interactIVe

Accident avoidance by active intervention for Intelligent Vehicles

# Deliverable D7.2 | Specifications of the Evaluation Framework

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SEVENTH FRAMEWORK PROGRAMME

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| 0.1 | 2010-11-19 | First version by TNO |
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# Summary

interactIVe has the objective to develop new integrated Advanced Driver Assistance Systems (ADAS). In order to evaluate these systems, an evaluation framework is required. Therefore, a horizontal subproject called “Evaluation and Legal Aspects” is part of interactIVe, with the main objective to provide this framework and give support to the vertical subprojects in their evaluation work.

This document outlines the specifications for the evaluation framework on the basis of the requirements as described in D7.1. The framework will be further developed in D7.4 (“Test and evaluation plans”).

Based on the use cases from deliverable D1.5 and the requirements from D7.1, hypotheses, indicators and test scenarios are formulated and included in this deliverable D7.2.

Evaluation has, as in D7.1, been divided in three main categories:

- Technical Assessment evaluates the performance of the developed interactIVe functions and collects information and data for safety impact assessment.
- User-Related Assessment assesses the functions from the user perspective, and also to provide further input to the safety impact assessment.
- Impact Assessment, estimates how and how much the functions influence traffic safety.

This deliverable has further defined the evaluation framework by:

- Hypotheses definition based on the research questions of D7.1. The hypotheses are set up in two categories per assessment (technical, user related and impact):
    - General
    - System specific (SECONDS, INCA, and EMIC).
- Indicator definition based on the hypotheses of this deliverable. The indicators are set up per assessment (technical, user related and impact).
- Test scenarios definition based on the use cases defined in D1.5.

Summarizing, the outcome of this deliverable is a list of hypotheses, indicators and test cases, which will be used to define specific test plans for the interactIVe functions in D7.4. The current status of the project is that the functions that will be developed in interactIVe are not yet totally outlined. This document has D1.5 (v16, Annex1 v2 and Annex2 v12) and D1.6 (v0998) as a basis. Meanwhile these documents may have been updated to newer versions, which is not dealt with in this version of D7.2 but will be integrated into D7.4 (due in M22). Moreover a process of reviewing the hypotheses and test scenarios by the VSPs has started (M17) and may result in an update of some of the hypotheses, indicators and test scenarios. These will also be part of D7.4. The results of the April 2011 SP workshop have been mostly integrated into this deliverable, further discussion will lead to other changes which will be reported in D7.4.

# 1 Introduction

interactIVe has the objective to develop new integrated Advanced Driver Assistance Systems (ADAS) and active safety systems. In order to evaluate these systems, an evaluation framework is required. This document outlines the specifications for the evaluation framework on the basis of the requirement as described in D7.1. The developed evaluation framework will be described in Deliverable 7.4.

The new ADAS comprise the following systems:

- SECONDS, dealing with continuous driving support in order to avoid dangerous situation at an early stage
- INCA combining longitudinal and lateral control of the vehicle preventing possible accidents
- EMIC, focusing on critical pre-crash applications where collision mitigation can be realised at reasonable cost

Each system, SECONDS, INCA or EMIC, consists of two or more functions.

Seven different demonstrator vehicles will be developed with different sets of functions of SECONDS, INCA or EMIC. Some vehicles will even combine functions of different systems (see Table 1.1).

| Demonstrator vehicle | Integrated interactIVe functions |
|---|---|
| BMW | enhanced Dynamic Pass Predictor (SECONDS), |
| CONTI | Emergency Steer Assist (EMIC) |
| CRF | Continuous Support (SECONDS) |
| FFA | Continuous Support (SECONDS),Curve Speed Control (SECONDS), Lane Change Collision Avoidance (INCA), Rear End Collision Avoidance (INCA), Run-off Road Prevention (INCA), Side Impact Avoidance (INCA) |
| VCC | Continuous Support (SECONDS), Safe Cruise (SECONDS), Run-off Road Prevention (INCA), Lane Change Collision Avoidance (INCA), |
| VTEC | Oncoming Vehicle Collision Avoidance/Mitigation (INCA), Rear End Collision Avoidance (INCA), Run-off Road Prevention (INCA), Side Impact Avoidance (INCA) |
| VW | Collision Mitigation System (EMIC) |

Table 1.1: Overview of the interactIVe demonstrator vehicles and the integrated interactIVe functions

Some of the functions developed in SECONDS and INCA have different implementations as the demonstrators have different scenarios. However, since the target scenarios and use cases for the functions do not differ, this implementation difference is not considered at this stage. It may become relevant in future (e.g. for D7.4) when the actual tests are specified.

In this chapter first the document structure is outlined, followed by a section describing the scope of SP7 (section 1.2). Section 1.3 describes the evaluation method of PReVAL and the position of the current document in the PReVAL method is given. Finally the following steps are outlined in section 1.4.

## 1.1 Document structure

This document deals with the specifications of the evaluation framework to be used to evaluate the interactIVe systems. It is structured in a similar way as D7.1. First, in Chapter 2, the hypotheses are defined along with the indicators that should test the hypotheses. This is first done for the technical evaluation, then for the user-related evaluation and finally for the safety impact assessment. Then, in Chapter 3 the basics for setting up the test scenarios are explained. The annexes provide an overview of the defined hypotheses and connected indicators (annex 1), and the defined test cases (annex 2).

The current status of the project is that the functions that will be developed in interactIVe are not yet totally outlined. This document has D1.5 (v16, Annex1 v2 and Annex2 v12) and D1.6 (v0998) as a basis. Meanwhile these documents may have been updated to newer version, which is not dealt with in this version of D7.2 but will be integrated into D7.4. This also holds for possible modifications to the contents of this report (hypotheses, indicators and test cases). The results of the April 2011 SP workshop have been mostly integrated into this deliverable, but further discussion will lead to other changes and these will be reported in D7.4.

## 1.2 Scope

Assessment, or evaluation, is always done against certain requirements or goals for technical assessment or against a reference for impact assessment. Depending on the development stage testing is different. The process of system development and testing is best described in the V-model, which is used more and more in automotive system development (see Figure 1.1).

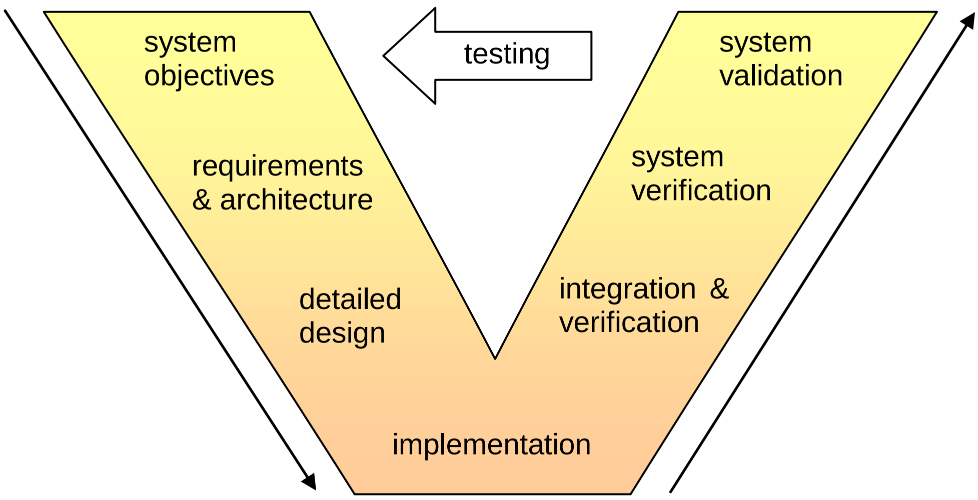


Figure 1.1: Generic V-model for system design and testing.

For evaluation of the interactIVe functions in the system validation phase of Figure 1.1 existing evaluation methods will be used; the PReVAL evaluation method. It provides a thorough framework containing technical, user-related and safety impact evaluation (see Figure 1.2)[1].

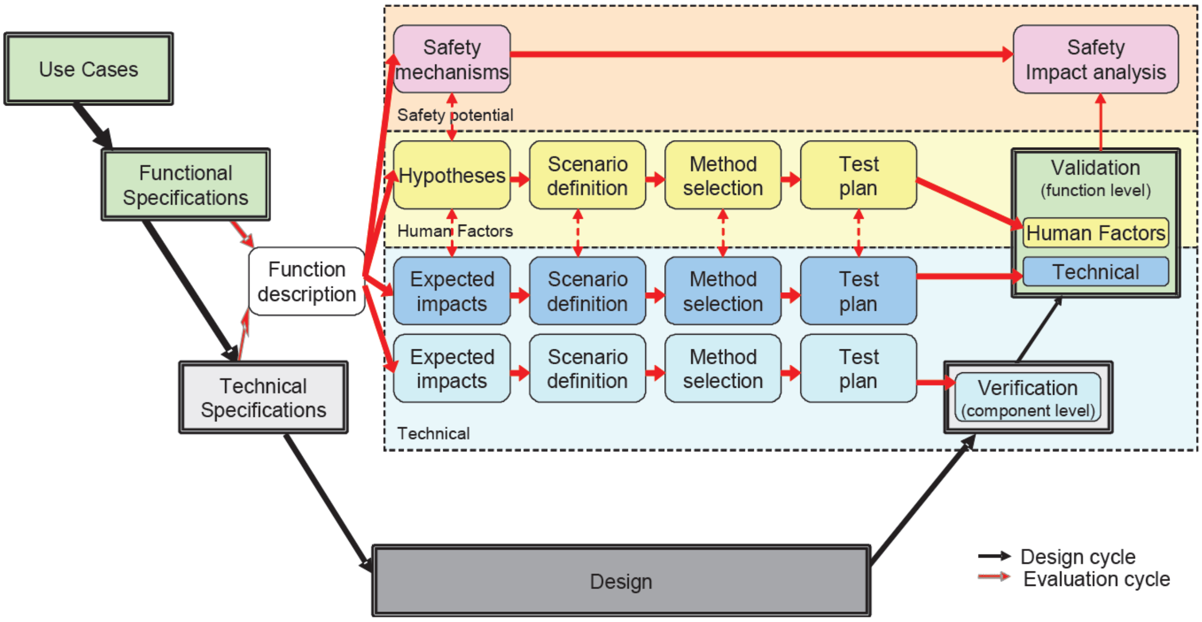


Figure 1.2: The PReVAL evaluation framework [PRE08]

One challenge to be faced for the evaluation is to address how to carry out the assessments and evaluations given all the different functions and vehicles. It has been decided that mainly the functions of the different systems are evaluated and, if time and budget allow it, some specific combinations of functions will be assessed. Hence there will be no ‘SECONDS’-, ‘INCA’- or ‘EMIC evaluation’ as such.

The main objective of the evaluation is to assess how well the different interactIVe functions perform to fulfil their objectives as specified by their target scenarios. Hence, the functions are evaluated from a development point-of-view and not from a consumer point-of-view (cf. EuroNCAP). Consumer evaluation may be too general for the specific system as they aim to test a multiple of similar systems in the same way to be able to still compare the systems. Nevertheless projects aiming at providing methods to assess from a consumer or regulations point of view (like e.g. ASSESS [ASS]) may provide useful insights for the evaluation framework and will be taken into consideration along with other projects (see Internal Report I-3 – Draft Evaluation Plan).

## 1.3 Evaluation framework

The general procedure of the PReVAL project identified following steps for the evaluation of ADAS:

**Step 0: System and function description**

In this step information is gathered on what the system is supposed to do and how it should work:

- general information

[1] Legal aspects will be considered in a separate work package.

[2] An object is correctly detected, when difference between the position of the object, which is provided from the sensor, and the position of objects, which is provided by the reference measurement system,

- functionality and use cases
- targeted accidents
- limitations
- subsystems

This step is reported in D7.1.

**Step 1: Expected impact and hypotheses**

Here, the evaluations are split up into technical, user-related and safety impact assessment. However, since the safety impact assessment requires input from user-related and technical evaluation and since user-related assessment requires input from technical evaluation, the hypotheses generation should be harmonized. In this way overlapping work can be kept to a minimum.

A first step in defining the hypotheses was made in D7.1 by defining the research questions. From these the hypotheses are derived in this deliverable.

Once the hypotheses are formulated, the indicators for establishing the impact or testing the hypotheses can be derived. This needs to be carried out for each function. In the end, there are common hypotheses or common indicators for several functions, but this certainly is not the case for all functions. Especially, but not exclusively, for technical evaluation the indicators are directly measured in the vehicle or derived from the measurements.

This step is reported in this deliverable.

**Step 2: Test scenario definition**

In this step the test scenarios for the evaluations are defined. Indeed these scenarios must be defined in way that they are relevant for evaluating the hypotheses. A foundation is formed by the work reported in D1.5 [MÄK10], the use cases and target scenarios, but also other projects may offer relevant scenarios, like e.g. the ASSESS scenarios [ASS].

The role of test scenarios in evaluation differs for each type of evaluation. Test scenarios are directly applicable to the technical tests and to some extent to the user related tests. They are only to a certain extent directly applicable in the safety assessment. The safety impact related to direct impact on driver behaviour, such as speed or time headways, braking behaviour, lane keeping, lane change, etc., can be determined with the help of test scenarios. Indirect effects, such as interactions between users and non-users or exposure, can (usually) not be directly measured from the test scenarios. Nonetheless, test scenario definitions should try to take indirect effects into account as much as possible.

Moreover, this step is taken into account in this deliverable.

**Step 3: Evaluation method selection**

With the hypotheses, indicators and scenarios available, the most appropriate evaluation method must be determined. Testing can be done through full simulation, software-in-the-loop simulation, hardware-in-the-loop simulation and real world trials on test tracks or on public road, either with professional drivers or (potential) users. The choice depends on many factors, the most important ones are:

- required outcome (e.g. opinion of a driver on the acceptance of the system or the amount of reduced speed at impact, determining false alarm rate, etc.)
- safety of a scenario
- required number of vehicles for a scenario

- availability of suitable targets (dummy vehicles)
- availability of simulators
- time and budget constraints
- legal aspects (e.g. the vehicle is not certified to drive on public roads) and company constraints (e.g. only professional test drivers are allowed to drive the demonstrator vehicle)

Once the evaluation method has been chosen, identification of suitable and available tools follows naturally.

The final evaluation method will be reported in deliverable D7.4.

**Step 4: Measurement plan**

In this step the actual measurements and evaluations are specified. This involves defining the signals to be logged, the experimental design of the test including the number of tests and subjects, and other details which are required to acquire statistically significant results in order to test the hypotheses and carry out the impact assessment.

The measurement plan will also be reported in D7.4.

**Step 5: Test execution and analysis**

This final step consists of conducting the tests and analysing the results. The challenge in this project is the coordination of the tests as the VSPs are responsible for the testing and recording of the data (supported by SP7, as agreed at the workshop in November 2010) but the analysis and assessment will be done by SP7.

This step will be reported in deliverable D7.5.

## 1.4 Next steps for the development of the test and evaluation plan

This chapter describes the next steps towards the deliverable D7.4 “Test and evaluation plans”. Deliverable D7.4 is also the first milestone for subproject 7 “Evaluation and Legal Aspects” and intends to describe the test and evaluation plans for the interactIVe functions and systems. Hence, this document will be the basis for all test activities as well as the assessment of the interactIVe functions.

The development process of the test and evaluation plan is divided into four main steps. These four steps are the internal report I-3, the deliverables D7.1 and D7.2 and finally the deliverable D7.4. An overview of the deliverables and the internal report of SP7 are given in Figure 1.3 “Schedule of SP7 Evaluation” and Table 1.2. The deliverable D7.3 “Legal aspects” deals with the legal aspects of the interactIVe functions. This deliverable is not directly related to the development process of the test and evaluation plan. Due to this, D7.3 will not be described in detail here.

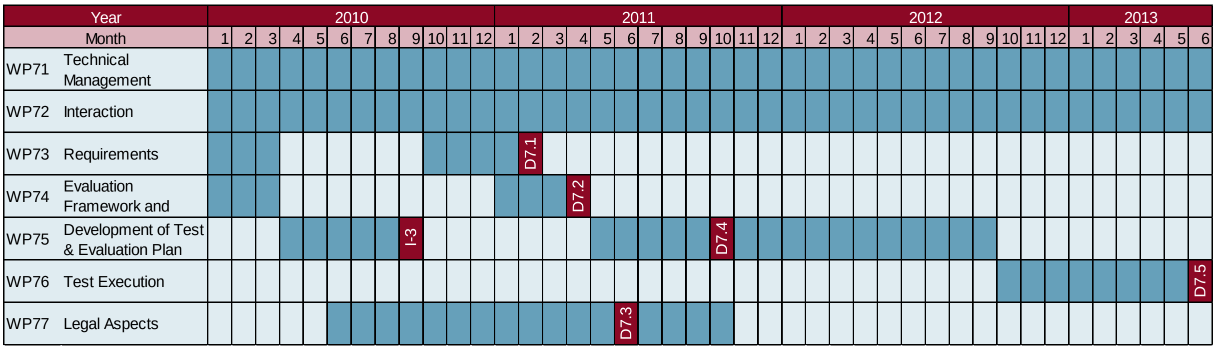


Figure 1.3: Schedule of SP7 "Evaluation"

| Deliverable | Description | Due Date | Partner |
|---|---|---|---|
| D7.1 | Requirements for the evaluation framework | M14 | CTAG + All |
| D7.2 | Specification of the evaluation framework | M16 | TNO + All |
| D7.3 | Legal aspects | M18 | BASt |
| D7.4 | Test and evaluation plans | M22 | VTEC + All |
| D7.5 | Impact assessment of the developed application – Overall interactIVe assessment | M42 | IKA +All |
| Internal report | Description | Due Date | Partner |
| I-3 | Draft evaluation plan | M09 | IKA + All |

Table 1.2: Deliverables and internal report of SP7

The first step in the development process has been the internal report I-3 - Draft evaluation plan. The draft evaluation plan describes the first ideas and plans of SP7 for the technical, user-related and safety-impact assessment. The basis for the described evaluation methodology of the internal report has been a literature review of other research projects, e.g. PReVENT.

Furthermore, the internal report was the fundament for the discussion with the VSPs on the evaluation methodology. A continuous and close contact between the VSPs and SP7 is essential in order to adjust the testing process, which is needed for the final evaluation of the functions and is conducted by the VSPs. Therefore the feedback of the VSPs on the internal report is considered in the deliverables D7.1, D7.2 and D7.4.

The second step of SP7 to formulate an evaluation framework has been reported in "D7.1 Requirements for the evaluation framework". It includes step 0 and the beginning of step 1 of the PReVAL procedure as it describes the functions and the research questions, which concern the evaluation of the interactIVe functions.

This deliverable, "D7.2 Specifications for the evaluation framework", is the third step of the development process for the evaluation plan (step 1 and 2 of the PReVAL procedure). The objective of this document is to describe how the interactIVe functions will be evaluated through defining hypotheses and indicators to accept or reject the hypotheses. The hypotheses are derived from the descriptions of the functions, their use cases and the research questions as described in "D7.1 Requirements for the evaluation framework". The VSPs are invited to react to the stated hypotheses and test scenarios. In fact, this process has already started (M17) using the annexes of this document. Possible changes to the hypotheses and test scenarios will be included in D7.4 (due date M22).

The final step of the development process for the evaluation plan is the deliverable D7.4 “Test and evaluation plan” (step 3 and 4 of the PReVAL procedure). This document will describe the whole evaluation process for the three vertical subproject SECONDS, INCA and EMIC in detail. Therefore the results of the deliverables D7.1 and D7.2 as well as the feedback on these deliverables will be considered for D7.4.

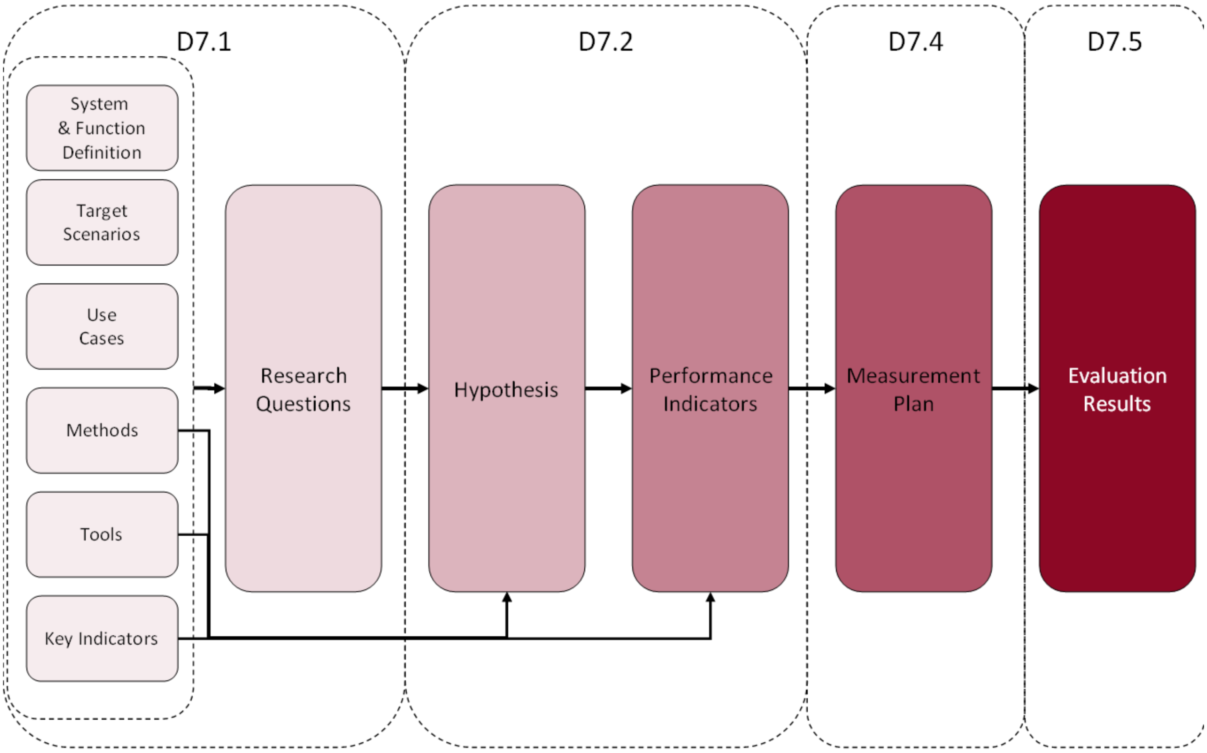


Figure 1.4: Overview of the steps and deliverables of SP7.

# 2 Hypotheses and indicators for the evaluation of the interactIVe systems

This chapter reports on step 1 of the PReVAL evaluation method: determines what the expected impacts of the system are and defines hypotheses and indicators to test them (see chapter 1).

In this chapter the hypotheses and indicators are first discussed from a general point-of-view. The hypotheses description is directly followed by the indicators used to test the hypotheses. Then, for each interactIVe system specific hypotheses are formulated when appropriate. The general and the specific hypotheses and indicators are described per assessment.

