vs	Braking	Environment
Low adherence surface (ice, water, grass,..) on the right	Passenger	V_s	Smooth	µ-split asphalt
Low adherence surface (ice, water, grass,..) on the right	Passenger	V_s	Hard	µ-split asphalt
Low adherence surface (ice, water, grass,..) on the left	Passenger	V_s	Smooth	µ-split asphalt
Low adherence surface (ice, water, grass,..) on the left	Passenger	V_s	Hard	µ-split asphalt

Example of control and breaking distance on a wet µ-split surface of a vehicle equipped with ESC (Source: SAE)

Scenario name:	**Scenario identifier:**
Driver collision avoidance	Scen-C3-2



Objective:

This scenario is meant to evaluate the subject vehicle capability to avoid the loss of control in case of a sudden obstacle avoidance manoeuvre, followed by a come back to the original lane in order to avoid the collision with an incoming vehicle.

Scenario relevance:

The scope of this scenario represents 15 % of the accidents.

The scenario will evaluate ICT-based safety systems such as ESC and ABS.

Description:

This is a single vehicle scenario. The subject vehicle is moving on a straight road at a V_S speed when the driver, in order to avoid a collision with an unexpected object, brakes the vehicle heavily, then tries to change the lane without running off the road and finally tries to come back to the original lane in order to avoid a front collision. Related to the subject vehicle, the scenario can consider all type of vehicles. The scenarios can be conducted at different weather and road conditions. The subject vehicle should be driven by professional test drivers or the manoeuvres may be executed by steering robots.

References:

German Accident Statistics 2006 report, eVALUE internal documentation, May 2008.

ISO 3888-2 Passenger cars – Test track for a severe lane change manoeuvre – Obstacle avoidance

Scenario name: Driver collision avoidance	**Scenario identifier:** Scen-C3-2

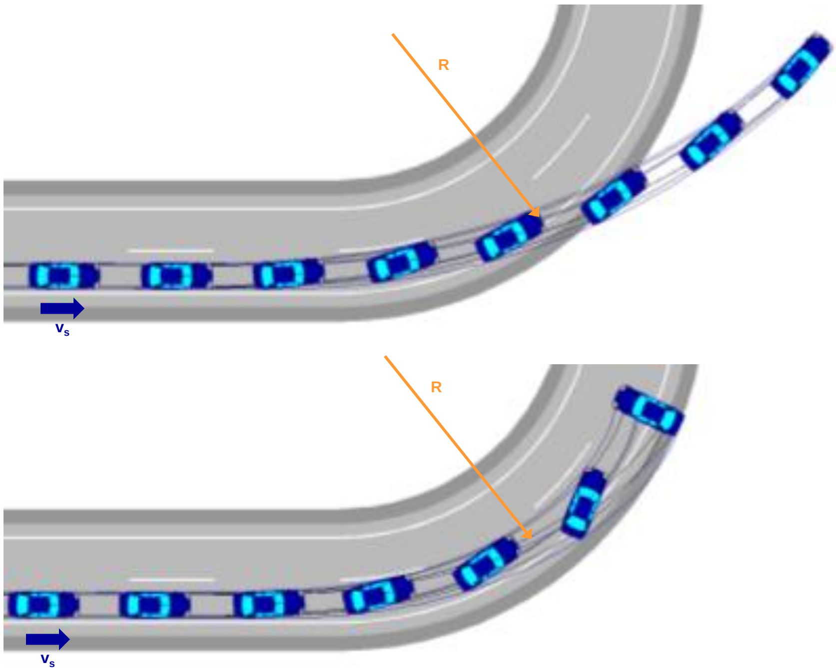
Scenario examples:

This scenario can represent a real traffic scenario in which the driver tries to perform a severe lane change, in order to avoid a collision with an unexpected obstacle or with a suddenly braking forward vehicle (T1 vehicle); then the driver tries to come back to the original lane in order to avoid a front collision with an incoming vehicle (T2 vehicle).