<table>
<tr><td colspan="6">In structuring the hypotheses, the following abbreviations and tagging rules have been selected to be used along this document (conforming to the research questions of D7.1):Tagging for research questions</td></tr>
<tr><td>Field #1</td><td>Field #2</td><td>Field #3</td><td>Field #4</td><td>Field #5</td><td>Field #6</td></tr>
<tr><td>Hyp</td><td>Nature</td><td>System</td><td>Function</td><td>Type</td><td>Number</td></tr>
<tr><td rowspan="6">Hyp</td><td rowspan="4">T</td><td>SEC</td><td>CS, CSC, EDPP, SC</td><td rowspan="4">Perf, Perc, Safe, TecU</td><td rowspan="6">01, 02, 03…</td></tr>
<tr><td>INC</td><td>RECA. LCCA, SIA, OVCA, RORP</td></tr>
<tr><td>EMI</td><td>CMS, ESA</td></tr>
<tr><td colspan="2">Gen</td></tr>
<tr><td>U</td><td colspan="2">Gen</td><td>Beh, T&A, Use</td></tr>
<tr><td>I</td><td colspan="3">SEC, INC, EMI</td></tr>
</table>

Table 2.1: Tagging for the research questions

Being:

- T: Technical
- U: User Related
- I: Impact Assessment
- SEC: Seconds
- INC: INCA
- EMI: EMIC
- Gen: General or Generic
- Perf: Performance
- Perc: Perception
- Safe: Safety Logic
- TecU: Technical User-related
- Beh: Driver Behaviour
- T&A: Trust and Acceptance

- Use: Usage

## 2.1 Technical assessment: hypotheses and derivation of indicators

This paragraph describes the derivation of the indicators for the technical evaluation of the developed ADAS functions of interactIVe. The objective of the technical assessment is twofold:

1. The first objective is to evaluate the performance and technical potential of the developed functions. This includes investigating under which situational and environmental conditions a function can operate as well as determining technical performance indicators (e.g. maximum deceleration and maximum detection range).
2. The second objective is to collect information and data for the safety impact assessment. For calculating safety impacts a deep understanding of the technical as well as the user-related behaviour of the functions is necessary. Therefore, it is indispensable to collect data of the functions' warning and intervention strategies (when and how does a function react on a situation). In this paragraph the technical behaviour of a function is investigated and not the interaction between the function and the user. This topic will be investigated in the user-related section.

The technical assessment will mainly focus on evaluation of whole functions and not on components of the functions (sub-functions). This restriction is made, because the functionality of the developed functions must be given for the whole function and not only for parts of the functions. Even though the objective is to focus on the whole function, this approach does not suit all cases. Therefore, in the second step of the technical assessment – if required – certain components of the functions will be contemplated. This step is necessary, when the function behaves in an inappropriate way. By means of considering the components it should be analysed, why the function behaves like it does. But in such a case the assessment of every component of the functions is not feasible, because of limited resources and time. Therefore the components need to be summarized on a certain level. For the technical assessment of the functions, which are developed in interactIVe, a division into the components "Perception" and "Logic" is appropriate, especially with regard to subprojects SP2 "Perception" and SP3 "IWI Strategies". New actuating or communication elements will not be analysed in detail, because the focus in interactIVe is not on the development of these components.

Based on the research questions of D7.1 the hypotheses and the indicators are defined. The research questions have been the first step for specifying the aim of the evaluation for the interactIVe functions. By means of the research question it has been defined what is evaluated in the technical assessment.

This section is divided into four parts. The first part covers the hypotheses and corresponding indicators which are common for all analyzed functions. The second, third and fourth part covers the indicators and corresponding hypothesis that are specific for a certain system.

### 2.1.1 General

First the general hypotheses of the technical assessment are discussed. These hypotheses are relevant for all interactIVe functions and therefore they should be assessed for all functions. The general hypotheses of the technical assessment are subdivided into four categories. The categories describe on which aspect of the function the hypothesis focuses. These categories have also been used for the technical research questions (for details see D7.1):

1. Full function performance
2. Perception

3. Safety logic
4. Technical user-related

Some of the indicators involve the Time To Collision (TTC), Time HeadWay (THW), Time To Line crossing and the Time exposed time-to-collision (TET). These measures are explained here first.

The Time to Collision (TTC) is computed from the distance between two objects (vehicles or vehicle and pedestrian etc.) and their relative speed (see also Figure 2.1):

$$TTC = \frac{x_r}{v_2 - v_1}.$$

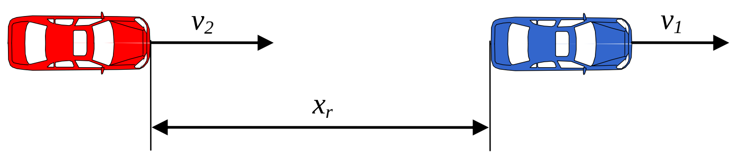


Figure 2.1: Definition of variables for the calculation of TTC and THW

The Time HeadWay (THW) is a measurement of time between two vehicles passing a certain location (see again Figure 2.1):

$$THW = \frac{x_r}{v_2}.$$

The TET (Time Exposed Time-to-collision) is the duration of exposition to safety-critical time to collision values over a specified time duration:

$$TET = \frac{time\ duration\ with\ TTC \leq TTC^*}{T_{total}} \cdot 100\%.$$

Finally, the TLC (Time to Line Crossing) is the time remaining before the vehicle will reach a lane boundary assuming that the current steering wheel angle and vehicle speed remain the same. There are several ways to calculate the TLC (depending on available data of the vehicle trajectory, vehicle state and lane geometry), the reader is referred to [MAM06] and references therein.

**Full function performance**

The functions designed in the interactIVe project are prototypes, and may not work under all environmental conditions. The different technologies have restrictions regarding the environmental conditions (amount of light needed to function, range dependency upon rain, fog or snow). Starting from knowledge on the sensor’s limitations, the availability of the function under different environmental conditions can be determined.

The environmental conditions include the following:

- Weather (rain, snow, fog, etc.)
- Road type
- Lighting conditions
- Road condition (dry, wet, black ice, ice, snow, oil)
- Gradient of the track
- GPS availability (urban canyons, tunnels)

- **Hyp_T_gen_perf_01: The function's availability is determined by the sensors' availability**
  - Indicators:
    - missed alarm rates
    - false alarm rates
    - rate function "on" per environmental condition
  - Related to RQ:
    - RQ_T_Gen_Perf_02

- **Hyp_T_gen_perf_02: Different environmental conditions do not affect the function's performance.**
  - Indicators:
    - TTC at point in time (alarm, intervention, first detection)
    - speed reduction (max)
    - impact speed
    - driver reaction
    - missed alarm rates
    - false alarm rates
    - information of the function description
  - Related to RQ:
    - RQ_T_Gen_Perf_02

For the analysis of these hypotheses it must be considered that only a limited number of different environmental conditions can be tested due to resource restrictions. The question, which environment will be tested, will be answered to later stage. Therefore also information of the function description can be used additionally.

- **Hyp_T_gen_perf_03: The function uses the maximum (possible) longitudinal acceleration in order to avoid an accident.**
  - Indicator:
    - longitudinal acceleration
  - Related to RQ:
    - RQ_T_Gen_Perf_03

The maximum (possible) longitudinal acceleration that will be reached is dependent on the road conditions (friction coefficient, gradient of the track etc). As in the previous two hypotheses, it will not be possible to test all conditions. Therefore the road conditions to actually assess needs to be chosen carefully depending on the available test environment and the resources.

- **Hyp_T_gen_perf_04: The function is able to brake up to stand still autonomously.**
  - Indicator:
    - speed reduction (mean, min, max)
  - Related to RQ:
    - RQ_T_Gen_Perf_03

For the assessment of the performance of the function it needs also to be investigated, whether false or missing activations are observed within the test. False activation of a function can decrease the trust of the driver in function and also create dangerous situation. Nevertheless it needs also to be considered that this project is a research project. Due to this it could not be expected that the results will be comparable to market ready functions. An activation of the function includes a warning as well as an intervention by the function.

- **Hyp_T_gen_perf_05: There are no false negative activations of the function (during the test).**
  - Indicators:
    - number of false negative detections
    - false negative rate
  - Related to RQ:
    - RQ_T_Gen_Perc_04

- **Hyp_T_gen_perf_06: There are no false positive activations of the function (during the test).**
  - Indicators:
    - number of false positive detections
    - false positive rate
  - Related to RQ:
    - RQ_T_Gen_Perc_05
    - RQ_T_INC_RECA_Safe_02

The function is expected to work according to the specifications: detect threats, make decisions and warn and intervene in the target scenarios according to one of the alternative flows described in D1.5.

- **Hyp_T_gen_Perf_07: The function detects threats and target scenarios according to the specifications**
  - Indicators:
    - CAR (Correct Alarm Rate)
    - FAR (False Alarm Rate)
    - MAR (Missed Alarm Rate)
    - function activation in a test scenario
  - Related to RQ:
    - RQ_T_INC_Gen_Perf_01
    - RQ_T_INC_RECA_Perc_01
    - RQ_T_INC_RECA_TecU_02
    - RQ_T_INC_RECA_Perf_04
    - RQ_T_INC_OVCA_Safe_01

**Perception**

The following hypotheses and indicators are related to perception in the sense that for the tests the relevant information is provided to the function's logic. With these hypotheses and indicators it is studied whether the perception components provide correct data. Note that these hypotheses are only intended to be tested, when other tests indicate that the perception platform may not work as specified.

- **Hyp_T_gen_perc_01: Information on the relevant target(s) is provided to the function's logic (during the test).**
  - Indicators:
    - missed detections
    - number of false positive detections

    - number of false negative detections
    - rate of correct detection
    - time target visible and in sensor coverage area until first detection
  - Related to RQ:
    - RQ_T_Gen_Perc_01

The more "statistical" indicators such as missed alarm rates will be hard to investigate in detail during the testing phase because multiple tests with multiple targets are generally necessary to give some indication regarding this type of indicator. However, they are listed here for completeness. Evaluation of the hypotheses will be based on available test results.

- **Hyp_T_gen_perc_02: Information on the relevant target is provided in time to assure that the function can react as intended.**
  - Indicators:
    - TTC (at first detection)
    - THW (at first detection)
  - Related to RQ:
    - RQ_T_Gen_Perc_03

**Safety logic**

The following hypotheses and indicators are related to the safety logic. The results of these hypotheses and indicators can directly be used in the impact assessment.

- **Hyp_T_gen_safe_01: The function reduces the impact speed.**
  - Indicator:
    - impact speed
  - Related to RQ:
    - RQ_T_Gen_Safe_01
    - RQ_T_EMI_Gen_Perf_02
    - RQ_T_EMI_CMS_Perf_02
    - RQ_T_INC_Gen_Perf_01

- **Hyp_T_gen_safe_02: The function improves traffic safety by avoiding an accident in a target scenario.**
  - Indicator:
    - TTC (at start of intervention)
    - distance to target object (min)
    - lateral and longitudinal accelerations (max)
    - duration of intervention
    - vehicle speed (at the end of the intervention)
    - vehicle position (at the end of the intervention)
  - Related to RQ:
    - RQ_T_Gen_Safe_01
    - RQ_T_EMI_Gen_Perf_02
    - RQ_T_INC_Gen_Perf_01

The above mentioned hypotheses are focusing on avoiding an accident. Next hypotheses focus specifically on collision mitigation systems.

- **Hyp_T_gen_safe_03: The function improves the orientation of the car for impact.**
  - Indicator:
    - impact orientations
  - Related to RQ:
    - RQ_T_Gen_Safe_01

        - RQ_T_EMI_CMS_Perf_02

Furthermore, it needs to be analysed, when the function intervenes respectively warns the driver, and whether the intervention respectively the warning is appropriate.

- **Hyp_T_gen_safe_04: The function warns the driver in all tested scenarios, in which a warning is required.**
    - Indicators:
        - function warning status
        - function intervention status
        - brake pressure / force (extra applied)
        - steering torque (extra applied)
        - TTC (at alarm)
        - THW (at alarm)
        - number of false alarms
        - number of missed alarms
        - distance to target object – (longitudinal) (at alarm)
    - Related to RQ:
        - RQ_T_Gen_Safe_02

- **Hyp_T_gen_safe_05: The function intervenes in all tested scenarios, in which an intervention is required.**
    - Indicators:
        - function intervention status
        - duration of intervention
        - TTC (at start of intervention)
        - distance to target object – (longitudinal) (at intervention)
        - THW (at start of intervention)
        - distance to target object (lane, barrier) – (longitudinal) (at start of intervention)
        - TLC (at start of intervention)
        - number of false interventions
        - number of missed interventions
    - Related to RQ:
        - RQ_T_Gen_Safe_03

- **Hyp_T_gen_safe_06: The function never intervenes without first giving a warning to the driver.**
    - Indicators:
        - function warning status
        - function intervention status
        - brake pressure / force (extra applied)
        - steering torque (extra applied)
        - driver reaction
        - time between two actions (warning & intervention)
    - Related to RQ:
        - RQ_T_Gen_Safe_04

The next hypothesis checks whether the system repeatable gives the same results in similar situations.

- **Hyp_T_gen_safe_07: The function behaves in the same way in similar situations.**
    - Indicators:
        - function warning status
        - function intervention status

        - impact speed
        - impact orientation
    - Related to RQ:
        - RQ_T_Gen_Safe_05

Next, the timing of the systems will be checked focusing on the preparation and the start of the intervention.

- **Hyp_T_gen_safe_08: The function prepares (e.g. brake pre-filling) the vehicle for an evasive or braking maneuver before the accident (in the scenario).**
    - Indicators:
        - TTC (at preparation)
        - distance to target object – (longitudinal) (at preparation)
        - distance to target object (lane, barrier) – (longitudinal) (at preparation)
        - THW (at preparation)
        - function intervention status
        - TLC (at preparation)
    - Related to RQ:
        - RQ_T_Gen_Safe_06

**Technical User-Related**

The following hypotheses and indicators are technical but also user-related. These hypotheses and indicators are mainly focusing on the timing aspect of the warning. Next to that, it is studied if the user can always override the function, which is important from liability perspective and with respect to the controllability.

The following hypothesis tests if the warning is given in due time, such that the driver can react or intervene to avoid a critical situation.

- **Hyp_T_gen_TecU_01: The driver has enough time to react and avoid the accident, when the warning is issued.**
    - Indicators:
        - TTC (at alarm)
        - driver braking reaction (after the alarm)
        - driver steering reaction (after the alarm)
    - Related to RQ:
        - RQ_T_Gen_TecU_01
        - RQ_T_INC_RECA_TecU_01

When the function starts to intervene, it must be assured that this intervention is needed, i.e. the driver alone would not be able to avoid a critical situation.

- **Hyp_T_gen_TecU_02: The driver has not enough time to react and avoid the accident, when the function starts to intervene in the driving behaviour.**
    - Indicators:
        - TTC (at start of intervention)
        - driver braking reaction (after the alarm)
        - driver steering reaction (after the alarm)
    - Related to RQ:
        - RQ_T_Gen_TecU_02

- **Hyp_T_gen_TecU_03: The accident cannot be avoided although a warning is given before the accident.**
    - Indicators:
        - longitudinal acceleration (max)

        - lateral acceleration (max)
        - longitudinal acceleration required to avoid collision (at time of warning)
        - lateral acceleration required to avoid collision (at time of warning)
        - duration of intervention
        - TTC (at alarm)
    - Related to RQ:
        - RQ_T_Gen_TecU_02

- **Hyp_T_gen_TecU_04: The function can always be overridden by the driver.**
    - Indicators:
        - function on/off
        - brake pedal angle (during intervention)
        - steering wheel angle (during intervention)
        - function "on" per brake pedal angle
        - function "on" per steering wheel angle
    - Related to RQ:
        - RQ_T_Gen_TecU_03

Summarizing, this subchapter defined the general hypotheses for the technical evaluation of the interactIVe systems. Next subchapters will focus on the specific functions of interactIVe and their specific hypotheses.

### 2.1.2 SECONDS

After the general hypotheses and accompanying indicators have been presented, the focus is put on the specific systems or functions. This subchapter deals with the hypotheses and indicators of the system "SECONDS". First the hypotheses are presented, which are valid for all or most of the SECONDS functions. Then the hypotheses are described that are related to one specific function.

Information and warnings must be provided to the driver in such time that the driver has the possibility to avoid an imminent accident by himself. The related hypothesis is checked by means of the longitudinal and lateral acceleration, which is required to avoid an accident when the warning is issued. This acceleration is a theoretical indicator calculated based on the motion of the vehicle and the target at the time point when the warning is issued.

- **Hyp_T_SEC_Gen_Perf_01: In general it is possible to avoid a imminent accident when a warning is issued**
    - Indicators
        - longitudinal acceleration required to avoid collision (at warning)
        - lateral acceleration required to avoid collision (at warning)
        - TTC(at warning)
    - Related to RQ:
        - RQ_T_Gen_TecU_02
        - RQ_T_SEC_CS_Perf_01

For the SECONDS functions that are able to intervene in the vehicle behaviour, it is important to determine, at which point they intervene and whether the driver could avoid an imminent accident on his own at this point. The related hypothesis is also verified by means of the accelerations required to avoid the imminent accident.

- **Hyp_T_SEC_Gen_Perf_02: In general it is possible to avoid an imminent accident when the function starts to intervene in the driving behaviour.**
    - Indicators

        - longitudinal acceleration required to avoid collision (at start of intervention)
        - lateral acceleration required to avoid collision at start of intervention)
        - TTC (at start of intervention)
    - Related to RQ:
        - RQ_T_Gen_TecU_02

One special aspect of some of the SECONDS functions is that they also intend to reduce fuel consumption. The indicator for this hypothesis is the mean fuel consumption.

- **Hyp_T_SEC_Gen_Parf_03: The function reduces fuel consumption**
    - Indicators
        - mean fuel consumption
    - Related to RQ:
        - RQ_I_SEC_09

The Continuous Support (CS) functions should also warn for static objects (standing vehicles, etc.) especially in the rear end collision scenarios. The verification of this hypothesis is conducted by means of the rate of correct detections2 and the distance, at which the object is detected the first time.

- **Hyp_T_SEC_Gen_Perc_01: The function warns the driver for standing still objects in the vehicle path**
    - Indicators
        - max distance at first detection of object
        - mean distance at first detection of object
        - min distance at first detection of object
        - max time distance at first detection of object
        - mean time distance at first detection of object
        - min time distance at first detection of object
        - Rate of correct detections
    - Related to RQ:
        - RQ_T_SEC_CS_Perc_01

For the use cases related to crossing scenarios, the detection performance with respect to the whole situation must be evaluated. For this it is important to evaluate if the right of way situation is correctly determined by the function, and if the detection of the other vehicles depends on the availability of car-2-car communication.

- **Hyp_T_SEC_CS__Safe_01: The function determines right of way situation correctly.**
    - Indicators
        - rate of correct detections (way of right situations)
    - Related to RQ:
        - RQ_T_SEC_CS_Safe_01

- **Hyp_T_SEC_CS_Perc_03: The functionality of the function is not influenced negatively, when the other vehicles are not equipped with car-2-car communication.**
    - Indicators

[2] An object is correctly detected, when difference between the position of the object, which is provided from the sensor, and the position of objects, which is provided by the reference measurement system, is smaller than the defined tolerance.

        - rate correct detection (detected vehicles)
    - Related to RQ:
        - RQ_T_SEC_CS_Perc_04
        - RQ_T_SEC_CS_Perf_02

For the category of use cases “Collisions with vulnerable road users (VRU)” it should also be analysed, whether there are restrictions for the detection regarding motion or size of the vulnerable road user (pedestrian and animals) Therefore the rate of correct detection and the distance at which the VRU is detected for the first time, will be analysed.

- **Hyp_T_SEC_CS_Perc_04: The function detects vulnerable road users independently of their size**.
    - Indicators
        - rate correct detection (vulnerable road users)
        - distance to target object (at first detection)
    - Related to RQ:
        - RQ_T_SEC_CS_Perc_05

- **Hyp_T_SEC_CS_Perc_05: The function detects vulnerable road user moving in all directions**
    - Indicators
        - rate correct detection (vulnerable road users)
        - distance to target object (at first detection)
    - Related to RQ:
        - RQ_T_SEC_CS_Perc_05

For use cases concerning “unintended lane departure accidents” it is checked, if the warning behaviour differs when the road is bordered by a side barrier instead of other lane markings. The second hypothesis is to verify, whether the warning behaviour differs, when a lane of the road ends e.g. due to a narrowed roadway. As indicators the Time to Lane Crossing (TLC) and the distance at certain time points are used.

- **Hyp_T_SEC_CS_Perf_01: The function reacts not earlier, when the road has a side barrier**
    - Indicators
        - TLC (at warning)
        - TLC (at start of intervention)
        - (lateral) distance to target object (lane, barrier) at warning
        - (lateral) distance to target object (lane, barrier) at intervention
    - Related to RQ:
        - RQ_T_Gen_Perf_02

Besides the situation, when the host vehicle drifts to the lane boundary, also a relevant situation, in which the function should warn the driver, is when the lane ends and the driver of host vehicle does not make any attempt to change the lane, because the driver is not focused on the road.

- **Hyp_T_SEC_CS_Perf_02: The function will warn the driver, when the lane ends and the driver does not initiate a lane change.**
    - Indicators
        - min TLC
        - (lateral) distance to target object (end of lane) (at warning)
        - (lateral) distance to target object (end of lane) (at intervention)
    - Related to RQ:
        - RQ_T_SEC_CS_Perf_03

In the category of use cases „Traffic rule violations“ and “Excessive speed accidents” it is important, that the function detects the speed bumps or speed limits correctly. This is analysed by means of the detection rate and, for the speed limit detection, also by means of the difference between current and detected speed limit.

- **Hyp_T_SEC_CS_Perf_03: The function is able to detect zone, which required a lower speed (e.g. speed bumps)**.
  - Indicators
    - rate of correct detections (speed zones)
  - Related to RQ:
    - RQ_T_SEC_CS_Perf_04

- **Hyp_T_SEC_CS_Perc_06: The function detects the current given speed limit always correctly.**
  - Indicators
    - max difference of detected and current speed limit
    - mean difference of detected and current speed limit
    - rate of correct detections (speed limits)
  - Related to RQ:
    - RQ_T_SEC_CS_Perc_06

Regarding the detection of the speed limit it is further verified, how robust the detection is. To this end it must be analysed, if dynamic speed limits are detected correctly and if the function can distinguish between speed limit signs and other similar traffic signs. Additionally the performance of the function with regards to signal recognition in longitudinal and lateral direction is evaluated. For the analysis of these hypotheses the correct detection rate and the distance, at which the speed limit is correctly detected the first time, are used.