Depending on Vs (subject vehicle velocity), speed and size for the target objects and the environment conditions, different real traffic scenarios can be emulated. If the subject vehicle is travelling at speed V_S the following table shows how the other parameters can be selected to create different scenarios:

Scenario examples	SVehicle	SBraking	TVehicles	Vt1	T1Braking	Vt2	Environment
Severe lane change on the left and back into the lane	Passenger	Hard	Passenger	0	No	V_{t2} = Low	Dry asphalt
Severe lane change on the left and back into the lane	Passenger	Smooth	Passenger	V_{t1}	Smooth	V_{t2} = Low	Dry asphalt
Severe lane change on the left and back into the lane	Passenger	Hard	Passenger	0	No	V_{t2} = High	Dry asphalt
Severe lane change on the left and back into the lane	Passenger	Smooth	Passenger	V_{t1}	Smooth	V_{t2} = High	Dry asphalt

Scenario name: Driver collision avoidance	Scenario identifier: Scen-C3-2
 Example on Driver Collision avoidance (Source: CRF)	

Scenario name: Fast driving into a curve	Scenario identifier: Scen-C3-3
	
Objective: This scenario is meant to evaluate the subject vehicle capability to avoid a loss of control as well as a lane/road departure in the case of a curve approached too fast.	

Scenario name: Fast driving into a curve	Scenario identifier: Scen-C3-3

Scenario relevance:

The scope of this scenario represents 15 % of the accidents. The preparation of this scenario is quite simple: it requires only a flat surface (dynamic platform) with marked constant radius circles.

The scenario will evaluate ICT-based safety systems such as ESC and ASR.

Description:

This is a single vehicle scenario. The subject vehicle is moving on a straight road at a V_S speed when the driver tries to negotiate a curve with a radius too small for the vehicle speed, so it tends to depart road edge outside or inside the curve depending on its understeering or oversteering behaviour. Related to the subject vehicle, the scenario considers mainly cars and light commercial vehicles. The scenarios can be conducted at different weather and road conditions. The subject should be driven by professional test drivers or the manoeuvres may be executed by steering robots.

References:

German Accident Statistics 2006 report, eVALUE internal documentation, May 2008.

Development of Crash Imminent Test Scenarios for Integrated Vehicle-Based Safety Systems (IVBSS), Publication DOT 810 757, U.S. Department of Transportation, National Highway Traffic Safety Administration. (Run-off road crash imminent test scenario 3)

Scenario examples:

This scenario can represent a real situation in which the driver hasn't well evaluated the geometry of the road.

Depending on Vs (subject vehicle velocity), the road radius, the environment conditions and the type of vehicle, different real traffic scenarios can be emulated. If the subject vehicle is travelling at speed Vs the following table shows how the other parameters can be selected to create different scenarios:

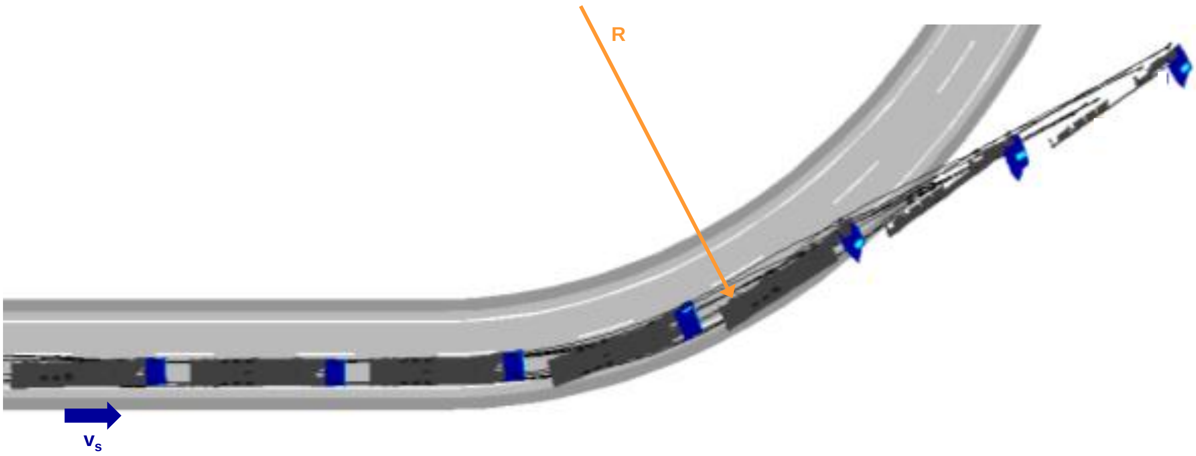
Scenario examples	SVehicle	V_s	Direction*	R	Environment
Bending at high speed on the right	Passenger	V_s	Right	Curve Radius	Dry asphalt
Bending at high speed on the right	Passenger	V_s	Right	Curve Radius	Icy asphalt
Bending at high speed on the left	Passenger	V_s	Left	Curve Radius	Dry asphalt
Bending at high speed on the left	Passenger	V_s	Left	Curve Radius	Icy asphalt

* Side of the curve

Scenario name: Fast driving into a curve	Scenario identifier: Scen-C3-3

Example on fast driving into a curve scenario (Source: CRF)

Scenario name: Roll stability scenario	Scenario identifier: Scen-C3-4



Scenario name: Roll stability scenario	**Scenario identifier:** Scen-C3-4

Objective:
This scenario is meant to evaluate the subject vehicle capability to avoid a loss of stability which may result in a rollover event while negotiating a long curve, such as highway entrance or exit ramps.

Scenario relevance:
A National Highway Traffic Safety Administration report showed that rollover occurred in 52% of the accidents, involving heavy duty trucks, in which the driver was killed. The preparation of this scenario is simple as it requires only a flat surface but the execution will require complex safety equipments (outriggers).

The scenario will evaluate ICT-based safety systems such as ESC and antiroll systems.

Description:
This is a single vehicle scenario. The subject vehicle is moving on a straight road at a V_S speed when the driver tries to negotiate a long curve for which such speed is excessive. Related to the subject vehicle, the scenario considers mainly heavy-duty trucks. The scenarios can be conducted at different weather and road conditions. The subject should be driven by professional test drivers or the manoeuvres may be executed by steering robots.

References:
NHTSA Reports on heavy duty truck accidents.

Scenarios examples:

This scenario can represent a real situation in which the driver hasn't well evaluated the geometry of the road. Moreover, considering that a heavy-duty truck can have a dynamic behaviour significantly different depending on the load condition, the driver can experience a dangerous condition also on well known roads.

Depending on Vs (subject vehicle velocity), the road radius, the environment conditions and the vehicle load condition, different real traffic scenarios can be emulated. If the subject vehicle is travelling at speed Vs the following table shows how the other parameters can be selected to create different scenarios:

Scenario examples	SVehicle	SLoad	Direction*	R	Environment
Negotiating a long curve on the right	Truck	Unloaded semi-trailer	Right	Curve Radius	Dry asphalt
Negotiating a long curve on the right	Truck	Full loaded semi-trailer, load centred	Right	Curve Radius	Dry asphalt
Negotiating a long curve	Truck	Full loaded semi-trailer,	Right	Curve	Dry asphalt

Scenario name: Roll stability scenario	**Scenario identifier:** Scen-C3-4

on the right		load shifted to the left		Radius	
Negotiating a long curve on the left	Truck	Unloaded semi-trailer	Left	Curve Radius	Dry asphalt
Negotiating a long curve on the left	Truck	Full loaded semi-trailer, load centred	Left	Curve Radius	Dry asphalt
Negotiating a long curve on the left	Truck	Full loaded semi-trailer, load shifted to the right	Left	Curve Radius	Dry asphalt

* Side of the curve

Example on Roll stability scenario (Source: CRF)

5 eVALUE CONCEPT TESTS CONCLUSIONS

This document delivers the concepts definitions of the eVALUE test, which are classified under design review, laboratory test and physical vehicle tests. Under the scenario approach, selected and approved among all the partners, the tests compiled on the following chart have been defined. In order to have a better understanding of the chart there are two aspects that should be bared in mind, test sequence and information flow between the tests.