- **Hyp_T_SEC_CS_Perc_07: The function detects dynamic speed limits correctly.**
  - Indicators
    - rate of correct detections (speed limits)
  - Related to RQ:
    - RQ_T_SEC_CS_Perc_06

- **Hyp_T_SEC_CS_Perc_08: The speed limit is detected correctly up to a covering of x (50 %) of the sign.**
  - Indicators
    - rate of correct detections
    - max distance at first detection of object
    - mean distance at first detection of object
    - min distance at first detection of object
  - Related to RQ:
    - RQ_T_SEC_CS_Perc_07

- **Hyp_T_SEC_CS_Perc_09: The speed limit is detected correctly up to a lateral distance of x (7.5 m) from the outline of the vehicle.**
  - Indicators
    - rate of correct detections
    - max (lateral and longitudinal) distance at first detection of object
    - mean (lateral and longitudinal) distance at first detection of object
    - min (lateral and longitudinal) distance at first detection of object
    - position of sign with respect to vehicle
  - Related to RQ:
    - RQ_T_SEC_CS_Perc_07

- **Hyp_T_SEC_CS_Perc_10: The speed limit can distinguish between speed limits and other traffic signs (e.g. height limit, speed limit change in x m).**
  - Indicators
    - Rate of correct detections
    - max distance at first detection of object
    - mean distance at first detection of object
    - min distance at first detection of object
  - Related to RQ:
    - RQ_T_SEC_CS_Perc_07

Another important aspect of the function is the correct presentation of the speed limit to the driver.

- **Hyp_T_SEC_CS_Safe_02: The proposed speed limit of the function will be equal to the actual valid speed limit.**
  - Indicators
    - proposed vehicle speed (at start of speed limit)
    - mean difference between given and proposed speed
    - max difference between given and proposed speed
  - Related to RQ:
    - RQ_T_SEC_CS_Safe_02

For the Curve Speed Control (CSC) it will be analysed, whether the proposed speed of the function ensures a safe negotiating of the curve. If the velocity is higher than the safe speed for the upcoming curve the function will warn the driver. If also the ACC is active the function will adjust the set speed to the safe speed.

- **Hyp_T_SEC_CSC_Safe_01: The proposed velocity ensures a safe negotiating of the curve.**
  - Indicators
    - proposed vehicle speed (at certain locations)
    - vehicle speed (at certain locations)
    - mean max. lateral acceleration
    - curve radius
  - Related to RQ:
    - RQ_T_SEC_CSC_Safe_02

- **Hyp_T_SEC_CSC_Safe_02: The proposed velocity is adapted appropriate to the geometry of the upcoming curve.**
  - Indicators
    - proposed vehicle speed (at certain locations)
    - vehicle speed (at certain locations)
    - mean max. lateral acceleration
    - curve radius
    - curve angle
  - Related to RQ:
    - RQ_T_SEC_CSC_Safe_02

Although the CSC function intervenes by means of the ACC in the driving behaviour, it needs to be analysed whether the intervention could have a negative influence on driving behaviour of the vehicle, because the intervention takes place shortly before a curve or even in a curve. A wrong intervention by the vehicle could destabilise the vehicle. This is analysed through the location where the intervention is initiated, the yaw rate and the reduction of speed achieved by the function.

- **Hyp_T_SEC_CSC_Perf_01: The intervention of the function has no negative influence on the driving behaviour.**
    - Indicators
        - distance to curve at initiation the intervention
        - time gap to curve at initiation the intervention
        - max speed reduction
        - min speed reduction
        - mean speed reduction
        - max yaw rate
        - min yaw rate
        - mean yaw rate (in the curve)
        - standard deviation of the yaw rate (in the curve)
        - mean steering angle
        - standard deviation of the steering angle
        - max steering velocity
        - yaw rate (before / after intervention)
    - Related to RQ:
        - RQ_T_SEC_CSC_Perc_02

The enhanced Dynamic Pass Predictor (eDPP) should additionally to the general technical hypotheses be evaluated for negative influences, when oncoming vehicles are not equipped with car-2-car communication.

- **Hyp_T_SEC_eDPP_Perc_01: The function is not impaired when the other vehicles are not equipped with car-2-car communication.**
    - Indicators
        - rate of correct detection
    - Related to RQ:
        - RQ_T_SEC_eDPP_Perc_01

The function (eDPP) should also be able to detect overtaking prohibitions in order to provide correct information to the driver. The rate of the correct detected prohibitions is used in order to determine, whether the function detects correctly the passing prohibitions.

- **Hyp_T_SEC_eDPP_Perc_02: The function detects correctly the passing prohibitions (lane markings as well as traffic signs).**
    - Indicators
        - rate of correct detection (passing prohibitions)
    - Related to RQ:
        - RQ_T_Gen_Perf_01,
        - RQ_T_Gen_Perc_01

The Safe Cruise (SC) function takes over the vehicle control in lateral as well as longitudinal direction to enable safe car following. Hence, it should be verified that no critical situations due to e.g. short time headway (legal boundary in Germany 1.8 s [NN09]) and low TTC can occur in the test while the function is active and controls the vehicle. Note that this is also relevant for the impact assessment. This is checked by means of following two hypotheses. The minimum TTC and THW and the time exposed time-to-collision (TET) are the indicators for these hypotheses.

- **Hyp_T_SEC_SC_Perf_01: The function prevents imminent rear-end collision before they become critical.**
    - Indicators
        - min TTC
        - min THW

  - Related to RQ:
    - RQ_T_SEC_SC_Perf_01
- **Hyp_T_SEC_SC_Perf_02: During driving the TTC does not drop under x (e.g. 1.5 s [VAN93 ]) when the function is active.**
  - Indicators
    - Time exposed time-to-collision (TET)
    - min TTC
  - Related to RQ:
    - RQ_T_SEC_SC_Perf_01

Additionally, for the rear-end collision scenarios, it is analysed – similar as for the Continuous Support function – whether the function reacts also to static objects.

- **Hyp_T_SEC_SC_Perc_01: The function also detects static objects in the vehicle path.**
  - Indicators
    - max distance at first detection of object
    - mean distance at first detection of object
    - min distance at first detection of object
    - max time distance at first detection of object
    - mean time distance at first detection of object
    - min time distance at first detection of object
    - rate of correct detections
  - Related to RQ:
    - RQ_T_SEC_CS_Perc_01

Next hypotheses involve the performance of the autonomous speed adjustment of the SC function, which should ensure that the speed limit is not exceeded. There are various indicators, which are used for the testing of the hypothesis. The duration of speed exceeding, the difference between given speed limit and driven speed, the speed at certain points and the distance towards the speed limit, when the function imitate the deceleration of the vehicle are used as indicators for this hypothesis.

- **Hyp_T_SEC_SC_Perf_03: The function will ensure the correct speed autonomously (without intervention by the driver).**
  - Indicators
    - duration of speed exceeding
    - max. difference of detected and current speed limit
    - mean difference of detected and current speed limit
    - vehicle speed (at speed limit, before and after speed limit)
    - distance to speed limit at initiating deceleration
    - time distance to speed limit at initiating deceleration
  - Related to RQ:
    - RQ_T_SEC_SC_Perf_02

For the SC function, which as mentioned before may take over control of the vehicle from the driver, the interaction with the driver is an important aspect since it must be ensured that the driver is still focused on the road and does not perform secondary tasks. Hence the function needs to observe the driver in order to determine whether the driver is still focused on the road when the function has taken over control. The observation of the driver by the function is analysed in the following two hypotheses by means of the function status depending on the position of the eyes or the hands. Only technically measureable observations of the driver are evaluated here.

- **Hyp_T_SEC_SC_TecU_01: When the driver is not focusing on the road for a certain time, the function is switched off.**
  - Indicators
    - rate function "on" per status (gazing direction and time)
  - Related to RQ:
    - RQ_T_SEC_SC_TecU_01
- **Hyp_T_SEC_SC_TecU_02: When the driver takes his/her hands off the steering wheel, the function is switched off.**
  - Indicators
    - rate function "on" per status (position of the hands and time)
  - Related to RQ:
    - RQ_T_SEC_SC_TecU_01

A second aspect of the interaction with driver is that the function must inform the driver if the function switches itself off. Otherwise it cannot be ensured that the driver is ready to take over control again. Therefore the time between warning and switch off of the function are considered.

- **Hyp_T_SEC_SC_TecU_03: The driver will be warned in time before the function switches itself off.**
  - Indicators
    - time between two events (warning and switch off)
  - Related to RQ:
    - RQ_T_SEC_SC_TecU_02

### 2.1.3 INCA

This subchapter deals with the hypotheses and indicators of the "INCA" system. First the hypotheses, which are valid for all or most of the INCA functions (RECA – Rear End Collision Avoidance; OVCA – Oncoming Vehicle Collision Avoidance; LCCA – Lane Change Collision Avoidance; SIA – Side Impact Avoidance and RORP – Run off road protection) are presented. The hypotheses and indicators are also based on the specifications of the INCA functions.

- **Hyp_T_INC_Safe_01: The function selects the appropriate method to avoid collisions or driving-off-road accidents**
  - Indicators
    - function activation in a test scenario
    - minimum distance to threat during maneuver
    - Max. acceleration during maneuver
    - Max. braking force/steering torque during maneuver
  - Related to RQ:
    - RQ_T_INC_Gen_Perf_01
    - RQ_T_INC_RECA_Perc_01
    - RQ_T_INC_RECA_TecU_02
    - RQ_T_INC_RECA_Perf_04
    - RQ_T_INC_OVCA_Safe_01

An activation is correct if the system behaves according to the specifications in the target scenario; relevant targets are detected, a warning issued, the correct activation selected, and activated following the one of the alternative flows from the specifications.

- **Hyp_T_INC_Safe_02: After intervention the situation was correctly perceived to be safe enough to return the control back to the driver.**
  - Indicators
    - distance to threat (at returning of control)

        - lateral position in lane (at returning of control)
        - longitudinal speed (at returning of control)
        - longitudinal acceleration (at returning of control)
        - lateral acceleration (at returning of control)
        - yaw rate (at returning of control)
        - yaw angle (at returning of control)
        - steering wheel angle (at returning of control)
        - brake pedal angle (at returning of control)
        - brake pressure / force (at returning of control)
    - <u>Related to RQ:</u>
        - RQ_T_INC_RECA_TecU_02

At the end of the intervention, the vehicle is in a safe position (e.g. complete standstill or moving at the same speed of heading vehicle in the middle of the lane, depending on the function under study).

- **Hyp_T_INC_Safe_03: The intervention avoids or mitigates the collision and does not aggravate it.**
    - <u>Indicators</u>
        - minimum TTC during maneuver
        - impact speed
        - relative orientation of vehicles at impact
        - speed reduction (mean)
    - <u>Related to RQ:</u>
        - RQ_T_INC_RECA_Perf_03

The function is expected to avoid or mitigate collisions, and not to aggravate collisions.

- **Hyp_T_INC_Perf_01: The function works within the specified speed and acceleration range**
    - <u>Indicators</u>
        - vehicle speed and relative longitudinal and lateral speed at start of maneuver
        - max. longitudinal and lateral acceleration during maneuver
    - <u>Related to RQ:</u>
        - RQ_T_INC_RECA_Safe_02

Different functions have different speed ranges and specifications regarding the allowable longitudinal or lateral acceleration.

- **Hyp_T_INC_Perf_02: The function is able to avoid collisions with moving obstacles**
    - <u>Indicators</u>
        - relative longitudinal and lateral speed of host and target vehicle at start of maneuver and at the end of the maneuver
        - minimum TTC during the maneuver
        - target vehicle speed
    - <u>Related to RQ:</u>
        - RQ_T_INC_RECA_Safe_05

The function should be able to accurately estimate the target vehicle's velocity and decide whether the vehicle is on a critical path, how the vehicle will move and how the host vehicle should move in order to avoid a collision.

- **Hyp_T_INC_Perf_03: The functionality of the function is not influenced by road curvature**

- Indicators
  - road curvature
  - vehicle speed and acceleration
  - relative longitudinal and lateral speed of host and target vehicle at the start of the maneuver
  - CAR (Correct Alarm Rate), FAR (False Alarm Rate), MAR (Missed Alarm Rate)
  - minimum TTC during the maneuver
  - vehicle speed at start of maneuver
- Related to RQ:
  - RQ_T_INC_RECA_Safe_03
  - RQ_T_INC_RECA_Perf_02

The road shape (road curvature) may affect to the estimation of relative longitudinal and lateral speed, and affect the decision whether the target vehicle is on a critical path, and hence provide warnings to the driver or activate automatic braking or steering.

- **Hyp_T_INC_Perf_04: The function is able to avoid rear and side collisions according to the specifications**
  - Indicators
    - minimum distance between vehicles during maneuver
    - minimum TTC during maneuver
  - Related to RQ:
    - RQ_T_INC_RECA_Perf_01
    - RQ_T_INC_LCCA_Perc_01
    - RQ_T_INC_LCCA_Perc_02
    - RQ_T_INC_LCCA_Perf_01
    - RQ_T_INC_LCCA_TecU_01

- **Hyp_T_INC_Perc_01: The function correctly detects a free lane or road shoulder in target scenarios (the system does not move into occupied lanes or outside road)**
  - Indicators
    - incorrect route planning or intervention in a test case
    - amount of time that the vehicle is outside the lane
  - Related to RQ:
    - RQ_T_INC_RECA_Safe_01
    - RQ_T_INC_RECA_Safe_02

The system should avoid moving into a lane which is not free, and not allow moving outside the road or into a lane when there are traffic restrictions.

### 2.1.4 EMIC

The two EMIC functions (CMS & ESA) are intended for mostly the same, but also for some different categories of use cases. In D7.1 table 4.3 (see also Annex 1) an overview is given for which categories of use cases the EMIC functions are intended. For these categories research questions are defined from which the next EMIC specific hypotheses and indicators are derived:

The EMIC functions are designed such that they start their intervention after recognising an avoiding action of the driver.

- **Hyp_T_EMI_gen_01: The function always recognizes the avoiding steering action of the driver (in the scenarios).**

- Indicator:
  - steering wheel angle (at intervention)
- Related to RQ:
  - RQ_T_EMI_Gen_Perc_01
  - RQ_T_EMI_Gen_Perc_04
  - RQ_T_EMI_ESA_Perc_01

- **Hyp_T_EMI_gen_02: Too weak or too strong reaction of the driver is recognized.**
  - Indicator
    - error between driver input and required input as calculated by the logic (max)
  - Related to RQ:
    - RQ_T_EMI_Gen_Perc_02
    - RQ_T_EMI_CMS_Perc_01

- **Hyp_T_EMI_gen_03: After intervention the situation was correctly perceived to be safe enough to stop the driver support.**
  - Indicators
    - driver status (at returning of control)
    - longitudinal acceleration (at returning of control)
    - lateral acceleration (at returning of control)
    - yaw rate (at returning of control)
    - yaw angle (at returning of control)
    - steering wheel angle (at returning of control)
    - brake pedal angle (at returning of control)
    - brake pressure / force (at returning of control)
  - Related to RQ:
    - RQ_T_EMI_Gen_Perf_03
    - RQ_T_EMI_Gen_TecU_01
    - RQ_T_EMI_Gen_TecU_02
    - RQ_T_EMI_ESA_Perc_02

- **Hyp_T_EMI_gen_04: The (steering) intervention mitigates the collision and does not aggravate it.**
  - Indicators
    - TTC (at intervention)
    - impact speed
    - impact orientation
    - speed reduction (mean)
  - Related to RQ:
    - RQ_T_EMI_Gen_Perf_01
    - RQ_T_EMI_Gen_TecU_01

All technical hypotheses and indicators have now been defined. The next section will describe the hypotheses for the user-related evaluation, including the derivation of the indicators.

## 2.2 User-related assessment: hypotheses and derivation of indicators

This subchapter deals with the hypotheses and the corresponding indicators which have been formulated and derived from the user-related research questions presented in D7.1. As in D7.1, hypotheses and indicators common to all systems are presented first and followed by the details unique for the specific systems. In general however, it has been the aim to keep as much in common as possible, as this will allow for a more coherent over-all analysis of the interactIVe functions.

### 2.2.1 General

The concept of situational control has been central for the formulation of research questions and hypotheses regarding interactIVe systems. Situational control basically means whether the joint driver-vehicle system (JDVS) has enough control in a specific situation to prevent a collision [LJU10]. Measuring and understanding driver behaviour in terms of speed, lane position and similar, partly overlaps the technical evaluation domain but is one important group of indicators of situational control. The two most important key factors in the purely user-related domain are usability and driver's acceptance of the system. These two factors include both the efficiency, which the driver and system react to and interact in critical situations, as well as how the driver perceives, understands, accepts and trusts the system's operating principles. To ensure an appropriate degree of usability and acceptance is crucial since, for example an insufficient understanding of the system's functionalities or operating conditions may lead to over trust (that the system will resolve a specific situation when in fact it does not). It must also be ensured that the driver accepts and trusts the greater degree of control (both braking and steering) exerted by the interactIVe systems to avoid unintended/unwanted behaviour or even that the system is switched off.

The user-related evaluation is divided into three major categories, namely:

- Driver Behaviour,
- Function usage and
- Trust/acceptance

**Driver Behaviour**

The "Driver Behaviour" category comprises a range of driver responses to the different scenarios, for which the functions have been designed for, but also the general behaviour is addressed. The first RQ, RQ_U_Gen_Beh_01 (How does the function affect driver behaviour in the different scenarios defined?) is a general question which relates to basically all the following driver behaviour RQs. So no specific hypothesis for this RQ will be presented here. Belonging also to this RQ are, however, also some function-specific hypotheses, which will be discussed in the function-specific sections later on. It should also be noted that all hypotheses in this section are formulated as null hypotheses even if the expectation is that the function will produce the changes it was designed for without producing unwanted negative changes.

- **Hyp_U_Gen_Beh_01: Driving speed does not differ when driving with the function compared to driving without the function.**
    - Indicators:
        - speed profile
        - spot speed at selected sections
        - speed variance
    - Related to RQ:
        - RQ_U_Gen_Beh_02

Several studies show a strong relationship between speed level, speed variance and accidents (see for example [FIN94], [ELV04], [NIL04], [SAL81]; [O'CI94]). Speed depends directly on the driver's decisions and since drivers can control it very easily, this parameter is directly linked with the driver's intentions.

- **Hyp_U_Gen_Beh_02: The number and/or the severity of traffic conflicts do not differ when driving with the function compared to driving without the function.**
    - Indicators:
        - number of traffic conflicts
        - severity of traffic conflicts (measured by Time to Accident defined below)
    - Related to RQ**:**
        - RQ_U_Gen_Beh_03

A conflict is defined as a near-miss accident. A serious conflict has the same development of events as an accident, with the exception that in a near-miss accident there is no collision between the vehicle and another object (e.g. vehicle). The number of serious conflicts is approximately proportional to the number of crashes of similar type.

This hypothesis considers also the severity of the conflicts which will be measured by TA (Time to Accident) which is a TTC value in the moment the driver initiates an evasive action together with speed, in the same moment to define the severity of the conflict.

- **Hyp_U_Gen_Beh_03: There is no difference in alarm length when driving with the function compared to driving without the function.**
    - Indicators:
        - alarm length (s)
    - Related to RQ:
        - RQ_U_Gen_Beh_04

The alarm length is the time duration from the sensor detects a critical situation until the driver exit from the critical situation and gets into a safe state. Since the point of the function in most cases is to warn the driver in a timely manner, the expectation is that the length of alarms will decrease when driving with the function activated. When driving without the function the driver is not informed when the sensor detects the situation.

- **Hyp_U_Gen_Beh_04: There is no difference in temporal point of reaction (TPR) when driving with the function compared to driving without the function.**
    - Indicators:
        - TPR (s), warning to accelerator release
        - TPR(s), warning to brake press
        - TPR (s). warning to steering wheel response
    - Related to RQ:
        - RQ_U_Gen_Beh_05

The time when the driver initiates corrective action (accelerator pedal release, brake press, steering wheel response, which may be different depending on function/use case under study) due to a hazardous situation, is logged and can be extracted from these data. The temporal point of reaction is measured from the moment the sensor detects a critical situation until driver response. When driving without the function, the driver is not informed or warned by the function in critical situations. The expectancy is naturally that the drivers RT will be lower when warnings are presented compared to when they are not.

- **Hyp_U_Gen_Beh_05: There is no difference in time distance to the vehicle ahead when driving with the function compared to driving without the function.**
    - Indicators

        - time distance (s) to the vehicle ahead
    - Related to RQ:
        - RQ_U_Gen_Beh_06

Car-following behaviour is another important key indicator which is often used to describe driver behaviour. Time gap is also a parameter which drivers focus on, so it is linked to drivers' conscientious behaviour.

- **Hyp_U_Gen_Beh_06: There is no difference in lane keeping when driving with the function compared to driving without the function.**
    - Indicators:
        - standard deviation of side position in the lane
        - mean side position in the lane
    - Related to RQ:
        - RQ_U_Gen_Beh_07

The lateral position is obviously relevant to the interactIVe functions since they also provide lateral control or support.

- **Hyp_U_Gen_Beh_07: There is no difference in lane changing behaviour when driving with the function compared to driving without the function.**
    - Indicators:
        - rate correct lane changes/total lane changes
    - Related to RQ:
        - RQ_U_Gen_Beh_08

A correct lane change is a lane change performed without disturbing other vehicles (e.g. no cut–in),

- **Hyp_Hyp_U_Gen_Beh_08: There is no difference in correct interaction behaviour when driving with the function compared to driving without the function.**
    - Indicators:
        - number of correct interactions with other road users
    - Related to RQ:
        - RQ_U_Gen_Beh_09

Yielding behaviour has been shown to be an important safety indicator. In different studies it has been found out that erroneous yielding behaviour accounts for a large proportion of accidents and that failure to yield is one of the main driver failures leading to urban traffic accidents [CAR88], [CAR89].

**Function usage**

This group of hypotheses and indicators concerns the driver's effectiveness when using the functions, but also the driver's online response to function usage (such as emotional reaction). It should be noted that there may be a slight overlap between the function usage hypotheses and driver behaviour and trust/acceptance hypotheses.

The following RQ's and corresponding hypotheses are related to functions' usage:

- **Hyp_U_Gen_Use_01: The driver uses the function as it is intended to be used.**
    - Indicators:
        - number of times the driver uses/reacts to the function as intended.
    - Related to RQ:
        - RQ_U_Gen_Use_01

One of the most important aspects regarding the interaction between the driver and the function is assuring that the function is used as intended since an incorrect use of the function could lead to an unsafe situation. Non-appropriate use of the function could indicate a misunderstanding of the function. The main indicator to test this hypothesis is *the number of times the driver uses/reacts to the function as intended*. The indicator can be recorded by observers in the car or from video recordings of the driver (interjudges assessment). By means of this the correct or incorrect use of the functions can be classified, in conjunction with logged vehicle data providing information on function activation.

- **Hyp_U_Gen_Use_02: The driver does not delegate responsibility for tasks that the function is not designed for.**
    - Indicators:
        - number of looks in rear / side mirrors
        - use of turning indicator
        - gear changing behaviour
    - Related to RQ:
        - RQ_U_Gen_T&A_03

Hyp_U_Gen_Use_02 is related to the previous one but test instead the “delegation of responsibility”. By this is meant that the driver delegates tasks to the function, which the function is not designed for. Such events thus represent an inappropriate usage of the function. The indicator for this hypothesis consists of a range of variables, including use of turning indicator, the behaviour in terms of changing gears, etc.

The hypothesis will also be corroborated by interviews concerning the driver’s understanding of the function described in Hyp_U_Gen_Use_05 and Hyp_ U_Gen_T&A_04 below.

- **Hyp_U_Gen_Use_03: The driver’s emotional state is not influenced when driving with the function compared to driving without the function.**
    - Indicators:
        - self assessed emotional response (valence/activation)
        - physiological response (valence/activation)
    - Related to RQ:
        - RQ_U_Gen_Use_02

Previous studies have shown the relevance of the driver’s emotional state in the driving behaviour, especially in the driver’s process of adapting to the changes in a driving situation [BRA94]. From an evolutionary perspective, emotions can be seen as the human alarm system, where positive emotions signal that everything is safe while negative emotions signal a potential threat and a need to take quick action. Emotions thus have strong consequences for behaviour and information processing.

In order to measure the influence of the driver’s emotional state while driving with the system/function, the primary indicator will be the *Self-Assessment Manikin, SAM scales* [BRA94] which can be quite easily administrated after each incident within the test. Physiological measures of valence (positive-negative reactions) and activation/arousal are commonly used together with these scales. These physiological measures include the *Galvanic Skin Response (GSR)* on fingertips to measure activation and *EEG (Electroencephalography)* of the facial muscles to measure valence. Such physiological measures are however relatively intrusive, requires special equipment and quite a lot of post-processing of recorded data, so it has to be decided case-by-case whether these can be used or not.

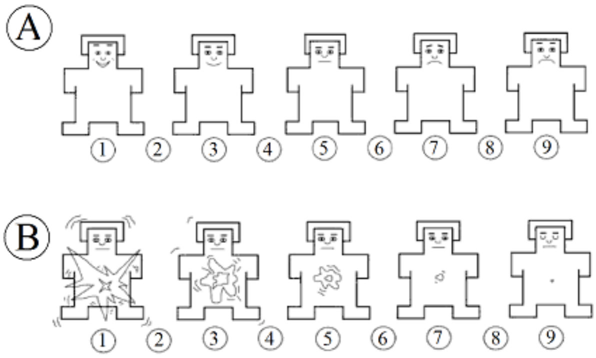


Figure 2.2: Self-Assessment Manikin (SAM) scales for measuring the emotional dimensions valence (top) and activation (bottom) [BRA94].

- **Hyp_U_Gen_Use_04: The driver's mental workload is not influenced when driving with the function compared to driving without the function.**
  - Indicators:
    - Raw Task Load Index (RTLX)
  - Related to RQ:
    - RQ_U_Gen_Use_03

Driver’s workload is defined as the amount of resources (or abilities) allocated by the driver, in terms of effort and attention, to achieve the driving task. We here address whether and how much of the driver’s resources are absorbed by the functions and how this could influence the normal driving behaviour (might be leading to an unsafe situation).The main indicator, which will be used to test the workload hypothesis, is the *subjective RTLX-index,* which is a set of six questions addressing [LAA97]:

1) Mental demand (any mental activity required when performing the driving task. That is how much thinking, deciding, looking, searching, etc. was required when you were driving? Was the driving task easy/simple (low) or complex/demanding (high)?
2) Physical demand which refers to any physical activity required when driving. For example, operating accelerator, brake or steering wheel and adjusting stereo settings. Was it easy/restful (low) or strenuous and laborious (high)?
3) Time pressure refers to how hurried or harassed you felt while driving. Was the pace of driving slow and leisurely (low) or rapid and rushed (high)
4) Performance - how satisfied were you with your performance when driving?
5) Effort refers to how hard you had to work (mentally and physically) to achieve your level of performance when driving. Was little effort (low) or a large amount of effort (high) required?
6) Frustration level refers to how relaxed or stressed you felt while driving. Did you feel secure, content, relaxed and complacent (low) or insecure, discourage, irritated stressed and annoyed (high)?

- **Hyp_U_Gen_Use_05: The driver perceives and understands the transition of control between the driver and the vehicle in the correct way**
    - Indicators:
        - interviews
        - questionnaire items
        - online ratings
    - Related to RQ:
        - RQ_U_Gen_Use_04

Transition of control is a relatively new area of research so there are no established indicators or methods. We propose however a combination of different approaches to get a better understanding of the driver's reaction to and preference for the various interactIVe transition schemes. This means using both objective data collected during the tests and using post-drive semi-structured interviews and questionnaires, supported by video sequences showing the vehicle and driver behaviour in the test situation.

A suggestion of an interview script for addressing the transition of control hypothesis is presented below:

- How was the situation handled?
- If the situation was handled by both you and the function, how was that achieved?
- Were you comfortable with this? (*referring to previous question*)
- If the function handled the situation, did you feel the need to brake / steer in and do something to change what the function was doing?
- Did you break in and change what the function was doing?
- Would you have been comfortable breaking in?
- Did you feel comfortable with the function handling the situation?
- When do you think the function started acting? How did you notice that the function started acting?
- How did you experience that? (any surprise, orientation, etc) How did you feel this changed the expectations you had on yourself driving, on what you needed to handle?
- When do you think the function stopped acting? How did you notice that the function stopped acting?
- How did you experience that? (any surprise, orientation, etc) How did you feel this changed the expectations you had on yourself driving, on what you needed to handle?
- What did you think of the way the function started and stopped? Was it helpful that the function handled (parts of) the situation?
- What would you have wished had happened in a different way?

In addition, scales covering the aspects in the interview are under development, as are methodologies for more post-on-line ratings (the scenario is replayed to the driver and he/she rates online the perception of control locus) and will be tested during the SP3 experiments. One should also mention that the emotional reaction hypothesis taps into this hypothesis as well, since lack of control or confusion regarding who is in control most likely will induce negative emotions.

**Trust & Acceptance**

The following RQs and hypotheses relate to trust and acceptance:

- **Hyp_U_Gen_T&A_01: The driver trusts the function**
  - Indicators:
    - interview
    - questionnaire items
  - Related to RQ:
    - RQ_U_Gen_T&A_01

This hypothesis will be tested by means of a set of interview-style scales/questions currently being tested in another EU-funded research programme (ADAPTATION):

- How did the warning (and intervention) affect your ability to handle this event?
- What was your level of confidence as you experienced the critical event? (Very Unconfident- Very confident)
- How confident would you feel about your ability to handle this event if you hadn't received a warning? (Very Unconfident- Very Confident)
- How reliable was the function (not at all reliable – very reliable)? Did it do what it was supposed to do? Did you notice any false warnings? Where there any situations where you would have liked to have had a warning but no one was given?
- How did false warnings affect your perception of the function?
- Did you ever ignore a warning? Did you always look up when receiving a warning?
- Was the function useful despite the false warnings (even with false warnings)?
- Would you have turned off the warning function if you could have?

- **Hyp_U_Gen_T&A_02: The driver finds the function useful and satisfying**
  - Indicators:
    - van der Laan acceptance questionnaire
  - Related to RQ:
    - RQ_U_Gen_T&A_04

An established method of assessing acceptance (the degree to which the driver finds the function useful and satisfying) is the van der Laan questionnaire, currently being used in e.g. euroFOT [LAA97]. This consists of nine bipolar items covering the dimensions of usefulness and satisfactoriness:

- useful–useless
- pleasant–unpleasant
- bad–good
- nice–annoying
- effective–superfluous
- irritating–likeable
- assisting–worthless
- undesirable–desirable

- raising alertness–sleep-inducing

- **Hyp_U_Gen_T&A_03: The driver perceives the function as being safe**
    - Indicators:
        - questionnaire items
    - Related RQ:
    - RQ_U_Gen_T&A_02: What is the perceived safeness of the driver?

Part of trust and acceptance of the interactIVe functions, is also the perceived safeness of the functions. The safeness hypothesis will be tested using a set of currently used items addressing:

- Overall perceived safeness
- Increased awareness
- Reduction of speeding events, distraction, lane departures
- Improved driving

- **Hyp_U_Gen_T&A_04: What are the advantages and disadvantages with the function**
    - Indicators:
        - interview questions regarding advantages/disadvantages
    - Related RQ:
        - RQ_U_Gen_T&A_05

As can be seen, there is no specific hypothesis for RQ_U_Gen_T&A_05, but this open question will allow for acquiring the driver's general perception of and attitude towards the function and the advantages and disadvantages there might be. It is furthermore hoped that, by asking these questions, one will get more insight of both intended effects as well as unintended (positive/negative) effects.

- **Hyp_U_Gen_T&A_05: The driver would like to have this function installed in his/her car/truck if it was available in the aftermarket.**
    - Indicators
        - questionnaire items on willingness to buy
    - Related RQ:
        - RQ_U_Gen_T&A_06
- **Hyp_U_Gen_T&A_06: The price the driver is willing to pay for the function is the same as the price of a currently available ADAS designed for a similar target scenario.**
    - Indicators:
        - questionnaire item with willing-to-pay price ranges
    - Related RQ:
        - RQ_U_Gen_T&A_07

These two related hypotheses are of course related to the market potential of the interactIVe functions, but can also be used to corroborate hypotheses on trust, acceptance and perceived safeness.

**Other**

In addition to the indicators presented above, background information of each test participant will be collected concerning:

- Gender
- Age
- Education level
- Driving experience and licenses
- Previous driving studies participation
- Attitude and speed/driver profile
- Technical experience and experience with other IVIS/ADAS
- Purchasing power

### 2.2.2 SECONDS

**Driver behaviour**

For the SECONDS functions, such as Continuous Support, Curve Speed Control, Enhanced Dynamic Pass Predictor, Safe Cruise, specific hypotheses and indicators are formulated about driver behaviour: These hypotheses are based on earlier findings that ‘’... behavioural adaptation to road safety programmes does occur although not consistently’’ [OECD90]. An OECD scientific expert group [OECD90] defined “behavioural adaptation” as ‘’those behaviours which may occur following the introduction of changes to the road-vehicle-user system and which were not intended by the initiators of the change’’. Behavioural adaptation generally did not eliminate safety gains from measures, but tended to reduce the size of the expected effects. Behavioural adaptation can, in practice, appear in many different driving manoeuvres: in change of speed, change of following distance, way and frequency of overtaking, way and frequency of lane changing, late braking, change of level of attention, etc. [DRA94]. In hypothesising and testing behavioural adaptation it is important to take into consideration the fact that it is an effect that does not appear immediately when the driving context is changed, but usually appears only after a familiarization period (ibid). Even if the time-span of the interactIVe project does not allow to test the long term effects on driver behaviour of the developed systems, it is important to “keep an eye” on the possibility of behavioural adaptation effects. Mechanisms that can lead to behavioural adaptation are ‘’delegation of responsibility’’, ‘’behaviour diffusion’’, and ‘’compensatory behaviour’’. [CAR93] describes ‘’delegation of responsibility’’ as follows: ‘’...in situations people consider uncontrollable, they want to know who is ‘responsible’ for certain events. If other, generally more powerful people assume responsibility, it is not unusual to delegate responsibility to them. This delegation of responsibility can lead to behaviour which is potentially more risky, e.g. in emergency situations where those at risk should make their own decisions’’. In the case of vehicle-based systems for driver support the driver might delegate the responsibility to the system. A driver supported by an assistance system is able to devote more attention to the other driving tasks. On the other hand he might become over-reliant on the system. For example, the driver might consider that the system will always know what the speed limit is and will always issue a warning at inappropriate speeds. ‘’Behaviour diffusion’’ might occur in situations where drivers are not supported by the system, e.g. when driving outside the areas covered by the system, driving non-equipped vehicles or when the system fails [CAR94]. In these cases drivers who become totally reliant on the system might have difficulty in following the changes in the actual speed limits. The notion of ‘’compensatory behaviour’’ has its origin in the ‘’risk compensation’’ theory of [WIL94] (the notion that road users will use up some of the margin afforded by safety improvements by, for example, driving faster) and the ‘‘risk homeostasis’’ theory of Wilde (the notion that road users seek to keep their risk constant).

***Hypotheses and indicators about driver behaviour, specific for the function Continuous Support***

- **Hyp_U_SEC_CS_Beh_01: Driver attention to blind spot does not differ when driving with the function compared to driving without the function.**
    - Indicators:
        - number of gazes at rear mirrors
        - number of blind spot checks above shoulder
    - Related RQ:
        - RQ_U_Gen_Beh_01

- **Hyp_U_SEC_CS_Beh_02: Yield/stop behaviour at intersections does not differ when driving with the function compared to driving without the function.**
    - Indicators:
        - Percentage correct yield/stop behaviour of total at intersections
    - Related RQ:
        - RQ_U_Gen_Beh_01

- **Hyp_U_SEC_CS_Beh_03: Speed adaptation at critical sites does not differ when driving with the function compared to driving without the function.**
    - Indicators:
        - speed profile, spot speed at selected sites
    - Related RQ:
        - RQ_U_Gen_Beh_01

- **Hyp_U_SEC_CS_Beh_04: Speed limit exceeding does not differ when driving with the function compared to driving without the function.**
    - Indicators:
        - percentage of driving time above speed limit
        - Maximum speed exceeding
        - Mean of difference between driven speed and given speed limit
    - Related RQ:
        - RQ_U_Gen_Beh_01

***Hypotheses and indicators about driver behaviour, specific for the function Curve Speed Control***

- **Hyp_U_SEC_CSC_Beh_01: Speed adaptation in curves does not differ when driving with the function compared to driving without the function.**

- Indicators:
  - speed profile, spot speed at curve entry and curve apex
- Related RQ:
  - RQ_U_Gen_Beh_01

***Hypotheses and indicators about driver behaviour, specific for the function Enhanced Dynamic Pass Predictor***

- **Hyp_U_SEC_eDPP_Beh_01: Overtaking behaviour does not differ when driving with the function compared to driving without the function.**
  - Indicators:
    - number of initiated/aborted overtakings
    - Minimum distance to an upcoming vehicle
  - Related RQ:
    - RQ_U_Gen_Beh_01

***Hypotheses and indicators about driver behaviour, specific for the function Safe Cruise***

- **Hyp_U_SEC_SC_Beh_01: The driver is engaged in no more/less secondary task when driving with the function compared to driving without the function.**
  - Indicators:
    - number of initiated secondary tasks during driving
    - Accumulated time for conducting secondary tasks
  - Related RQ:
    - RQ_U_Gen_Beh_01

- **Hyp_U_SEC_SC_Beh_02: Speed limit exceeding does not differ when driving with the function compared to driving without the function.**
  - Indicators:
    - percentage of driving time above speed limit
    - Maximum speed exceeding
    - Mean of difference between driven speed and given speed limit
  - Related RQ:
    - RQ_U_Gen_Beh_01

### 2.2.3 INCA

Below are shown the INCA specific hypotheses.

- **Hyp_U_INC_Beh_01: The driver does not (try to) override the active intervention. (by accelerating, countersteering)**
  - Indicators:
    - driver counteractions (accelerate, brake, steer)

        - interview (corroborative)
    - Related to RQ:
        - RQ_U_Gen_Beh_01

Since drivers in general are not used to strong active intervention measures, it is possible that such measures will cause irrational behaviour of the driver, e.g. that they try to countersteer the active steering intervention. This hypothesis is included to test whether such behaviour, which may decrease situational control, occurs or not. The primary indicator is drivers' counter actions, but the hypothesis will also be corroborated by indicators used in the systems usage and trust & acceptance sections (by means of interviews, questionnaires).

- **Hyp_U_INC_Beh_02: Situational control during intervention is not modulated by a (pre-)warning.**
    - Indicators:
        - driver counteractions (accelerate, brake, steer)
        - alarm length (see Hyp_U_Gen_Beh_03)
        - number/severity of traffic conflicts (see Hyp_U_Gen_Beh_02)
        - interview (corroborative)
    - Related to RQ:
        - RQ_U_Gen_Beh_01

For most use cases, the INCA interventions are preceded by a warning. In some use cases, the warning is concurrent with the intervention. It would therefore be interesting to investigate whether these warnings actually improve the situation by making the driver initiate actions which the function then strengthens, or if driver reaction in any sense is made worse as a result of the warnings. As with the previous hypothesis, this one also will find explanations in the interviews performed part of the other sections hypotheses.

- **Hyp_U_INC_Beh_03: Driver attention to blind spot does not differ when driving with the function compared to driving without the function.**
    - Indicators:
        - number of gazes at rear mirrors
        - number of blind spot checks above shoulder (applicable to car demonstrators only
    - Related RQ:
        - RQ_U_Gen_Beh_01

This hypothesis is relevant only for the lateral functions SIA and LCCA.

### 2.2.4 EMIC

In this subchapter, the hypotheses and indicators defined for EMIC and its particular functions are defined. The hypotheses are divided like the general hypotheses in three main groups: driver behaviour, system usage and trust and acceptance.

Hypotheses and indicators about driver behaviour, specific for the CMS function are:

- **Hyp_U_EMI_CMS_Beh_01. Driver behaviour at intersections doesn't change with the function compared to driving without the function.**
    - Indicators:

        - Number of lane changes at intersections
        - Mean distance to lead vehicle at intersections
        - Lane position in intersections
        - Idle time at intersections
    - Related to RQ:
        - RQ_U_Gen_Beh_06
        - RQ_U_Gen_Beh_07
        - RQ_U_Gen_Beh_08
        - RQ_U_Gen_Beh_09

- **Hyp_U_EMI_CMS_Beh_02. There is no difference in lane keeping when driving with the function compared to driving without the function.**
    - Indicators:
        - standard deviation of side position in the lane
    - Related to RQ:
        - RQ_U_Gen_Beh_07

Hypotheses and indicators about driver behaviour, specific for the ESA function, are:

- **Hyp_U_EMI_ESA_Beh_01. The driver behaviour in front of an obstacle (pedestrian, unparked vehicle, end of traffic jam) in the road doesn't change with the function compared to driving without the function.**
    - Indicators:
        - behaviour in front an obstacle in terms of speed, steering wheel angle and maximum steering velocity
    - Related to RQ:
        - RQ_U_Gen_Beh_09

**Trust and Acceptance**

Hypothesis and indicators for all EMIC functions related with trust and acceptance are:

- **Hyp_U_EMI_T&A_01: The driver perceives correctly the level of control that the function provides.**
    - Indicators:
        - level of control
    - Related to RQ:
        - RQ_U_Gen_T&A_03

Not specifically a research question, but also advantages and disadvantages felt by the driver will be asked through questionnaires. This is related to RQ_U_Gen_T&A_05: What advantages and what disadvantages does the driver feel when driving with the function?

## 2.3 Safety Impact assessment: hypotheses and derivation of indicators

The main objective of the safety impact assessment is to evaluate how and how much the different functions influence traffic safety. In order to determine the impact of the interactIVe functions on traffic safety, accident frequency in the relevant use cases output from technical assessment on technical performance of the functions and from user related tests on driver behaviour when driving with the function (such as, speed, distance keeping, lane keeping, reaction time, etc.) will be used. Apart from the impact on traffic safety, which is determined for all systems, the impact on fuel efficiently for the SECONDS functions also needs to be studied. The hypotheses are based on the research questions, which have been widely defined and described in deliverable D7.1. This deliverable is focused on the direct effects of the function. But the indirect effects will also be considered for the impact assessment. Therefore the related hypotheses will be described in deliverable D7.4, which will describe the methodology for the impact assessment.

The hypotheses and indicators are presented in the next subchapters. Following the same structure as in the technical and user-related assessment, the general hypotheses and indicators are presented first. Then the hypotheses and indicators related to specific functions or systems are described. The tables with all the detailed information on the hypotheses and indicators can be found in Annex 1.

### 2.3.1 General

The first and most important hypothesis for all interactIVe functions is derived from the main objective to improve the traffic safety. For all functions this hypothesis determines, whether they improve the traffic safety.

- **Hyp_I_Gen_01: The function improves the traffic safety.**
    - Indicators
        - number of accidents
        - reduction of the accident severity
    - Related to RQ:
        - RQ_I_SEC_01
        - RQ_I_INC_01
        - RQ_I_EMI_01

An improvement of traffic safety can indeed be achieved by the functions in two ways. The first way is through avoidance of accidents, which results in a decrease of the number of accidents, and the second way is through the reduction of the accidents severity. In order to make a thorough analysis, the hypothesis Hyp_XX1 is divided in two. In the first hypothesis the reduction of the accident number is verified and in the second hypothesis the reduction of the accident severity is analysed. The answers to both hypotheses are combined and used as indicators for finally answering the hypothesis Hyp_xx1.

- **Hyp_I_Gen_02: The function decreases the number of accidents.**
    - Indicators
        - Accidents rate;
        - max longitudinal relative velocity at which an accident is avoided
        - max lateral relative velocity at which an accident is avoided;
        - lateral acceleration required to avoid collision, when warning is given or the function starts to intervene
        - longitudinal acceleration required to avoid collision, when warning is given or the function starts to intervene
    - Related to RQ:
        - RQ_I_SEC_01…08
        - RQ_I_INC_02

        - RQ_I_EMI_01, RQ_I_EMI_03

- **Hyp_I_Gen_03: The function decreases the severity of accidents.**
    - Indicators
        - mean (impact speed)
        - max speed reduction
        - mean speed reduction
        - speed at warning
        - speed at starting of intervention
        - reduction of kinematic energy by intervention
        - min speed reduction
        - location point of impact
        - impact orientation
        - mass of vehicle
    - Related to RQ:
        - RQ_I_SEC_01…08
        - RQ_I_INC_03
        - RQ_I_EMI_02, RQ_I_EMI_04

Both hypotheses need to be analysed overall as well as for each category of corresponding use cases. The different categories of use cases are:

- rear-end collision
- head on collision
- lane change collision
- cross traffic collision
- collision with vulnerable road user
- unintended lane departure accidents
- excessive speed accidents
- traffic rule violations

The indicators used in order to verify whether the number of accidents has decreased, are the accident rate in the test scenarios, the maximum longitudinal and lateral relative velocity at which an accident is avoided, as well as the lateral and longitudinal acceleration necessary to avoid an accident. The reduction of the accident severity is on the other hand determined using the indicators achieved speed reduction, kinematic energy reduction, the impact speed, the speeds at warning and intervention, the impact location and the impact orientation.

A second very important hypothesis for the impact assessment is to check, whether the functionality of one function is influenced by another function. This check is important, because otherwise it would not be possible to distinguish between the effects of different function and which effect is assigned to which function. This problem becomes more serious by the fact that in the demonstrator vehicle different functions are integrated – in some demonstrator vehicles even function of different systems are combined. If the different functions are not studied separately, this could result in an over- or underestimation of the safety impact of a function. The hypothesis is verified by the status of the different functions within the different test scenarios. Additionally the specification of the function will be used in order to identify possible negative interactions between the functions.

- **Hyp_I_Gen_04: The safety impact of the function is not negatively influenced by another function.**
    - Indicators

        - function warning status
        - function intervention status
        - function specification
    - Related to RQ:
        - RQ_I_INC_05
        - RQ_I_INC_06

For the interactIVe function, which intervenes in the dynamic behaviour of the vehicle, it is important for the impact assessment to understand, under which circumstance the function is able to intervene, and whether there are limitations for the intervention. One restriction could be for example the limitation of the intervention duration. This is verified by means of the maximum duration of intervention, which is monitored during the tests, as well as by using the technical specifications of the function.