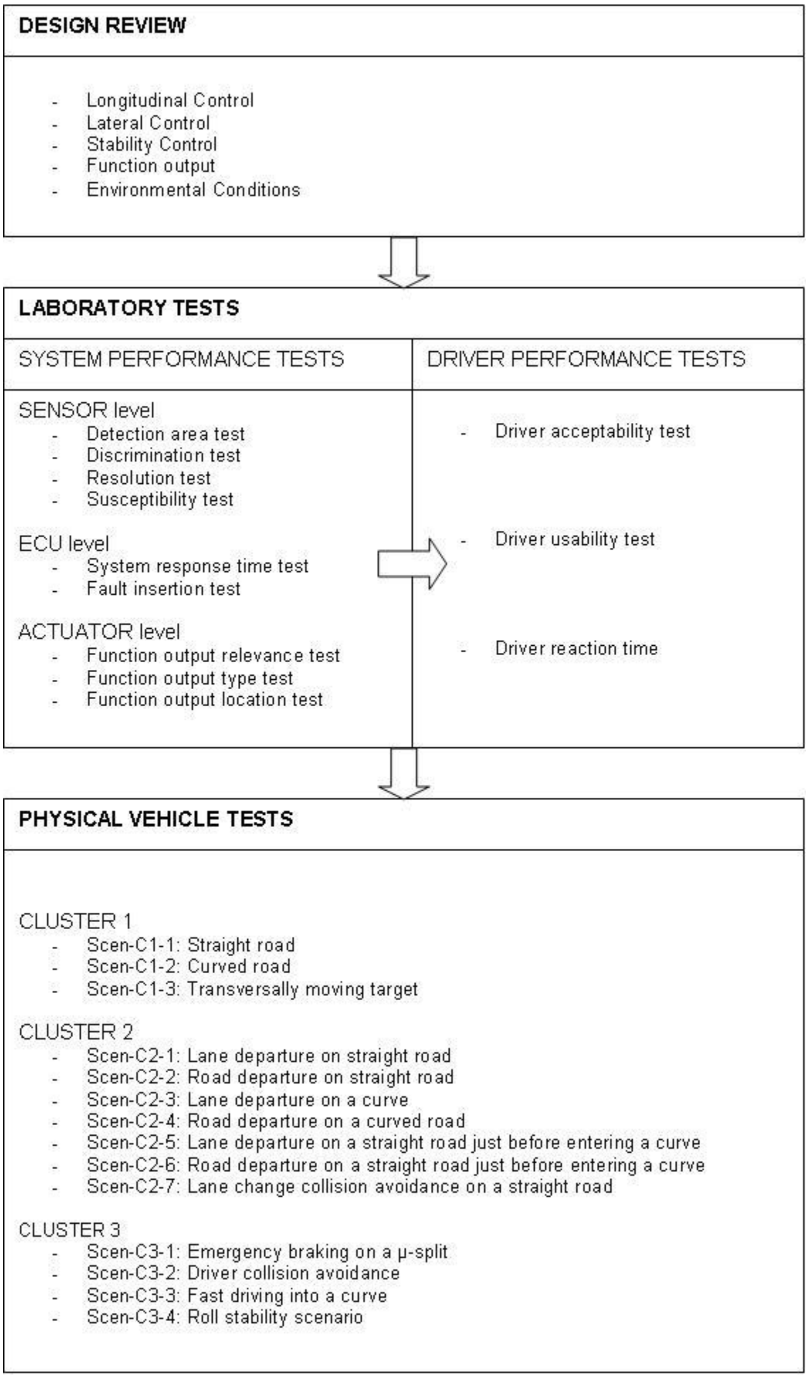


Fig. 5-1: Pert diagram of eVALUE tasks involved in deliverable D1.2.

6 GLOSSARY and ACRONYMS

Design Review	Systematic, comprehensive, and documented analysis of a design to determine its capability and adequacy to meet its requirements. A design review also serves to identify present and potential problems.
Driver acceptance	System acceptance is referred to driver's subjective evaluation about ICT-based safety systems, taking into account two aspects: system usefulness, namely how useful the system(s) was in terms of traffic safety, and system satisfaction, namely how pleasant was driving with the system(s) on.
Driver distraction	This parameter under eVALUE could be further divided into cognitive and sensitive distraction. Moreover, distraction could be measured as a momentary value (e.g. "eyes-off-road") or as a time averaged value (e.g. average time spent on the road within a 5-second time window).
Driver performance	It refers to the quantitative measurement of one or more variables with respect to driver changes in speed (reaction time) and accuracy (hit rate).
Driver usability	The extent to which a safety system can be used by individual drivers to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use of the subject vehicle.
Driver workload	Amount of information processing capacity used to perform the driving task.
Driving Simulator tests	Tests to evaluate the features and quality of the safety system's HMI and the human response to critical safety situations, from the driver point of view.
Function	Implementation of a set of rules to achieve a specified goal.
Function output	Describes the resulting output of the system/function in terms of information. Continuous information or a warning is issued to the driver via different channels: optical/ acoustical/ haptic support: amplify the driver action to a higher level. No autonomous action is taken by the system/ function, but the system "prepares itself" to reduce e. g. system reaction time. No action like steering or braking is taken without an initiation by the driver action: the system/ function acts autonomously without any action of the driver
Functional Safety	Functional safety for a safety system is specified in terms of safety functions and safety integrity levels. Each safety function has a safety integrity level assigned. Safety functions are designed to provide the risk reduction pointed out by the risk and hazard analysis, by eliminating or mitigating dangerous faults or critical system states.
Human factors	Human abilities, limitations and other human characteristics.