Furthermore, it is important for the safety impact assessment to consider, whether the functions takes also the surrounding traffic into account correctly before issuing a warning or intervening. Therefore the intervention and accident status is checked in the test scenarios with more than two vehicles and scenarios with congested traffic are considered as well.

- **Hyp_I_Gen_05: The intervention time of the function is not limited.**
    - Indicators
        - max. duration of intervention
        - function specification
    - Related to RQ:
        - RQ_I_INC_04

- **Hyp_I_Gen_06: The function will avoid also accidents scenarios if more than one vehicle is involved.**
    - Indicators
        - accident status in test scenarios
        - function intervention status
    - Related to RQ:
        - RQ_I_INC_04

- **Hyp_I_Gen_07: Evasive manoeuvre will not be executed in congested traffic situations.**
    - Indicators
        - function intervention status;
        - intervention rate
    - Related to RQ:
        - RQ_I_INC_04

Safety relevant hypotheses, tested in the technical assessment and user-related assessment are important for the safety impact assessment. Hence the safety impact assessment will use – when necessary and possible – the results from the other assessments.

For an adequate safety impact assessment of the different functions, it must be taken into account when a function is able to operate and under which (environmental) conditions the functions work. Not knowing the function's limitations would result in overestimation of the safety impact. Hence it is important to establish whether there are limitations regarding for example the road type, the light conditions, the traffic conditions or the speed range, in which the function operates. This yields the following set of hypotheses.

- **Hyp_I_Gen_08: The function operates on all road types.**
    - Indicators
        - mean function status (per road type)
    - Related to RQ:
        - RQ_T_Gen_Perf_02

- **Hyp_I_Gen_09: The function works under all weather conditions.**
  - Indicators
    - mean function status(per weather conditions)
  - Related to RQ:
    - RQ_T_Gen_Perf_02

- **Hyp_I_Gen_10: The function works under all light conditions.**
  - Indicators
    - mean function status (per light conditions)
  - Related to RQ:
    - RQ_T_Gen_Perf_02

- **Hyp_I_Gen_11: The function works in all traffic conditions.**
  - Indicators
    - mean function status (per traffic conditions)
  - Related to RQ:
    - RQ_T_Gen_Perf_02

- **Hyp_I_Gen_12: The function works over the whole speed ranges of the vehicle.**
  - Indicators
    - mean function status (per driven speed)
  - Related to RQ:
    - RQ_T_Gen_Perf_02

All these hypotheses are answered using the function's status depending on the environmental or vehicle status.

How the user interacts with the function is also an important aspect for the impact assessment that should be considered; especially how the user behaviour changes in using the system over time. For this reason the number of warnings and interventions is closely monitored in order to assess, whether the driver starts relying too much on the function and gets careless while driving. The input from the user related assessment is vital here. This gives the following set of hypotheses.

- **Hyp_I_Gen_13: The number of warnings will not increase as a consequence of the driver relying too much on the function.**
  - Indicators
    - alarm rate
  - Related to RQ:
    - RQ_I_SEC_02

- **Hyp_I_Gen_14: The number of interventions will not increase as a consequence of the driver relying too much on the function.**
  - Indicators
    - intervention rate
  - Related to RQ:
    - RQ_I_SEC_02

For the safety impact assessment it is also important, how the intervention rate changes over the time. But due to the fact that no long term tests are planned, this hypothesis is hard to analyse.

- **Hyp_I_Gen_15: The intervention rate will not increase over time.**
  - Indicators
    - intervention rate

Finally, a wrong intervention by the function may result in a worse situation. Hence this needs to be checked. If this is the case in the tests, the negative effects of these situations need to be considered for the impact assessment. The hypotheses are verified by means of the impact orientation, the location of the impact point and the impact speed.

- **Hyp_I_Gen_16: The intervention of the function will not result in a worse situation.**
    - Indicators
        - impact orientation;
        - location point of impact
        - impact speed

This section described the general hypotheses concerning safety impact. Next subchapters the hypotheses are described, which are related to one special function or system.

### 2.3.2 SECONDS

Most of the hypotheses regarding the SECONDS system are already incorporated in the general hypotheses described above.

The Safe Cruise (SC) function is an automatic function that will enable the vehicle to autonomously follow a lead vehicle at a safe distance. The hypotheses with regard to the safety impact assessment of the SC as well as for the fuel consumption are as follows:

- **Hyp_I_SEC_01: Safe Cruise increases the average THW.**
    - Indicators
        - average THW

- **Hyp_I_SEC_02: Safe Cruise decreases average speed.**
    - Indicators
        - Mean speed

The fuel consumption is also analysed for the Continuous Support Curve Speed Control, Safe Cruise function. But the fuel consumption will not be analysed for EMIC or INCA function. Hence it is unique for the SECONDS system.

- **Hyp_I_SEC_03: The usage of the function reduces the fuel consumption.**
    - Indicators
        - fuel consumption
        - mean speed
        - standard deviation speed
        - mean longitudinal acceleration
        - standard deviation longitudinal acceleration
    - Related to RQ:
        - RQ_I_SEC_10

### 2.3.3 INCA

For INCA the situation differs from the other systems, because some INCA functions are not only intended for passenger cars but also for trucks. This fact is considered by the hypothesis “The safety impact of the function will be equal for passenger cars and trucks”. For this hypothesis the same indicators are used as for the hypothesis Hxx1.

- **Hyp_I_INC_01: The safety impact of the function will be equal for passenger cars and trucks.**
  - Indicators
    - number of accidents
    - reduction of the accident severity
  - Related to RQ:
    - RQ_I_INC_07

Because the INCA function can intervene in the vehicle behaviour in lateral as well as longitudinal direction, it needs to be studied for the impact assessment, whether the function intervenes more often in lateral or in longitudinal direction. The hypotheses are checked by means of the maximum acceleration and by the intervention status of the function.

- **Hyp_I_INC_02: The function will try to avoid imminent accidents more often by braking than steering.**
  - Indicators
    - maximum longitudinal acceleration
    - maximum lateral acceleration
    - function intervention status
  - Related to RQ:
    - RQ_I_INC_04

- **Hyp_I_INC_03: The function will try to mitigate accident more often by braking than steering.**
  - Indicators
    - maximum longitudinal acceleration
    - maximum lateral acceleration
    - function intervention status
  - Related to RQ:
    - RQ_I_INC_04

### 2.3.4 EMIC

Most of the hypotheses and indicators, which are analysed for INCA, need also to be analysed for EMIC. Therefore they are not described in detail in this subchapter. One difference between and the INCA and EMIC function is that due to the specification of the EMIC system only the mitigation of accident need to be analysed and not the avoidance. But for this hypothesis it must be considered that only the CMS function can intervene by braking.

- **Hyp_I_EMI_01: The function will try to mitigate accident more often by braking than steering.**
  - Indicators
    - maximum longitudinal acceleration
    - maximum lateral acceleration
    - function intervention status
  - Related to RQ:
    - RQ_I_INC_04

# 3 Test scenario definition

Based on the research questions, category of use cases (see D7.1 and D1.5), hypotheses and indicators (chapter 2), the required test scenarios and test cases were defined. Based on the defined test cases the test plans for the demonstrator vehicles will be elaborated, which will be part of the deliverable D7.4.

This chapter uses following definitions for 'test scenario", 'test case' and 'test':

- Test scenario:
    - group of test cases, which are related to the same type of critical situation,
    - comparable to "category of use case" or "category of target scenario".
- Test case:
    - a general description of a tested situation
    - one test case includes different tests, for which the relevant parameters are varied,
    - comparable to "use case" or "target scenario".
- Test :
    - detailed description of a tested situation
    - the description includes a detailed definition of the relevant parameters.

Following figure shows the naming or the test scenarios, test cases and tests.

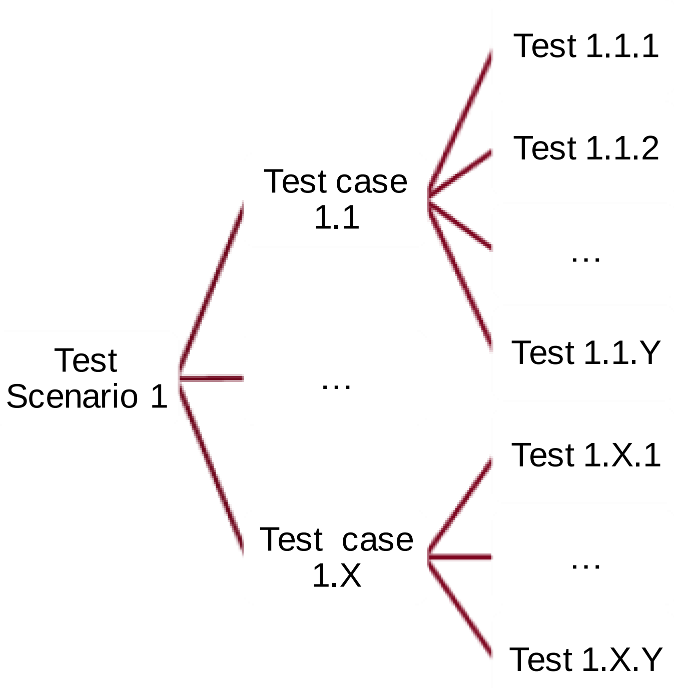


Figure 3.1: Naming convention for the test scenarios, test cases and tests

An overview on the different functions and the related test scenario is given in the following tables

Table 3.1: Test scenarios relevant for the respective SECONDS functions

| | SECONDS function | | | |
|---|---|---|---|---|
| Test scenario | CS | CSC | EDPP | SC |
| 1. Rear-end interaction with other vehicle | √ | | | √ |
| 2. Overtaking situations | | | √ | |
| 3. Interaction with other vehicles during lane change | √ | | | |
| 4. Interaction with crossing traffic | √ | | | |
| 5. Interaction with pedestrian or animal on the road | √ | | | |
| 6. Unintended lane departure | √ | | | |
| 7. Hazardously high speed in curve | √ | √ | | |
| 8. Exceeding speed limit | √ | | | √ |

√ = the function is aimed at the test scenario

Table 3.2: Test scenarios relevant for the respective INCA functions

| | INCA function | | | | |
|---|---|---|---|---|---|
| Test scenario | LCCA | OVCA | RECA | RORP | SIA |
| 1. Rear-end interaction with other vehicle | | | √ | | |
| 2. Overtaking situations | √ | √ | | | |
| 3. Interaction with other vehicles during lane change | √ | | | | √ |
| 4. Interaction with crossing traffic | | | | | |
| 5. Interaction with pedestrian or animal on the road | | | | | |
| 6. Unintended lane departure | | | | √ | |
| 7. Hazardously high speed in curve | | | | √ | |
| 8. Exceeding speed limit | | | | | |

√ = the function is aimed at the test scenario

Table 3.3: Test scenarios relevant for the respective EMIC functions

| | EMIC function | |
|---|---|---|
| Test scenario | CMS | ESA |
| 1. Rear-end interaction with other vehicle | √ | √ |
| 2. Overtaking situations | √ | |

| | | |
|---|---|---|
| 3. Interaction with other vehicles during lane change | | |
| 4. Interaction with crossing traffic | √ | √ |
| 5. Interaction with pedestrian or animal on the road | √ | √ |
| 6. Unintended lane departure | √ | |
| 7. Hazardously high speed in curve | | |
| 8. Exceeding speed limit | | |

√ = the function is aimed at the test scenario

## 3.1 Technical assessment

The project-level test and target scenarios, based on identified accident types, are split into several test cases for technical evaluation. An example of a technical test case is the Rear-end collision test case 1.1, where the test vehicle is approaching a stationary target. Another word describing a test case would be a 'situation'.

Multiple test cases are defined for each target scenario, with initial ideas on what parameters to vary in the actual tests. The detailed test plans with detailed specification of the test will be defined later in D7.4 after feedback from VSPs and further iteration of test plans.

It is evident, that the technical test cases defined here can support safety and user-related assessment as well. SP7 will further harmonize, prioritize and combine the test cases when creating the final test plans.

This document gives a rather comprehensive list of test cases to collect evaluation data. Even so, the test cases have been defined to be rather clear and simple. Mostly they can be executed on a test track or in a laboratory, repeated to analyze variation and the level of danger to testers and equipment should be minimal.

The test cases include basic system performance tests and a few verification tests to check specifications. The SPs should continue to design more verification tests to test e.g. sensor detection ranges and system operational status in different speeds, if deemed necessary. The system performance tests are designed to produce data for evaluating mainly safety impacts and gaining an overview of the capabilities. Finally, the test cases include a few so-called challenging cases. These challenging test cases are known to present some difficulties for current collision avoidance and mitigation systems in general.

The list of technical test cases is included in Annex 2.

## 3.2 User related assessment

Test scenarios for user-related evaluation are defined in a similar way as for the technical evaluation, and are derived directly from the use cases – see Annex 2. These are the following:

- Rear-end interaction with other vehicle
- Overtaking situations
- Interaction with other vehicles during lane change
- Interaction with crossing traffic
- Interaction with pedestrian or animal on the road
- Unintended lane departure

- Hazardously high speed in curve
- Exceeding speed limit

During the field trials in real-life traffic environment the in-car observers' task is to monitor driver behaviour continually and register observation variables in these test scenarios. Also, logged data will be analysed from these scenarios. For the systems, for which the tests involve a high risk of collision (e.g. SC, eDPP or CMS), a driving simulator should be used. In the driving simulator these test scenarios above should be created, providing also guaranteed repeatability. Questionnaires will be handed to the test participants in order to assess their individual subjective feelings about the tested functions in the test scenarios.

## 3.3 Safety impact assessment

The tests for the impact assessment differ from tests for the technical and user-related assessment. For verification of the hypotheses two types of data will be used.

1. Data, which are not generated by tests.

   This data provide information on the current status with respect to the traffic in Europe and to the accident situation in different countries respectively regions in Europe. By means of this data the current situation is described, which is the basis for determination of the safety impact of the developed functions.

2. Data, which are generated by tests.

   The test data are needed in order to consider the performance and the interaction with user of the developed interactIVe functions for the impact assessment.

But in contrast to the technical and user-related assessment, the necessary data for the impact assessment are not generated in special test scenarios. The impact assessment will use the data and test scenarios, which have been generated by the other two assessments. Through this the testing effort should be reduced as much as possible.

For the technical and user-related assessment the different test cases are used without any constraints.

Although the data of the other assessments are used, the focus for the evaluation in the impact assessment will differ slightly from the other two assessments. For the technical test scenarios the focus in the impact assessment will be on the performance of the function to avoid an accident and to reduce of the accident severity. In the user-related tests the impact assessment will concentrate on the reaction of the driver to warnings respectively interventions.

Nevertheless at the moment it is not possible to ensure that all needed data for the impact assessment will be provided by the technical and user-related assessment or other tests conducted by the VSP. Hence additional test scenarios are for the impact assessment. The amount of tests for impact assessment will strongly depend on the function as well as the test, which will be conducted in the technical and user-related assessment.

The tests for the impact assessment can be divided in three different test types:

1. Verification tests. These tests verify if the function operates in the specified way. This needs especially to be checked for the operating conditions of the function (e.g. weather condition, road type, speed range). From today's point of view it is not very reasonable that additional tests for the impact assessment regarding this test type will be needed, because the verification of functionality must also be tested by the VSP and will additionally be considered in the technical assessment.
2. Tests for simulation. These tests have two objectives. The first and main objective is to ensure that the simulation models' behaviour matches with the real function's behaviour. The second and a more indirect objective of the test is to provide data, by

means of which it should be possible to analysed, whether there are changes in the driving behaviour with regard to the following or lane keeping behaviour while driving with and without the function. These tests are especially important for the Safe Cruse function, which takes over the car control in longitudinal and lateral direction.

3. Tests on fuel consumption. This test type is only needed for the SECONDS function and should provide data for the simulations that evaluates the changes in the fuel efficiency.

The tests for simulation and fuel consumption can be done separately or in one of the other defined test cases. It is also possible that the different tests for the simulation and the fuel consumption are combined in one special test case, which will be very similar to a normal driving situation (see test case 10.0/11.0 in the annex). How the tests will be conducted depends on the test environment. But independent of the question, whether the test cases are executed separately or not, the tests need to be conducted with different drivers in order to consider different driver behaviours.

The best testing environment would be real traffic. For testing in real traffic, the traffic density needs to be considered. Due to restrictions regarding the access to the demonstrators as well as concern about the legal aspects of testing in real traffic, this is not for all demonstrators a feasible option. Therefore the tests cases can also be tested on a test track. However in both cases an adjustment of the test cases regarding the testing environment is necessary.

A detailed description of the different test cases is given in Annex 2.

# 4 Conclusions

interactIVe aims for the development of multiple Advanced Driver Assistance Systems (ADAS applications). Therefore interactIVe is a project that covers from the implementation of a perception platform or IWI strategies to the proper integration of safety systems with the final target to avoid respectively mitigate an accident or minimize its consequences. The functions, which are developed in interactIVe, comprise three systems:

- SECONDS (support of the driver)
- INCA (collision avoidance)
- EMIC (cost-efficient collision mitigation)

There is an evident request for evaluation of the developed systems and functions. The evaluation of the functions will focus on three main aspects:

- Technical evaluation
- User-Related evaluation
- Impact Assessment

This deliverable has carried out the next step towards the definition of the evaluation framework by specifying the following elements:

- Hypotheses definition based on the research questions of D7.1. The hypotheses are set up in 2 categories per assessment (technical, user related and impact):
  - General
  - System specific (SECONDS, INCA, and EMIC).
- Indicators definition based on the hypotheses of this deliverable. The indicators are set up per assessment (technical, user related and impact).
- Test scenarios definition based on the use cases and target scenarios defined in D1.5.

This deliverable provides the second step in the definition of the evaluation platform for interactIVe. The next step is to define specific test plans. This will be the main focus for D7.4.

The presented hypotheses, indicators and test scenarios will be discussed by SP7 with the VSP's in order to ensure that all aspects of the developed function is correctly covered. Also the documents on which the research questions and hypotheses are based (has D1.5 (v16, Annex1 v2 and Annex2 v12) and D1.6 v0998) are subject to changes as well. The results of the April 2011 SP workshop has been mostly integrated into this deliverable, but further discussion will lead to other changes and these will be reported in D7.4.

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# Abbreviations

| Abbreviation | Description |
|---|---|
| ABS | Antilock Brake System |
| ACC | Adaptive Cruise Control |
| ADAS | Advanced Driver Assistance System |
| AV | Approaching Vehicle |
| C2C | Car to Car |
| CAN | Controlled Area Network |
| CMS | Collision Mitigation System |
| CS | Continuous Support |
| CSC | Curve Speed Control |
| CV | Crossing Vehicle |
| eDDP | enhanced Dynamic Pass Predictor |
| EC | European Commission |
| EEG | ElectroEncephaloGram |
| EMIC | EMergency Intervention for Collision mitigation |
| ESA | Emergency Steer Assist |
| ESC/ESP | Electronic Stability Control / Electronic Stability Program |
| EU | European Union |
| GIDAS | German In-depth Accident Study |
| GSR | Galvanic Skin Response |
| HMI | Human Machine Interface / Interaction |
| HV | Host Vehicle |
| INCA | INtegrated Collision Avoidance and vehicle path control |
| IWI | Information, Warning and Intervention |
| JDVS | Joint driver vehicle system |
| LCCA | Lane Change Collision Avoidance |
| LKS | Lane Keeping System |
| LV | Lead Vehicle |
| NEFZ | Neuer Europäischer Fahrzyklus (New European Driving Cycle) |
| OEM | Original Equipment Manufacturer |
| OV | Opponent Vehicle |
| OVCA | Oncoming Vehicle Collision Avoidance/Mitigation |
| PI | Performance Indicator |
| RECA | Rear End Collision Avoidance |
| RORP | Run-off Road Prevention |
| RQ | Research Question |

| Abbreviation | Description |
|---|---|
| RT | Reaction Time |
| SAM | Self Assessment Manikin |
| SC | Safe Cruise |
| SECONDS | Safety Enhancement through CONtinuous Driver Support |
| SIA | Side Impact Avoidance |
| SP | Subproject |
| SUS | System Usability Scale |
| TET | Time Exposed Time to collision |
| THW | Time Headway |
| TLC | Time to Line Crossing |
| TTC | Time To Collision |
| UA | Unattended Animal |
| UC | Use Case |
| VRU | Vulnerable Road User |
| VSP | Vertical Subproject |

# Glossary

| Glossary | Description |
|---|---|
| Aspect | A specific action that is part of a function and / or a system and that is common for different functions / systems. E.g., “automatic steer”. |
| Component | A device or a set of devices necessary for the implementation of an aspect, function or system. E.g., “perception component”, “logic component” |
| Function | A task, action, or activity that must be accomplished to achieve a desired outcome. E.g., “lane keeping” |
| System | A collection of components organized to accomplish a specific function or set of functions. E.g., “EMIC” |
| Target scenario | The general purpose of the target scenarios in interactIVe is to define the *problem* - in terms of an undesired outcome - that the envisioned interactIVe functions are to address |
| Test scenario | Scenario where a certain aspect, function or system is tested |
| Use case | *Use cases* which define *how the problem will be solved*, that is, how the function is intended to prevent the targeted accidents or mitigate their consequences |

# Annex 1: Hypotheses and indicators for interactIVe

This Annex summarizes all hypotheses and indicators for the evaluation of the interactIVe systems:

- All Hypotheses
- Indicators for the technical assessment
- Indicators for the user-related assessment
- Indicators for the safety impact assessment

| No | Hypotheses | Related RQ | SECONDS | INCA | EMIC | Indicator | | |
|---|---|---|---|---|---|---|---|---|
| Hyp_T_gen_perf_01 | The function's availability is determined by the sensor's availability | RQ_T_Gen_Perf_02 | x | x | x | Missed alarm rates | | |
| | | | | | | False alarm rates | | |
| | | | | | | Rate function "on" per status | | |
| Hyp_T_gen_perf_02 | Different environmental conditions do not affect the function's performance. | RQ_T_Gen_Perf_02 | x | x | x | TTC | at point in time (alarm, intervention, first detection) | |
| | | | | | | Speed reduction | | max |
| | | | | | | Impact speed | | |
| | | | | | | Driver reaction | | |
| | | | | | | Missed alarm rates | | |
| | | | | | | False alarm rates | | |
| Hyp_T_gen_perf_03 | The function uses the maximum (possible) longitudinal acceleration in order to avoid an accident. | RQ_T_Gen_Perf_03 | x | x | x | Longitudinal acceleration | | max |
| Hyp_T_gen_perf_04 | The function is able to brake up to stand still autonomously | RQ_T_Gen_Perf_03 | x | x | x | Speed reduction | | mean |
| | | | | | | Speed reduction | | min |
| | | | | | | Speed reduction | | max |
| Hyp_T_gen_perf_05 | There are no false negative activations of the function (during the test) | RQ_T_Gen_Perc_04 | | | | number of false negative detection (false negative detection rate) | | |
| Hyp_T_gen_perf_06 | There are no false positive activations of the function (during the test) | RQ_T_Gen_Perc_05<br>RQ_T_INC_RECA_safe_02 | | | | number of false positive detection (false positive detection rate) | | |
| Hyp_T_gen_Perf_07 | The system detects threats and target scenarios according to the specifications | RQ_T_INC_Gen_Perf_01, RQ_T_INC_RECA_Perc_01, RQ_T_INC_RECA_TecU_02, RQ_T_INC_RECA_Perf_04, | x | x | x | CAR | | |
| | | | | | | FAR | | |
| | | | | | | MAR | | |

| No | Hypotheses | Related RQ | SECONDS | INCA | EMIC | Indicator | | |
|---|---|---|---|---|---|---|---|---|
| | | RQ_T_INC_OVCA_Safe_01 | | | | function activation in a test scenario | | |
| Hyp_T_gen_perc_01 | The relevant target is always detected by the function (during the test). | RQ_T_Gen_Perc_01 | x | x | x | Missed alarm rates | | |
| | | | | | | Number of false positive detections | | |
| | | | | | | Number of false negative detections | | |
| | | | | | | Rate of correct detection | | |
| | | | | | | Time target visible and in sensor coverage area until first detection | | |
| Hyp_T_gen_perc_02 | Information on the relevant target is provided in time to assure that the function can react as intended. | RQ_T_Gen_Perc_03 | x | x | x | TTC | at first detection | |
| | | | | | | THW | at first detection | |
| Hyp_T_gen_perc_03 | There are no false negative detections (during the test) | RQ_T_Gen_Perc_04 | x | x | x | Number of false negative detections | | |
| | | | | | | False negative rate | | |
| Hyp_T_gen_perc_04 | There are no false positive detections (during the test) | RQ_T_Gen_Perc_05, RQ_T_INC_RECA_Safe_02 | x | x | x | Number of false positive detections | | |
| | | | | | | False positive rate | | |
| Hyp_T_gen_safe_01 | The function improves the traffic safety by reducing the impact speed. | RQ_T_Gen_Safe_01, RQ_T_EMI_Gen_Perf_02, RQ_T_EMI_CMS_Perf_02, RQ_T_INC_Gen_Perf_01 | x | x | x | Impact speed | | |
| Hyp_T_gen_safe_02 | The function improves the traffic safety by avoiding an accident in a target scenario. | RQ_T_Gen_Safe_01, RQ_T_EMI_Gen_Perf_02, | x | x | x | TTC | at start of the intervention | |

| No | Hypotheses | Related RQ | SECONDS | INCA | EMIC | Indicator | | |
|---|---|---|---|---|---|---|---|---|
| | | RQ_T_INC_Gen_Perf_01 | | | | Distance to target object - (longitudinal) | | min |
| | | | | | | Distance to target object (lane, barrier) - (lateral) | | min |
| | | | | | | Lateral acceleration | | max |
| | | | | | | Longitudinal acceleration | | max |
| | | | | | | Duration of intervention | | |
| | | | | | | Vehicle speed | at the end of the intervention | |
| | | | | | | Vehicle position | at the end of the intervention | |
| Hyp_T_gen_safe_03 | The function improves the traffic safety by altering the orientation of the car at impact. | RQ_T_Gen_Safe_01, RQ_T_EMI_CMS_Perf_02 | x | x | x | Impact orientation | | |
| Hyp_T_gen_safe_04 | The function warns the driver in all tested scenarios, in which a warning is required | RQ_T_Gen_Safe_02 | x | x | x | Function warning status | | |
| | | | | | | Function intervention status | | |
| | | | | | | Brake pressure / force | Extra applied | |
| | | | | | | Steering torque | Extra applied | |
| | | | | | | TTC | at alarm | |
| | | | | | | THW | at alarm | |
| | | | | | | Number of false alarms | | |
| | | | | | | Number of missed alarms | | |
| | | | | | | Distance to target object - (longitudinal) | at alarm | |
| Hyp_T_gen_safe_05 | The function intervenes in all tested scenarios, in which an intervention is required | RQ_T_Gen_Safe_03 | x | x | x | Function intervention status | | |

| No | Hypotheses | Related RQ | SECONDS | INCA | EMIC | Indicator | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | TTC | at intervention | |
| | | | | | | Distance to target object - (longitudinal) | at intervention | |
| | | | | | | THW | at intervention | |
| | | | | | | Distance to target object (lane, barrier) - (lateral) | at intervention | |
| | | | | | | TLC | at intervention | |
| | | | | | | Number of false interventions | | |
| | | | | | | Number of missed interventions | | |
| Hyp_T_gen_safe_06 | The function never intervenes without first giving a warning to the driver | RQ_T_Gen_Safe_04 | x | x | x | Function warning status | | |
| | | | | | | Function intervention status | | |
| | | | | | | Brake pressure / force | Extra applied | |
| | | | | | | Steering torque | Extra applied | |
| | | | | | | Driver reaction | | |
| | | | | | | Time between two points | warning and intervention | |
| Hyp_T_gen_safe_07 | The function works the same in similar situations | RQ_T_Gen_Safe_05 | x | x | x | Function warning status | | |
| | | | | | | Function intervention status | | |
| | | | | | | Impact speed | | |
| | | | | | | Impact orientation | | |
| Hyp_T_gen_safe_08 | The function prepares the vehicle for an evasive or braking manoeuvre before the accident (in | RQ_T_Gen_Safe_06 | x | x | x | TTC | at preparation | |

| No | Hypotheses | Related RQ | SECONDS | INCA | EMIC | Indicator | | |
|---|---|---|---|---|---|---|---|---|
| | the scenario). | | | | | Distance to target object - (longitudinal) | at preparation | |
| | | | | | | THW | at preparation | |
| | | | | | | Function intervention status | | |
| | | | | | | TLC | at preparation | |
| | | | | | | Distance to target object (lane, barrier) - (lateral) | at preparation | |
| Hyp_T_gen_safe_09 | The function intervenes before the accident (in the scenario). | RQ_T_Gen_Safe_07, RQ_T_EMI_CMS_Perf_01 | x | x | x | TTC | at start of the intervention | |
| | | | | | | Distance to target object - (longitudinal) | at start of the intervention | |
| | | | | | | THW | at start of the intervention | |
| Hyp_T_gen_TecU_01 | The driver has enough time to react and avoid the accident, when the warning is issued | RQ_T_Gen_TecU_01, RQ_T_INC_RECA_TecU_01 | x | x | x | TTC | at alarm | |
| | | | | | | Driver braking reaction | after alarm | |
| | | | | | | Driver steering reaction | after alarm | |
| Hyp_T_gen_TecU_02 | The driver has not enough time to react and avoid the accident, when the function starts to intervene in the driving behaviour | RQ_T_Gen_TecU_02 | x | x | x | TTC | at intervention | |
| | | | | | | Driver braking reaction | after alarm | |
| | | | | | | Driver steering reaction | after alarm | |
| Hyp_T_gen_TecU_03 | The accident cannot be avoided although a warning is given before the accident. | RQ_T_Gen_TecU_02 | x | x | x | Longitudinal acceleration | | max |
| | | | | | | Lateral acceleration | | max |
| | | | | | | Longitudinal acceleration required to avoid collision | | |
| | | | | | | Lateral acceleration required to avoid collision | at warning | |

| No | Hypotheses | Related RQ | SECONDS | INCA | EMIC | Indicator | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Duration of intervention | | |
| | | | | | | TTC | at alarm | |
| Hyp_T_gen_TecU_04 | The function can be overridden by the driver. | RQ_T_Gen_TecU_03 | x | x | x | Function on/off | | |
| | | | | | | Brake pedal angle | during intervention | |
| | | | | | | Steering wheel angle | during intervention | |
| | | | | | | Function "on" per brake pedal angle | | |
| | | | | | | Function "on" per steering wheel angle | | |
| Hyp_T_SEC_Gen_Perf_01 | In general it is possible to avoid a imminent accident when a warning is issued | RQ_T_Gen_TecU_02, RQ_T_SEC_CS_Perf_01 | x | | | Longitudinal acceleration required to avoid collision | at warning | |
| | | | | | | Lateral acceleration required to avoid collision | at warning | |
| | | | | | | TTC | at warning | |
| Hyp_T_SEC_Gen_Perf_02 | In general it is possible to avoid an imminent accident when the function starts to intervene in the driving behaviour. | RQ_T_Gen_TecU_02 | x | | | Longitudinal acceleration required to avoid collision | at intervention | |
| | | | | | | Lateral acceleration required to avoid collision | at intervention | |
| | | | | | | TTC | at warning | |
| Hyp_T_SEC_Gen_Parf_03 | Function reduces the fuel consumption | RQ_I_SEC_09 | x | | | Fuel consumption | | mean |
| Hyp_T_SEC_Gen_Perc_01 | The function warns the driver for standing still objects | RQ_T_SEC_CS_Perc_01 | x | | | Distance to target object | at first detection | max |
| | | | | | | Distance to target object | at first detection | mean |

| No | Hypotheses | Related RQ | SECONDS | INCA | EMIC | Indicator | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Distance to target object | at first detection | min |
| | | | | | | Time distance | at first detection | max |
| | | | | | | Time distance | at first detection | mean |
| | | | | | | Time distance | at first detection | min |
| | | | | | | Rate of correct detection | | |
| Hyp_T_SEC_CS__Safe_01 | The function determines right of way situation correctly. | RQ_T_SEC_CS_Safe_01 | x | | | Rate of correct detection | way of right situations | |
| Hyp_T_SEC_CS_Perc_03 | The functionality of the function is not influenced negatively, when the other vehicles are not equipped with car-2-car communication | RQ_T_SEC_CS_Perc_04, RQ_T_SEC_CS_Perf_02 | x | | | Rate of correct detection | | |
| Hyp_T_SEC_CS_Perc_04 | The function detects vulnerable road user independently of their size. | RQ_T_SEC_CS_Perc_05 | x | | | Rate of correct detection | vulnerable road users | |
| | | | | | | Distance to target object | at first detection | mean |
| Hyp_T_SEC_CS_Perc_05 | The function detects vulnerable road user moving in all directions | RQ_T_SEC_CS_Perc_05 | x | | | Rate of correct detection | vulnerable road users | |
| | | | | | | Distance to target object | at first detection | mean |
| Hyp_T_SEC_CS_Perf_01 | The function reacts earlier, when the road has a side barrier | RQ_T_Gen_Perf_02 | | | | TLC | at warning | |
| | | | | | | TLC | at warning | |

| No | Hypotheses | Related RQ | SECONDS | INCA | EMIC | Indicator | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Distance to target object (lane, barrier) - (lateral) | at warning | |
| | | | | | | Distance to target object (lane, barrier) - (lateral) | at intervention | |
| Hyp_T_SEC_CS_Perf_02 | The function will warn the driver, if the lane ends and the driver does not initiate a lane change | RQ_T_SEC_CS_Perf_03 | x | | | TLC | | min |
| | | | | | | Distance to target object (lane, barrier) - (lateral) | at warning | |
| | | | | | | Distance to target object (lane, barrier) - (lateral) | at intervention | |
| Hyp_T_SEC_CS_Perf_03 | The function is able to detect zone, which required a lower speed (e.g. speed bumps). | RQ_T_SEC_CS_Perf_04 | x | | | Rate of correct detection | Speed zones | |
| Hyp_T_SEC_CS_Perc_06 | The function detects the current given speed limit always correctly | RQ_T_SEC_CS_Perc_06 | x | | | Difference of detected and current speed limit | | max |
| | | | | | | Difference of detected and current speed limit | | mean |
| | | | | | | Rate of correct detection | | |
| Hyp_T_SEC_CS_Perc_07 | The function detects dynamic speed limits correctly | RQ_T_SEC_CS_Perc_06 | x | | | Rate of correct detection | Speed limits | |
| Hyp_T_SEC_CS_Perc_08 | The speed limit is detected correctly up to a covering of x (50 %) of the sign. | RQ_T_SEC_CS_Perc_07 | x | | | Rate of correct detection | | |
| | | | | | | Distance to target object | at first detection | max |
| | | | | | | Distance to target object | at first detection | mean |
| | | | | | | Distance to target object | at first detection | min |

| No | Hypotheses | Related RQ | SECONDS | INCA | EMIC | Indicator | | |
|---|---|---|---|---|---|---|---|---|
| Hyp_T_SEC_CS_Perc_09 | The speed limit is detected correctly up to a lateral distance of x (7.5 m) from the outline of the vehicle. | RQ_T_SEC_CS_Perc_07 | x | | | Rate of correct detection | | |
| | | | | | | (lateral and longitudinal) distance at first detection of object | at first detection | max |
| | | | | | | (lateral and longitudinal) distance at first detection of object | at first detection | mean |
| | | | | | | (lateral and longitudinal) distance at first detection of object | at first detection | min |
| | | | | | | Sign position | with respect to driven path | |
| Hyp_T_SEC_CS_Perc_10 | The speed limit can distinguish between speed limits and other traffic signs (e.g. height limit, speed limit change in x m). | RQ_T_SEC_CS_Perc_07 | x | | | Rate of correct detection | | |
| | | | | | | Distance to target object | at first detection | max |
| | | | | | | Distance to target object | at first detection | mean |
| | | | | | | Distance to target object | at first detection | min |
| Hyp_T_SEC_CS_Safe_02 | The proposed speed of the function will be equal or lower compared to the given speed limit. | RQ_T_SEC_CS_Safe_02 | x | | | Speed difference | | |
| | | | | | | Vehicle speed | at a point in time | |
| | | | | | | Vehicle speed | proposed at start of speed limit | |
| Hyp_T_SEC_CSC_Safe_ | The proposed velocity ensures a safe negotiating of the curve. | RQ_T_SEC_CSC_Safe_02 | x | | | proposed vehicle speed | at certain locations | |

| No | Hypotheses | Related RQ | SECONDS | INCA | EMIC | Indicator | | |
|---|---|---|---|---|---|---|---|---|
| 01 | | | | | | vehicle speed | at certain locations | mean max |
| | | | | | | lateral acceleration | | mean max |
| | | | | | | curve radius | | |
| Hyp_T_SEC_CSC_Safe_02 | The proposed velocity is adapted appropriate to the geometry of the upcoming curve. | RQ_T_SEC_CSC_Safe_02 | x | | | proposed vehicle speed | at certain locations | max |
| | | | | | | vehicle speed | at certain locations | |
| | | | | | | lateral acceleration | | mean max |
| | | | | | | curve radius | | |
| | | | | | | curve angle | | |
| Hyp_T_SEC_CSC_Perf_01 | The intervention of the function has no negative influence on the driving behaviour | RQ_T_SEC_CSC_Perc_02 | x | | | Distance to curve | at initiation the intervention | |
| | | | | | | Time gap to curve | at initiation the intervention | |
| | | | | | | Speed reduction | | max |
| | | | | | | Speed reduction | | min |
| | | | | | | Speed reduction | | mean |
| | | | | | | Yaw rate | | max |
| | | | | | | Yaw rate | | min |
| | | | | | | Yaw rate | in the curve | mean |
| | | | | | | Yaw rate | in the curve | standard dev |
| | | | | | | Yaw rate | before intervention | |
| | | | | | | Yaw rate | after intervention | |

| No | Hypotheses | Related RQ | SECONDS | INCA | EMIC | Indicator | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Steering wheel angle | | standard dev |
| | | | | | | Steering wheel angle | | mean |
| | | | | | | Steering velocity | | max |
| Hyp_T_SEC_eDPP_Perc_01 | The function is not impaired when the other vehicles are not equipped with car-2-car communication. | RQ_T_SEC_eDPP_Perc_01 | x | | | Rate of correct detection | | |
| Hyp_T_SEC_eDPP_Perc_02 | The function detects correctly the passing prohibitions (lane markings as well as traffic signs) | RQ_T_Gen_Perf_01, RQ_T_Gen_Perc_01 | x | | | Rate of correct detection | | |
| Hyp_T_SEC_SC_TecU_01 | When the driver is not focusing onto the road for a certain time, the function is switched off. | RQ_T_SEC_SC_TecU_01 | x | | | Rate function "on" per status | | |
| Hyp_T_SEC_SC_TecU_02 | When the driver takes his/her hands off the steering wheel, the function is inhibited. | RQ_T_SEC_SC_TecU_01 | x | | | Rate function "on" per status | | |
| Hyp_T_SEC_SC_TecU_03 | The driver will be warned in time before the function switches itself off. | RQ_T_SEC_SC_TecU_02 | x | | | Time between two points | warning and switch off | |
| Hyp_T_SEC_SC_Perf_01 | The function prevents imminent rear-end collision before they become critical. | RQ_T_SEC_SC_Perf_01 | x | | | TTC | | min |
| | | | | | | THW | | min |
| Hyp_T_SEC_SC_Perf_02 | During driving the TTC does not drop under x (1,5 s) when the function is active | RQ_T_SEC_SC_Perf_01 | x | | | TET | | |
| | | | | | | TTC | | min |
| Hyp_T_SEC_SC_Perf_03 | The function will ensure the correct speed autonomously (without intervention by the driver). | RQ_T_SEC_SC_Perf_02 | x | | | Duration of speed exceeding | | |

| No | Hypotheses | Related RQ | SECONDS | INCA | EMIC | Indicator | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Difference of detected and current speed limit | | max |
| | | | | | | Difference of detected and current speed limit | | mean |
| | | | | | | Vehicle speed | at speed limit | |
| | | | | | | Distance to target object (speed limit) | at initiating deceleration | |
| | | | | | | THW | to target object (speed limit) at initiating deceleration | |
| Hyp_T_SEC_SC_Perc_01 | The function also detects static objects_in the vehicle path | RQ_T_SEC_CS_Perc_01 | x | | | Distance to target object | at first detection | max |
| | | | | | | Distance to target object | at first detection | mean |
| | | | | | | Distance to target object | at first detection | min |
| | | | | | | Time distance to target object | | |
| | | | | | | Time distance to target object | | |

| No | Hypotheses | Related RQ | SECONDS | INCA | EMIC | Indicator | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Time distance to target object | | |
| | | | | | | rate of correct detections | | |
| Hyp_T_INC_Gen_Safe_01 | The function selects the appropriate method to avoid collisions or driving off-road accidents | RQ_T_INC_Gen_Perf_01, RQ_T_INC_RECA_Perc_01, RQ_T_INC_RECA_TecU_02, RQ_T_INC_RECA_Perf_04, RQ_T_INC_OVCA_Safe_01 | | x | | function activation in a test scenario | | |
| | | | | | | minimum distance to threat during maneuver | | min |
| | | | | | | maximum acceleration during maneuver | | max |
| | | | | | | maximum braking force/steering torque during maneuver | | max |
| Hyp_T_INC_Safe_02 | After intervention the situation was correctly perceived to be safe enough to return the control back to the driver | RQ_T_INC_RECA_TecU_02 | x | x | | distance to threat | at returning of control | |
| | | | | | | lateral position in lane | | |
| | | | | | | longitudinal speed | | |
| | | | | | | longitudinal acceleration | | |
| | | | | | | lateral acceleration | | |
| | | | | | | yaw rate | | |
| | | | | | | yaw angle | | |
| | | | | | | steering wheel angle | | |
| | | | | | | brake pedal angle | | |
| | | | | | | brake pressure/force | | |
| Hyp_T_INC_Safe_03 | The intervention avoids or mitigates the collision and does not aggravate it | RQ_T_INC_RECA_Perf_03 | | x | | TTC | | min |
| | | | | | | impact speed | at impact | |
| | | | | | | relative orientation | | |
| | | | | | | speed reduction | | |

| No | Hypotheses | Related RQ | SECONDS | INCA | EMIC | Indicator | | |
|---|---|---|---|---|---|---|---|---|
| Hyp_T_INC_Perf_01 | The function works within the specified speed and acceleration range | RQ_T_INC_RECA_Safe_02 | | x | | Vehicle speed | at activation | |
| | | | | | | Relative speed | | |
| | | | | | | lateral acceleration | | |
| | | | | | | longitudinal acceleration | | max |
| Hyp_T_INC_Perf_02 | The function is able to avoid collisions with moving obstacles | RQ_T_INC_RECA_Safe_05 | | x | | relative speed | at start and end of maneuver | |
| | | | | | | TTC | | min |
| | | | | | | target vehicle speed | at start of maneuver | |
| Hyp_T_INC_Perf_03 | The functionality of the function is not influenced by road curvature | RQ_T_INC_RECA_Safe_03 RQ_T_INC_RECA_Perf_02 | | x | | relative speed | at start of maneuver | |
| | | | | | | road curvature | | |
| | | | | | | CAR, MAR, FAR | | |
| | | | | | | TTC | | min |
| | | | | | | speed | at start | |
| | | | | | | acceleration | | |
| Hyp_T_INC_Perf_04 | The system is able to avoid rear and side collisions according to the specifications | RQ_T_INC_RECA_Perf_01, RQ_T_INC_LCCA_Perc_01 , RQ_T_INC_LCCA_Perc_02 , RQ_T_INC_LCCA_Perf_01, \ RQ_T_INC_LCCA_TecU_01 | | x | | distance | | min |
| | | | | | | TTC | | min |
| Hyp_T_EMI_gen_01 | The function always recognises the avoiding steering action of the driver (in the scenarios). | RQ_T_EMI_Gen_Perc_01, RQ_T_EMI_Gen_Perc_04, RQ_T_EMI_ESA_Perc_01 | | x | x | Steering wheel angle | at intervention | |

| No | Hypotheses | Related RQ | SECONDS | INCA | EMIC | Indicator | | |
|---|---|---|---|---|---|---|---|---|
| Hyp_T_EMI_gen_02 | A too weak or too strong reaction of the driver is recognized. | RQ_T_EMI_Gen_Perc_02, RQ_T_EMI_CMS_Perc_01 | | x | x | error between driver input and required input as calculated by the logic | | max |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| Hyp_T_EMI_gen_03 | After intervention the situation was correctly perceived to be safe enough to stop the driver support. | RQ_T_EMI_Gen_Perf_03, RQ_T_EMI_Gen_TecU_01, RQ_T_EMI_Gen_TecU_02, RQ_T_EMI_ESA_Perc_02 | | x | x | Driver status | at returning of control | |
| | | | | | | Longitudinal acceleration | | |
| | | | | | | Lateral acceleration | | |
| | | | | | | Yaw rate | | |
| | | | | | | Yaw angle | | |
| | | | | | | Steering wheel angle | | |
| | | | | | | Brake pedal angle | | |
| | | | | | | Brake pressure / force | | |
| Hyp_T_EMI_gen_04 | The (steering) intervention mitigates the collision and does not aggravate it. | RQ_T_EMI_Gen_Perf_01, RQ_T_EMI_Gen_TecU_01 | | x | x | TTC | at intervention | |
| | | | | | | Impact speed | | |
| | | | | | | Impact orientation | | |
| | | | | | | Speed reduction | | mean |
| **User-related** | | | | | | | | |
| **general** | | | | | | | | |
| Hyp_U_gen_beh_01 | Driving speed does not differ when driving with the system compared to driving without the system. | RQ_U_Gen_Beh_02 | x | x | x | Speed profile | | |
| | | | | | | Spot speed | at selected sections | |
| | | | | | | Speed variance | during test drive | |