Human factors testing	Provides an understanding of how drivers perform as a system component in the safe operation of vehicles. This role recognizes that driver performance is influenced by many environmental, psychological and vehicle design factors.
Integrity	State of a system where it is performing its intended functions without being degraded or impaired by changes or disruptions in its internal or external environments.
ISS	Integrated safety system.
Laboratory Test	Tests that are driven on a static environment such as a laboratory or a workshop, in order to identify and determine the concepts, requirements, specifications and limitations of the safety systems and subsystems in the subject vehicle.
Nuisance alarm	An alarm that is perceived by the driver as a nuisance, this includes both false alarms and alarm where the system works as intended.
Safety indicator	Measurable quantity candidate to be used on a definition for the complete vehicle's safety performance measurement
Safety System	A safety system is characterised by the safety functions that are provided. The safety functions are composed by the interaction of safety-related modules and sub-functions. The correct operation of safety functions is specified by well defined safety parameters and safety attributes. The integration of the safety entities is summarised by the concept of functional safety
Scenario	Scenarios represent specific driving situations (related to real driving situations) which are relevant regarding the functionality of considered systems in the different clusters.
Subject vehicle	Vehicle equipped with the systems under evaluation
System performance	It refers to the quantitative measurement of one or more variables with respect to safety system changes in speed (reaction time) and accuracy (hit rate).
Target vehicle	Vehicle detected by the systems of the subject vehicle.
Test Procedure	A description of how to perform a test. It can contain specific driving manoeuvres, including different test cases (tests with different speeds, different weather conditions, etc.), laboratory tests or design reviews to evaluate the system. (A test procedure should be described in such detail so the test results will be repeatable. A test procedure will specify the test resources needed to perform the test.)
Test Program	Collection of all the test procedures for all clusters. The eVALUE Test Program will be integration of all the test procedures developed within the project.

Test Resource	Resources needed to perform a test, such as equipment, infrastructure and human resources.
Test Suite	A Test Suite is a collection of the tests procedures of a cluster which are representative for the evaluation of a safety function, a safety system or the behaviour of a vehicle under a specific scenario.
TLC	Time line crossing. Time remaining before the driver's vehicle will reach a lane boundary assuming the current steering wheel angle remains constant and the driver fails to intercede [Godthelp et al., 1984]
TTC	Time to collision. Time required for two vehicles to collide if they continue at their present speed and on the same path [Hayward, 1972]
Validation	Describes the process of evaluating the system impact e. g. on safety. That is, validation checks and tests whether the system "does what it was designed for", e. g. increase traffic safety by increasing headway, by avoiding impacts and so on. Driver-in-the-loop testing is required.
Verification	Describes the test of a system/ function against its requirements, that is, whether it fulfils its requirements.

ABS	Antilock Brake System	**IR**	Infrared
ACC	Adaptive Cruise Control	**ISO**	International Standardisation organisation
ACIM	Alternating Current Induction Motor	**IVBSS**	Integrated Vehicle-Based Safety System
ADAS	Advanced Driver Assistance Systems	**IVDC**	Interactive Vehicle Dynamic Control
AFS	Adaptive Front-Lighting System	**IVIS**	Integrated Vehicular Information System
AMR	Anisotropic Magnetoresistance	**LCDAS**	Lane Change Decision Aid System
BOS	Beginning of Steer	**LCW**	Lane Change Warning
BSD	Blind Spot Detection	**LDW**	Lane Departure Warning
BSM	Blind Spot Monitoring	**LDWS**	Lane Departure Warning System
CAN	Controller Area Network	**LED**	Light Emitting Diode
CCD	Charge Coupled Device	**LIDAR**	Light Detection and Ranging
CM	Collision Mitigation	**LIN**	Local Interconnect Network
CMbB	Collision Mitigation by Braking	**LKA**	Lane Keeping Assistance
CMBS	Collision Mitigation Braking System	**LRR**	Long Range Radar
CMOS	Complementary Metal Oxide Semiconductor	**LSF**	Low Speed Following
CPU	Central Processing Unit	**MCU**	Microprocessor Control Unit
CWS	Collision Warning System	**MMW**	Millimetre Wave
DC	Diagnostic Coverage	**MOST**	Media Oriented System Transfer
DC	Direct Current	**NHTSA**	National Highway Traffic Safety Administration
DTI	Diagnostic Test Interval	**NHTSA**	National Highway Traffic Safety Administration
E/E/PES	Electrical/Electronic/Programmable Electronic Safety	**NIR**	Near Infrared
ECU	Electrical Control Unit	**OEM**	Original Equipment Manufacturer
EM	Electromagnetic	**PCB**	Printed Circuit Board
EMI	Electromagnetic Interference	**PDT**	Peripheral Detection Task
EPS	Electric Power Steering	**PFH**	Probability of dangerous Failures per Hour
ESC	Electronic Stability Control	**Radar**	Radio Detection and Ranging
ESD	Electrostatic Discharge	**RBD**	Reliability Block Diagrams
EUC	Equipment Under Control	**RCS**	Radar Cross Section
EWB	Electronic Wedge Brake	**RCS**	Radar Cross Section
FCW	Forward Collision Warning	**SAE**	Society of Automotive Engineers
FIR	Far Infrared	**SAGAT**	Situation Awareness Global Assessment Technique
FMCW	Frequency Modulated Continuous Wave	**SART**	Structured Analysis for Real Time Systems
FMEA	Failure Modes and Effects Analysis	**SBW**	Steer by Wire
FMVSS	Federal Motor Vehicle Safety Standard	**SFF**	Safe Failure Fraction
FOV	Field of View	**SFF**	Safe Failure Fraction
FTA	Fault Tree Analysis	**SRR**	Short Range Radar
GES	General Estimates System	**SV**	Subject Vehicle
GPIO	General Purpose Input/Output	**SWA**	Steering Wheel Angle
GPS	Global Positioning System	**TC**	Traction Control
GVWR	Gross Vehicle Weight Ratio	**TLC**	Time to Line Crossing
HFT	Hardware Fault Tolerance	**TTC**	Time To Collision
HMI	Human Machine Interface	**UDF**	Uncoupled Double Filter
HUD	Head-Up Display	**V2I**	Vehicle to Infrastructure
IC	Integrate Circuit	**V2V**	Vehicle to Vehicle
ICT	Information and Communication Technologies	**VDM**	Visual Demand Measurement
IEC	International Electrotechnical Commission	**VIN**	Vehicle Identification Number

7 REFERENCE DOCUMENTS

RELATED DOCUMENTS FROM eVALUE or OTHER SOURCE			
N°	**Name**	**Responsible partner**	**Description**
[DOC 1]	eVALUE Annex 1	IKA	eVALUE Annex 1–Description of Work – Contract 215607
[DOC 2]	D1.1 “State of the art and eVALUE scope” (Version 31/3/08)	TECNALIA-RBTK	Description on the ICT-based safety systems selected under eVALUE scope, classified into four clusters, their technologies and an overview of the current test and evaluation methods.
[DOC 3]	D2.1 “Testing matrix definition”	IDIADA	Testing matrix, which relates proposed tests procedures with scenarios, ICT-based safety systems and types of tests.
[DOC 4]	ANNEX D1.2 ”Concepts definition”	TECNALIA-RBTK	Annex listing all the scenarios delivered and discussed under Task 1.3. and all the safety variables collected from the eVALUE partners.

8 ADDENDUM

The following V type diagram is representing the eVALUE approach. It shows the order of test activities, the requirements they meet on the left and the way they are related, i.e. the indicator that should be used for achieving the aimed objective (verification, validation or evaluation).