| No | Hypotheses | Related RQ | SECONDS | INCA | EMIC | Indicator | | |
|---|---|---|---|---|---|---|---|---|
| Hyp_U_gen_beh_02 | The number and/or the severity of traffic conflicts does not differ when driving with the system compared to driving without the system. | RQ_U_Gen_Beh_03 | x | x | x | Number of traffic conflicts | | |
| | | | | | | Severity of traffic conflicts | time to accident | TTC + speed |
| Hyp_U_gen_beh_03 | There is no difference in alarm length when driving with the system compared to driving without the system. | RQ_U_Gen_Beh_04 | x | x | x | Alarm length (s) | | |
| Hyp_U_gen_beh_04 | There is no difference in temporal point of reaction (TPR) when driving with the system compared to driving without the system. | RQ_U_Gen_Beh_05 | x | x | x | TPR (s) | situation detected to accelerator release | |
| | | | | | | TPR (s) | situation detected to brake press | |
| | | | | | | TPR (s) | situation detected to steering wheel response | |
| Hyp_U_gen_beh_05 | There is no difference in time distance to the vehicle ahead when driving with the system compared to driving without the system. | RQ_U_Gen_Beh_06 | x | x | x | Time distance (s) | to the vehicle ahead | |
| Hyp_U_gen_beh_06 | There is no difference in lane keeping when driving with the system compared to driving without the system. | RQ_U_Gen_Beh_07 | x | x | x | Side position in the lane | | Standard deviation |
| | | | | | | | | Mean |
| Hyp_U_gen_beh_07 | There is no difference in lane changing behaviour when driving with the system compared to driving without the system. | RQ_U_Gen_Beh_08 | x | x | x | Rate correct lane changes/total lane changes | | |
| Hyp_U_gen_beh_08 | There is no difference in correct interaction behaviour when driving with the system compared to driving without the system. | RQ_U_Gen_Beh_09 | x | x | x | Number of correct interactions | | |
| Hyp_U_gen_use_01 | The driver uses the system as it is intended to be used | RQ_U_Gen_Use_01 | x | x | x | Number of times the driver uses/reacts to the system | | |

| No | Hypotheses | Related RQ | SECONDS | INCA | EMIC | Indicator | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | as intended. | | |
| Hyp_U_gen_T&A_01 | The driver does not delegate responsibility for tasks other than the system is meant for. | RQ_U_Gen_T&A_03 | x | x | x | Number of looks in rear /side mirrors<br>Use of turning indicator<br>Gear changing behaviour | | |
| Hyp_U_gen_use_02 | The driver’s emotional state is not influenced when driving with the system compared to driving without the system. | RQ_U_Gen_Use_02 | x | x | x | Self assessed emotional response (valence/activation)<br>Physiological response (valence/activation) | | |
| Hyp_U_gen_use_03 | The driver's mental workload is not influenced when driving with the system compared to driving without the system. | RQ_U_Gen_Use_03 | x | x | x | Raw Task Load Index (RTLX) | | |
| Hyp_U_gen_use_04 | The driver perceives and understands the transition of control between the driver and the vehicle in the correct way | RQ_U_Gen_Use_04 | x | x | x | Interviews<br>Questionnaire items<br>On-line ratings | | |
| Hyp_U_gen_T&A_01 | The driver would trust the system/function | RQ_U_Gen_T&A_01 | x | x | x | Interview<br>Questionnaire items | | |
| Hyp_U_gen_T&A_02 | The driver finds the system/function useful and satisfying | RQ_U_Gen_T&A_04 | x | x | x | van der Laan acceptance questionnaire | | |
| Hyp_U_gen_T&A_03 | The driver perceives the system/function as being safe | RQ_U_Gen_T&A_02 | x | x | x | Questionnaire items | | |
| Hyp_U_gen_T&A_04 | What are advantages and disadvantages with the system/function | RQ_U_Gen_T&A_05 | x | x | x | Interview questions | regarding advantages/disadvantages | |
| Hyp_U_gen_T&A_05 | The driver would like to have this system installed in his/her car/truck if it was available in the aftermarket. The driver would order this system when buying a new car/truck. | RQ_U_Gen_T&A_06 | x | x | x | Questionnaire items | on willingness to buy | |
| Hyp_U_gen_T&A_06 | The price the driver is willing to pay for the function is the same as the price of a currently | RQ_U_Gen_T&A_07 | x | x | x | Questionnaire items | with willing-to-pay price | |

| No | Hypotheses | Related RQ | SECONDS | INCA | EMIC | Indicator | | |
|---|---|---|---|---|---|---|---|---|
| | available ADAS designed for a similar target scenario. | | | | | | ranges | |
| **SECONDS** | | | | | | | | |
| Hyp_U_SEC_CS_Beh_01 | Driver attention to blind spot does not differ when driving with the system compared to driving without the system. | RQ_U_Gen_Beh_01 | x | | | Number of gazes | at rear mirrors | |
| Hyp_U_SEC_CS_Beh_02 | Yield/stop behaviour at intersections does not differ when driving with the system compared to driving without the system. | RQ_U_Gen_Beh_01 | x | | | Correct/incorrect yield/stop behaviour behaviour | at intersections | |
| Hyp_U_SEC_CS_Beh_03 | Speed adaptation at critical sites does not differ when driving with the system compared to driving without the system. | RQ_U_Gen_Beh_01 | x | | | Speed profile | at selected sections | |
| | | | | | | Spot speed | at selected sections | |
| Hyp_U_SEC_CS_Beh_04 | Speed limit exceeding does not differ when driving with the system compared to driving without the system. | RQ_U_Gen_Beh_01 | x | | | Percentage of driving time above speed limit | | |
| Hyp_U_SEC_CSC_Beh_01 | Speed adaptation in curves does not differ when driving with the system compared to driving without the system. | RQ_U_Gen_Beh_01 | x | | | Speed profile | at curve | |
| | | | | | | Spot speed | at curve | |
| Hyp_U_SEC_eDPP_Beh_01 | Overtaking behaviour does not differ when driving with the system compared to driving without the system. | RQ_U_Gen_Beh_01 | x | | | Number of initiated /aborted overtaking | | |
| Hyp_U_SEC_SC_Beh_01 | The driver is engaged in more/less secondary task when driving with the system compared to driving without the system | RQ_U_Gen_Beh_01 | x | | | Number of initiated secondary tasks during driving | | |
| Hyp_U_SEC_SC_Beh_02 | Speed limit exceeding does not differ when driving with the system compared to driving without the system. | RQ_U_Gen_Beh_01 | x | | | Percentage of driving time above speed limit | | |
| **INCA** | | | | | | | | |
| Hyp_U_INC_Gen_Beh_01 | The driver does not (try to) override the active intervention. (by accelerating, countersteering) | RQ_U_Gen_Beh_01 | | x | | Driver counteractions (accelerate, brake, steer) | | |
| | | | | | | Interview (corroborative) | | |

| No | Hypotheses | Related RQ | SECONDS | INCA | EMIC | Indicator | | |
|---|---|---|---|---|---|---|---|---|
| Hyp_U_INC_Gen_Beh_02 | Situational control during intervention is not modulated by a (pre-)warning. | RQ_U_Gen_Beh_01 | | x | | Driver counteractions (accelerating, steering, braking) | | |
| | | | | | | Alarm length | | |
| | | | | | | Number/severity of traffic conflicts | | |
| | | | | | | Interview (corroborative) | | |
| Hyp_U_INC_Gen_Beh_03 | Driver attention to blind spot does not differ when driving with the function compared to driving without the function | RQ_U_INC_Beh_01 | | x | | Number of gazes at rear view mirrors | | |
| | | | | | | Number of blind spot checks over shoulder (car) | | |
| **EMIC** | | | | | | | | |
| Hyp_U_EMI_CMS_Beh_01 | Driver behaviour in intersections doesn't change with the system compared to driving without the system | RQ_U_Gen_Beh_06, RQ_U_Gen_Beh_07, RQ_U_Gen_Beh_08, RQ_U_Gen_Beh_09 | | | x | Correct/incorrect behaviour in intersections | | |
| Hyp_U_EMI_CMS_Beh_02 | There is no difference in lane keeping when driving with the system compared to driving without the system. | RQ_U_Gen_Beh_07 | | | x | Side position in the lane | | Standard deviation |
| Hyp_U_EMI_ESA_Beh_01 | The driver behaviour in front of an obstacle (pedestrian, unparked vehicle, end of traffic jam) in the road doesn't change with the system compared to driving without the system | RQ_U_Gen_Beh_09 | | | x | Behaviour in front an obstacle in terms of speed, steering wheel angle | | |
| Hyp_U_EMI_Gen_BT&A_01 | The driver perceives correctly the level of control that the function provides | RQ_U_Gen_T&A_03 | | | x | Level of control | | |
| **Safety - impact** | | | | | | | | |
| **General** | | | | | | | | |
| Hyp_I_Gen_01 | The function improves the traffic safety | RQ_I_SEC_01, RQ_I_INC_01, RQ_I_EMI_01 | x | x | x | Number of accidents | | |
| | | | | | | Reduction of the accident severity | | |

| No | Hypotheses | Related RQ | SECONDS | INCA | EMIC | Indicator | | |
|---|---|---|---|---|---|---|---|---|
| Hyp_I_Gen_02 | The function decreases the number of accidents. | RQ_I_SEC_01…08, RQ_I_INC_02, RQ_I_EMI_01, RQ_I_EMI_03 | x | x | x | Accidents rate | | |
| | | | | | | Longitudinal relative velocity | at which an accident is avoided | max |
| | | | | | | Lateral relative velocity | at which an accident is avoided | max |
| | | | | | | Lateral acceleration required to avoid collision | when warning is given or the function starts to intervene | |
| | | | | | | Longitudinal acceleration required to avoid collision | when warning is given or the function starts to intervene | |
| Hyp_I_Gen_03 | The function decreases the severity of accidents. | RQ_I_SEC_01…08, RQ_I_INC_03, RQ_I_EMI_02, RQ_I_EMI_04 | x | x | x | Impact speed | | mean |
| | | | | | | Speed reduction | | max |
| | | | | | | Speed reduction | | mean |
| | | | | | | Speed | at warning | |
| | | | | | | Speed | at starting of intervention | |
| | | | | | | Reduction of kinematic energy by intervention | | |
| | | | | | | Speed reduction | | min |
| | | | | | | Location point of impact | | |
| | | | | | | Impact orientation | | |
| | | | | | | Mass of vehicle | | |
| Hyp_I_Gen_04 | The safety impact of the function is not negatively influenced by another function. | RQ_I_INC_05, RQ_I_INC_06 | x | x | x | Function warning status | | |
| | | | | | | Function intervention status | | |
| | | | | | | Function specification | | |
| Hyp_I_Gen_ | The intervention time of the function is not | RQ_I_INC_04 | x | x | x | Duration of intervention | | max |

| No | Hypotheses | Related RQ | SECONDS | INCA | EMIC | Indicator | | |
|---|---|---|---|---|---|---|---|---|
| 05 | limited. | | | | | Function specification | | |
| Hyp_I_Gen_06 | The function will avoid also accidents scenarios if more than one vehicle is involved. | RQ_I_INC_04 | x | x | x | Accident status in test scenarios | | |
| | | | | | | Function intervention status | | |
| Hyp_I_Gen_07 | Evasive manoeuvre will not be executed in congested traffic situations. | RQ_I_INC_04 | x | x | x | Function intervention status; | | |
| | | | | | | Intervention rate | | |
| Hyp_I_Gen_08 | The function operates on all road types. | RQ_T_Gen_Perf_02 | x | x | x | Function status | | mean |
| Hyp_I_Gen_09 | The function works under all weather conditions. | RQ_T_Gen_Perf_02 | x | x | x | Function status | | mean |
| Hyp_I_Gen_10 | The function works under all light conditions. | RQ_T_Gen_Perf_02 | x | x | x | Function status | | mean |
| Hyp_I_Gen_11 | The function works in all traffic conditions. | RQ_T_Gen_Perf_02 | x | x | x | Function status | | mean |
| Hyp_I_Gen_12 | The function works over the whole speed ranges of the vehicle. | RQ_T_Gen_Perf_02 | x | x | x | Function status | | mean |
| Hyp_I_Gen_13 | The number of warnings will not increase as a consequence of the driver relying too much on the function. | RQ_I_SEC_02 | x | x | x | Alarm rate | | |
| Hyp_I_Gen_14 | The number of interventions will not increase as a consequence of the driver relying too much on the function. | RQ_I_SEC_02 | x | x | x | Intervention rate | | |
| Hyp_I_Gen_15 | The intervention rate will not increase over time. | | x | x | x | Intervention rate | | |
| Hyp_I_Gen_16 | The intervention of the function will not result in a worse situation. | | x | x | x | Impact orientation; | | |
| | | | | | | Location point of impact | | |
| | | | | | | Impact speed | | |
| **SECONDS** | | | | | | | | |
| Hyp_I_SEC_01 | Safe Cruise increases the average THW. | | x | | | THW | | mean |
| Hyp_I_SEC_02 | Cruise decreases average speed. | | x | | | Speed | | mean |

| No | Hypotheses | Related RQ | SECONDS | INCA | EMIC | Indicator | | |
|---|---|---|---|---|---|---|---|---|
| Hyp_I_SEC_03 | The usage of the function reduces the fuel consumption. | RQ_I_SEC_10 | x | | | Fuel consumption | | |
| | | | | | | Speed | | mean |
| | | | | | | Speed | | standard deviation |
| | | | | | | Longitudinal acceleration | | mean |
| | | | | | | Longitudinal acceleration | | standard deviation |
| **INCA** | | | | | | | | |
| Hyp_I_INC_01 | The safety impact of the function will be equal for passenger cars and trucks. | RQ_I_INC_07 | | x | | Number of accidents | | |
| | | | | | | Reduction of the accident severity | | |
| Hyp_I_INC_02 | The function will try to avoid imminent accidents more often by braking than steering. | RQ_I_INC_04 | | x | | Longitudinal acceleration | | max |
| | | | | | | Lateral acceleration | | max |
| | | | | | | Function intervention status | | |
| Hyp_I_INC_03 | The function will try to mitigate accident more often by braking than steering. | RQ_I_INC_04 | | x | | Longitudinal acceleration | | max |
| | | | | | | Lateral acceleration | | max |
| | | | | | | Function intervention status | | |
| **EMIC** | | | | | | | | |
| Hyp_I_EMI_01 | The function will try to mitigate accident more often by braking than steering. | RQ_I_INC_04 | | | x | Longitudinal acceleration | | max |
| | | | | | | Lateral acceleration | | max |
| | | | | | | Function intervention status | | |

# Technical Indicators

| Indicator | Variant 1 (Time or position) | Variant 2 |
|---|---|---|
| Brake pedal angle | general | |
| Brake pedal angle | | max |
| Brake pedal angle | at returning of control | |
| Brake pedal angle | during intervention | |
| Brake pressure / force | at returning of control | |
| Brake pressure / force | Extra applied | |
| Correct alarm rate (CAR) | | |
| Difference of detected and current speed limit | | mean |
| Difference of detected and current speed limit | | max |
| Distance to curve | at initiation the intervention | |
| Distance to target object | at first detection | min |
| Distance to target object | at first detection | mean |
| Distance to target object | at first detection | max |
| Distance to target object (lane, barrier) - (lateral) | at intervention | |
| Distance to target object (lane, barrier) - (lateral) | at warning | |
| Distance to target object (lane, barrier) - (lateral) | at preparation | |
| Distance to target object (lane, barrier) - (lateral) | | min |
| Distance to target object (lane, barrier) - (lateral) | | max |
| Distance to target object (speed limit) | at initiating deceleration | |
| Distance to target object - (longitudinal) | at alarm | |
| Distance to target object - (longitudinal) | at intervention | |
| Distance to target object - (longitudinal) | at preparation | |
| Distance to target object - (longitudinal) | | min |
| Distance to target object - (longitudinal) | at start of the intervention | |
| Driver reaction | | |
| Driver steering reaction | | |
| Driver braking reaction | | |
| Driver status | at returning of control | |
| Duration of intervention | | |
| Duration of speed exceeding | | |
| error between driver input and required input as calculated by the logic | | max |
| ESC status | | max |
| False alarm rate (FAR) | | |
| False negative rate | | |
| False positive rate | | |
| fuel consumption | | mean |
| Function activation | | |
| Function "on" per brake pedal angle | | |
| Function "on" per steering wheel angle | | |
| Function intervention status | | |
| Function on/off | | |
| Function warning status | | |
| Impact orientation | | |
| Impact speed | | |
| Lateral acceleration | | mean |
| Lateral acceleration | | max |
| Lateral acceleration | | max |
| Lateral acceleration | at returning of control | |
| Lateral acceleration required to avoid collision | at intervention | |
| Lateral acceleration required to avoid collision | at warning | |

| Indicator | Variant 1 (Time or position) | Variant 2 |
|---|---|---|
| Lateral position in lane | at returning of control | |
| Longitudinal acceleration | | max |
| Longitudinal acceleration | at returning of control | |
| Longitudinal acceleration required to avoid collision | at intervention | |
| Longitudinal acceleration required to avoid collision | at warning | |
| Missed alarm rate (MAR) | | |
| Number of false alarms | | |
| Number of false interventions | | |
| Number of false negative detections | | |
| Number of false positive detections | | |
| Number of missed alarms | | |
| Number of missed interventions | | |
| Rate of correct detection | way of right situations | |
| Rate of correct detection | | |
| Rate function "on" per status | | |
| Sign position | with respect to driven path | |
| Speed difference | | |
| Speed reduction | | min |
| Speed reduction | | max |
| Speed reduction | | mean |
| Steering velocity | | max |
| Steering wheel angle | | standard |
| Steering wheel angle | | dev |
| Steering wheel angle | | mean |
| Steering wheel angle | at returning of control | |
| Steering wheel angle | at intervention | |
| Steering wheel angle | during intervention | |
| Steering torque | Extra applied | |
| TET | | |
| Time between two points | warning and intervention | |
| Time between two points | warning and switch off | |
| Time spent outside lane | dependent on scenario | |
| Time gap to curve | at initiation the intervention | |
| Time target visible and in sensor coverage area until first detection | | |
| TLC | | min |
| TLC | at intervention | |
| TLC | at warning | |
| TLC | at preparation | |
| TTC | | min |
| TTC | at alarm | |
| TTC | at first detection | |
| TTC | at intervention | |
| TTC | at preparation | |
| TTC | at start of the intervention | |
| TTC | at point in time (alarm, intervention, first detection) | |
| THW | at first detection | |
| THW | to target object (speed limit) at initiating deceleration | |
| THW | at alarm | |
| THW | at intervention | |
| THW | at preparation | |

| Indicator | Variant 1 (Time or position) | Variant 2 |
| --- | --- | --- |
| THW | at start of the intervention | |
| Vehicle speed | at apex curve | |
| Vehicle speed | at activation | |
| Vehicle speed | at entrance curve | |
| Vehicle speed | at exit curve | |
| Vehicle speed | at point of time | |
| Vehicle speed | at returning of control | |
| Vehicle speed | at the end of the intervention | |
| Vehicle speed | proposed at start of speed limit | |
| Vehicle speed | at speed limit | |
| Vehicle position | at the end of the intervention | |
| Yaw angle | at returning of control | |
| Yaw rate | at returning of control | |
| Yaw rate | | max |
| Yaw rate | | min |
| Yaw rate | in the curve | mean |
| Yaw rate | in the curve | standard |
| Yaw rate | in the curve | dev |
| Yaw rate | before intervention | |
| Yaw rate | after intervention | |

## User related indicators

| Indicator | Variant 1 (Time or position) | Variant 2 |
|---|---|---|
| Advantages/disadvantages of the system | Answered by the drivers | |
| Alarm length | | |
| Answer to a question | | |
| Answer to a question | with price intervals | |
| Answer to the question | (different intervals to choose) | |
| Answer to the questions | about emotional state | |
| Answer to the questions | about transition of control | |
| Answers to an open question | | |
| Behaviour in front an obstacle in terms of speed, steering wheel angle | | |
| Change gear | | |
| Correct/incorrect behaviour in interactions | | |
| Correct/incorrect yield/stop behaviour | at intersections | |
| Distance to the leading vehicle | | |
| Driver reaction time | | |
| Gear changing behaviour | | |
| Interview | | |
| Interview questions | regarding advantages/disadvantages | |
| Level of | control | |
| Level of | driver mental workload | |
| Level of | preference for having the system in the car | |
| Level of | safeness | |
| Level of | satisfaction | |
| Level of | trust in the system | |
| Level of | usefulness | |
| | | |
| NASA RTLX index scores | | |
| Number of conflicts | | |
| Number of correct interactions | | |
| Number of correct lane changes | | |
| Number of gazes at rear mirrors | | |
| Number of initiated /aborted overtaking | | |
| number of initiated secondary tasks during driving | | |
| | | |
| Number of misuses | | |
| Number of times the driver uses/reacts to the system as intended. | | |
| Number of times the system is used as it was intended to be used | | |
| Number of traffic conflicts | | |
| On-line ratings | | |
| Percentage of driving time above speed limit | | |
| Physiological response (valence/activation) | | |
| Score obtained from questionnaire items | | |
| Score obtained from questionnaire items | on willingness to buy | |
| Score obtained from questionnaire items | with willing-to-pay price ranges | |
| Raw Task Load Index (RTLX) scores | | |

<table>
<tr><th>Indicator</th><th>Variant 1 (Time or position)</th><th>Variant 2</th></tr>
<tr><td>Reaction Time (s)</td><td>warning to accelerator release</td><td></td></tr>
<tr><td>Reaction Time (s)</td><td>warning to brake press</td><td></td></tr>
<tr><td>Reaction Time (s)</td><td>warning to steering wheel response</td><td></td></tr>
<tr><td>Self assessed emotional response (valence/activation)</td><td></td><td></td></tr>
<tr><td>Side position in the lane</td><td></td><td>Standard deviation</td></tr>
<tr><td>Side position in the lane</td><td></td><td>mean</td></tr>
<tr><td>Speed profile</td><td></td><td></td></tr>
<tr><td>Speed profile</td><td>at curves</td><td></td></tr>
<tr><td>Speed variance</td><td rowspan="2">at selected sections</td><td></td></tr>
<tr><td>Spot speed</td><td></td></tr>
<tr><td>Score from Likert Scale (0-100) about test driver's indication of his/her perception of the system's safety</td><td></td><td></td></tr>
<tr><td>Score from Likert Scale (0-100) about test driver's indication of his/her trust</td><td></td><td></td></tr>
<tr><td>Time distance to the vehicle ahead</td><td></td><td></td></tr>
<tr><td>Use of turning indicator</td><td></td><td></td></tr>
<tr><td>Usefulness / satisfactoriness scores</td><td>Van der Laan acceptance questionnaire</td><td></td></tr>
</table>

## Safety impact indicators

| Indicator | Variant 1 (Time or position) | Variant 2 |
|---|---|---|
| Accident status in test scenarios | | |
| Accidents rate | | |
| Alarm rate | | |
| Fuel consumption | | |
| Function intervention status | | |
| Function specification | | |
| Function status | | mean |
| Function warning status | | |
| Impact orientation | | |
| Impact speed | | mean |
| Impact speed | | |
| intervention rate | | |
| Lateral acceleration | | max |
| Lateral acceleration required to avoid collision | when warning is given or the function starts to intervene | |
| Lateral relative velocity | at which an accident is avoided | max |
| Location point of impact | | |
| Longitudinal acceleration | | mean |
| Longitudinal acceleration | | standard deviation |
| Longitudinal acceleration | | max |
| Longitudinal acceleration required to avoid collision | when warning is given or the function starts to intervene | |
| Longitudinal relative velocity | at which an accident is avoided | max |
| Mass of vehicle | | |
| Duration of intervention | | max |
| Number of conflicts | | |
| Reduction of kinematic energy by intervention | | |
| Reduction of the accident severity | | |
| Speed | at warning | |
| Speed | at starting of intervention | |
| Speed | | mean |
| Speed | | standard deviation |
| Speed reduction | | max |
| Speed reduction | | mean |
| Speed reduction | | min |
| Time-Headway | | average |
| Time to Collision | | min, mean min |

# Annex 2: Test scenarios for interactIVe evaluation

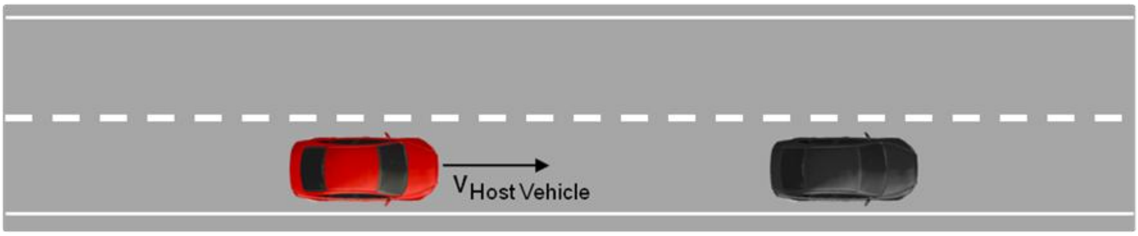
This annex contains all test scenarios defined to test the interactIVe systems.