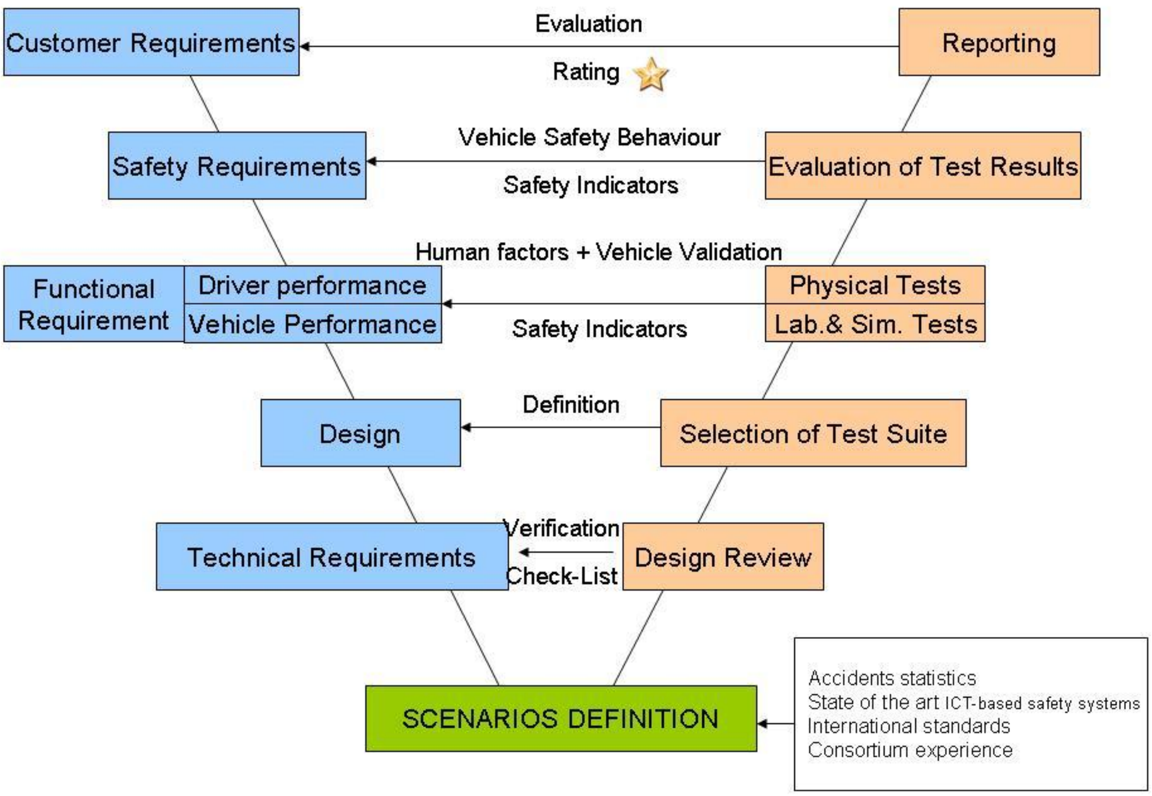


Fig. 8-1: eVALUE approach V-model

The scenario approach (refer to Fig. 4-2: eVALUE approach) to define the different tests is based on four factors: accidents statistics available both from European National Statistics and from up to date European projects (such as TRACE and PReVENT), the state of the art on current ICT-based safety systems, international standards (such as ISO and SAE) and the own consortium experience.

The main objective of eVALUE project is to obtain tools and methods for the evaluation of the safety behaviour of the vehicles from the customer's point of view through a rating scale (similar to the Euro NCAP stars rating system).

The safety behaviour of the vehicles, i.e. how safe the vehicle is, is obtained from the evaluation of the vehicle and driver performance. To determine the performance of the vehicle and the driver in a particular scenario, safety indicators are used.

A safety indicator (refer to euroFOT, http://www.eurofot-ip.eu/) is a quantitative or qualitative indicator, derived from one or several measurements, agreed on beforehand, expressed as a percentage, index, rate or other value, which is monitored at regular or irregular intervals and can be compared to one or more criteria. Converting these indicators into safety, it can be determined how “safe” is the performance of a particular vehicle in a specific scenario.