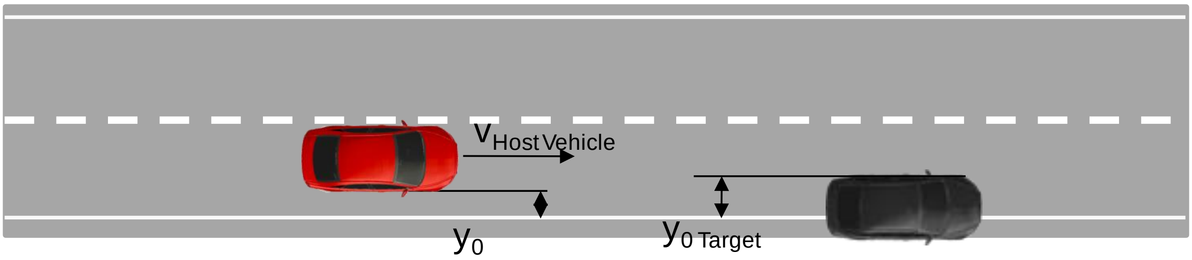
The content is as follows:

1. Rear-end collisions:
    - 1.1. Approaching stationary target
    - 1.2. Approaching parked target
    - 1.3. Approaching end of traffic jam
    - 1.4. Approaching slower vehicle
    - 1.5. Approaching slower vehicle, left lane blocked by other vehicle
    - 1.6. Approaching slower vehicle (traffic)
    - 1.7. Braking front vehicle
2. Head on collisions:
    - 2.1. Oncoming vehicle while overtaking
    - 2.2. Oncoming vehicle in own lane
    - 2.3. oncoming vehicle (traffic) while overtaking
    - 2.4. Intended lane change with oncoming traffic
    - 2.5. Conflict with oncoming vehicle while turning left
    - 2.6. Road works
    - 2.7. Upcoming curve
    - 2.8. Upcoming intersection
    - 2.9. Upcoming hill
    - 2.10. Overtaking prohibition
    - 2.11. Difficult traffic routing
3. Lane change collisions
    - 3.1. Vehicle in blind spot 1
    - 3.2. Vehicle in blind spot 2
    - 3.3. Past approaching vehicle
    - 3.4. Vehicle in blind spot 1 with lead vehicle
4. Cross traffic collisions
    - 4.1. Crossing traffic standing still 1
    - 4.2. Crossing traffic standing still 2
    - 4.3. Crossing traffic (moving) 1
    - 4.4. Crossing traffic (moving) 2
    - 4.5. Crossing traffic (moving) 3
    - 4.6. Parking 1
    - 4.7. Parking 1b (Reverse)
    - 4.8. Parking 3: unparking vehicle and steer assist

    4.9. Parking 4
5. Collisions with vulnerable road users
    5.1. Standing still pedestrian
    5.2. Moving pedestrian (crossing)
    5.3. Stopped pedestrian
    5.4. Stopped pedestrian – steering assist
    5.5. Moving pedestrian (oncoming)
    5.6. Standing still animal
    5.7. Stopped animal
6. Unintended lane departure accidents
    6.1. Unintended lane departure (right)
    6.2. Unintended lane departure towards an obstacle (right)
    6.3. Unintended lane departure (left)
    6.4. Unintended lane departure with oncoming traffic (left)
    6.5. Unintended lane departure with opponent vehicle
    6.6. Barrier
    6.7. End of Lane
    6.8. Lane departure in curve
7. Excessive speed accidents
    7.1. Speed curve
    7.2. Unsteady circling
    7.3. Approaching speed bump
8. Traffic rule violations
    8.1. Approaching speed limit
    8.2. Approaching series of speed limits
    8.3. Approaching dynamic speed limit
    8.4. Approaching partially covered speed limit
    8.5. Approaching similar speed limit signs
    8.6. Approaching speed limit (country)
    8.7. End of speed limitation
9. Verification tests:
    9.1. Speed range
    9.2. Braking capacity
    9.3. Weather conditions
10. Simulation tests
    10.1. Car following
    10.2. Lane keeping

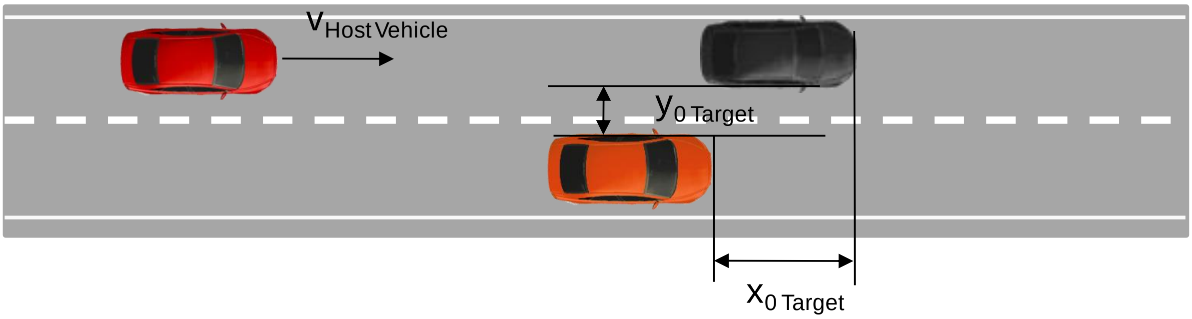
# Technical assessment

| Test Scenario | Rear-end collision |
|---|---|
| Test Case | 1.1 |
| **Approaching stationary target** | |
|  | |
| Description | Host vehicle approaches a stand still target object. The host vehicle as well as the target drives in the centre of the lane. |
| Relevant functions | CS, SC, RECA, CM, ESA |
| Use case | UC_01_531_v1, UC_01_601_v2, UC_01_602_v2, UC_01_603_v3 |
| Vehicle parameters | $v_{host\ vehicle}$ |
| Number vehicles | 2 |
| Target objects required (only for real test) | 1 stationary target (balloon car) |
| Environmental parameters | Road radius, number of lanes (2,3), driven lane (left, right, middle) |
| Road radius | ∞, 500 m |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | at least 2 lanes need, it would be better to have 3 lanes |

| Test Scenario | Rear-end collision |
|---|---|
| Test Case | 1.2 |
| **Approaching parking target** | |
|  | |
| Description | Host vehicle approaches a stand still target object. The position of the target vehicle depends on the test. But there is an offset between the host vehicle and target. |
| Relevant functions | CS, SC, RECA, CM, ESA |
| Use case | UC_01_531_v1, UC_01_601_v2, UC_01_602_v2, UC_01_603_v3 |
| Vehicle parameters | $v_{0}$; $v_{host\ vehicle}$, $v_{0\ target}$ |
| Number vehicles | 2 |
| Target objects required (only for real test) | 1 stationary target (balloon car) |
| Environmental parameters | Road radius |
| Road radius | ∞, 500 m |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment: | It should also be tested that the host vehicle passes the target vehicle without collision. |

| Test Scenario | Rear-end collision |
|---|---|
| Test Case | 1.3 |

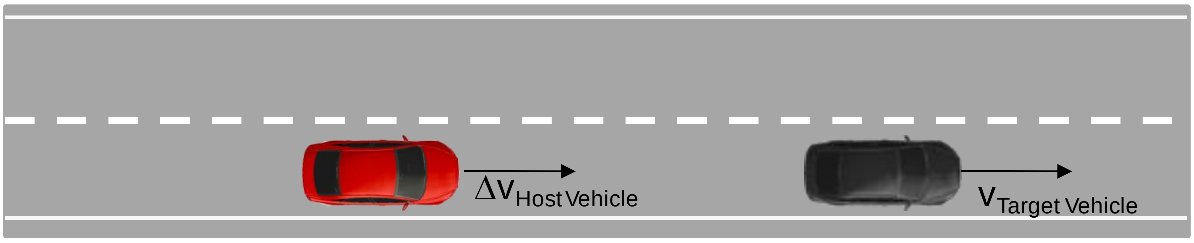
## Approaching end of traffic jam



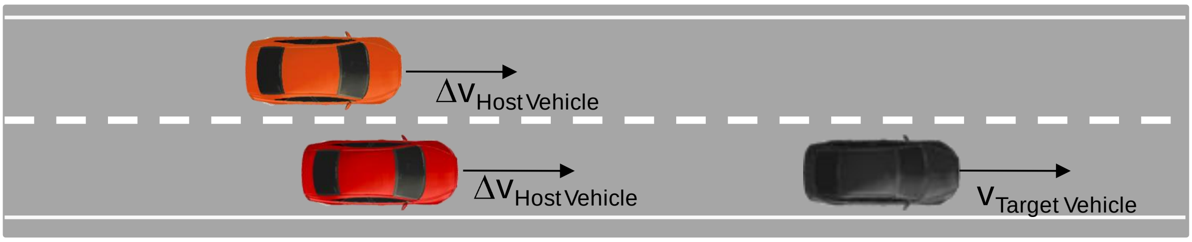

| | |
|---|---|
| Description | Host vehicle approaches the end of a traffic jam. Both lanes are blocked by other vehicles. The position of the targets depends on the test |
| Relevant functions | CS, SC, RECA, CM, ESA |
| Use case | UC_01_531_v1, UC_01_601_v2, UC_01_602_v2, UC_01_603_v3 |
| Vehicle parameters | $v_{host\ vehicle}$, $x_{0\ target}$, $v_{0\ target}$ |
| Number vehicles | 3 |
| Target objects required (only for real test) | 2 stationary targets (balloon car) |
| Environmental parameters | Road radius |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment: | In at least one test the $\Delta y_{Gap}$ should be too small for an evasive manoeuvre and in at least one test the gap should be sufficient for an evasive manoeuvre. |

| Test Scenario | Rear-end collision |
|---|---|
| Test Case | 1.4 |

## Approaching slower vehicle

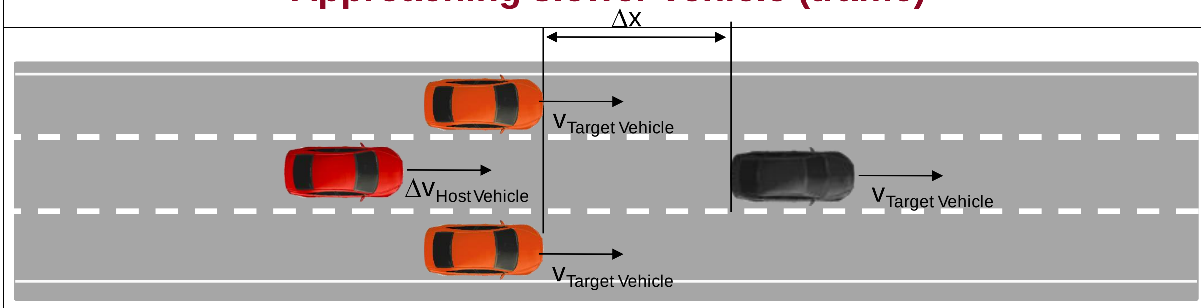



| | |
|---|---|
| Description | The host vehicle approaches a front vehicle with a higher speed. Both vehicles drive in the centre of the lane. The target keeps a constant speed during the whole manoeuvre |
| Relevant functions | CS, SC, RECA, CM, ESA |
| Use case | UC_01_401_v2, UC_01_531_v1 |
| Vehicle parameters | $v_{\text{target vehicle}}$, $\Delta v_{\text{host vehicle}}$ |
| Number vehicles | 2 |
| Target objects required (only for real test) | 1 moving target (moving balloon car / rabbit vehicle) |
| Environmental parameters | Number of lanes (1, 2, 3), driven lane (left, right, middle), road radius |
| Road radius | ∞, 500 m |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Rear-end collision |
|---|---|
| Test Case | 1.5 |
| **Approaching slower vehicle, left lane blocked by other vehicle** | |
|  | |
| Description | The host vehicle approaches a front vehicle with a higher speed. Both vehicles drive in the centre of the lane. The target keeps a constant speed during the whole manoeuvre. An evasive manoeuvre is not possible, because the left lane is blocked by another vehicle |
| Relevant functions | CS, SC, RECA, CM, ESA |
| Use case | UC_01_401_v2, UC_01_531_v1 |
| Vehicle parameters | $v_{target\ vehicle}$, $\Delta v_{host\ vehicle}$ |
| Number vehicles | 3 |
| Target objects required (only for real test) | 2 moving target (moving balloon car / rabbit vehicle) |
| Environmental parameters | Road radius |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Rear-end collision |
|---|---|
| Test Case | 1.6 |

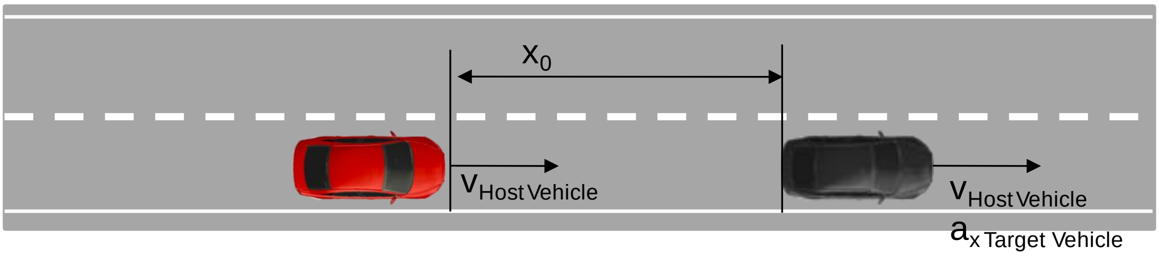
## Approaching slower vehicle (traffic)



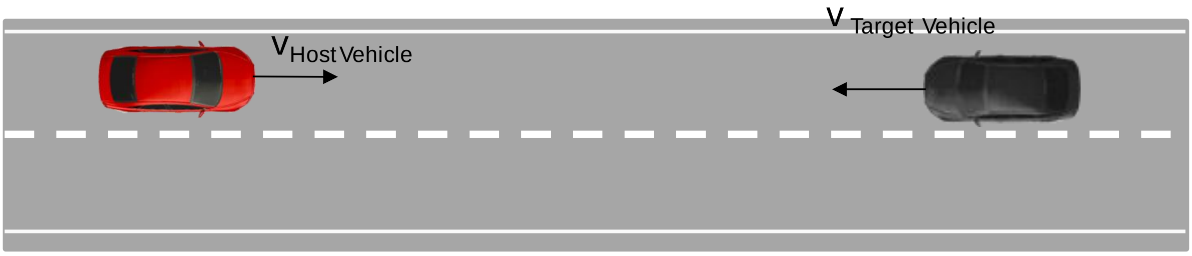

| | |
|---|---|
| Description | The host vehicle approaches a front vehicle with a higher speed. Both vehicles are driving in the centre of the lane. The adjacent lanes are blocked by other vehicles. Hence the host vehicle cannot perform an evasive manoeuvre at early stage. The target vehicle as well as the other vehicles, which drives in the adjacent lanes, are driving at the same constant speed |
| Relevant functions | CS, SC, RECA, CM, ESA |
| Use case | UC_01_401_v2, UC_01_531_v1 |
| Vehicle parameters | $v_{target\ vehicle}$, $\Delta v_{host\ vehicle}$, $x_{0\ target\ vehicle}$ |
| Number vehicles | 4 |
| Target objects required (only for real test) | 1 moving target (balloon car) |
| Environmental parameters | Road radius |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | Δx must be chosen as safe distance in order to avoid damage on other vehicles; 3 lanes are required for this test case. |

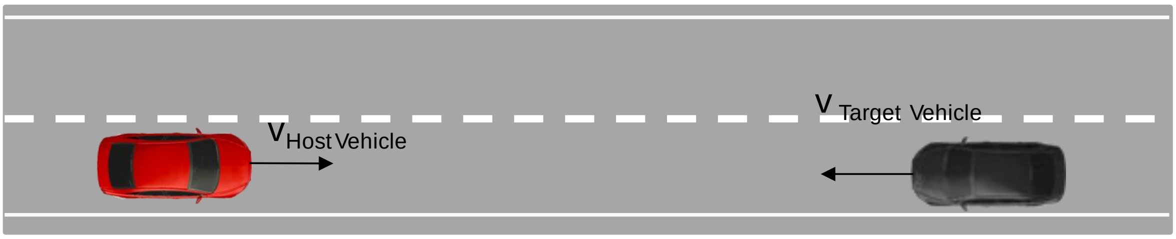
| Test Scenario | Rear-end collision |
|---|---|
| Test Case | 1.7 |

## Braking front vehicle



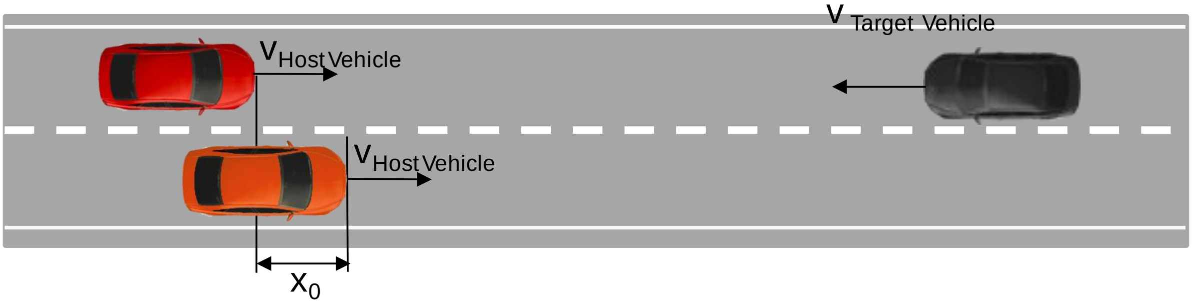

| | |
|---|---|
| Description | The host vehicle follows a lead vehicle with at short THW (~ 1s or less). The front vehicle suddenly starts to brake with a defined deceleration. |
| Relevant functions | CS, SC, RECA, CM, ESA |
| Use case | UC_01_402_v0, UC_01_504_v2, UC_01_531_v1, UC_01_601_v2 |
| Vehicle parameters | $v_{host vehicle}$, $a_{x braking}$, $x_0$ (distance at start of braking) |
| Number vehicles | 2 |
| Target objects required (only for real test) | 1 moving target (balloon car) |
| Environmental parameters | Number of lanes (1,2), driven lane (left, right), road radius |
| Road radius | ∞, 500 m |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Head on collisions |
|---|---|
| Test Case | 2.1 |
| **Oncoming vehicle while overtaking** | |
|  | |
| Description | Host vehicle drives in the opposite lane while there is oncoming vehicle in the same lane |
| Relevant functions | eDPP, LCCA, OCVA, CMS |
| Use case | UC_02_434_v0, UC_02_501_v2, UC_02_532_v1, UC_02_534_v1, UC_02_604_v0 |
| Vehicle parameters | $v_{host\ vehicle}$, $v_{target\ vehicle}$ |
| Number vehicles: | 2 |
| Target objects required (only for real test) | 1 moving target (balloon car) |
| Environmental parameters | Road radius |
| Road radius | ∞, 500 m |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Head on collisions |
|---|---|
| Test Case | 2.2 |
| **Oncoming vehicle in own lane** | |
|  | |
| Description | Host vehicle drives in its own lane while there is oncoming vehicle in the same lane. |
| Relevant functions | eDPP, LCCA, OCVA, CMS |
| Use case | UC_02_506_v2, UC_02_535_v1 |
| Vehicle parameters | $v_{host\ vehicle}$, $v_{target\ vehicle}$ |
| Number vehicles | 2 |
| Target objects required (only for real test) | 1 moving target (balloon car) |
| Environmental parameters | Road radius |
| Road radius | ∞, 500 m |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Head on collisions |
|---|---|
| Test Case | 2.3 |

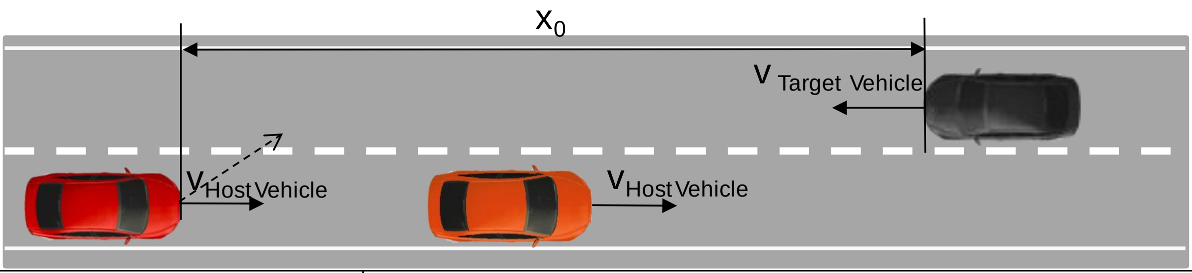
## Oncoming vehicle (traffic) while overtaking



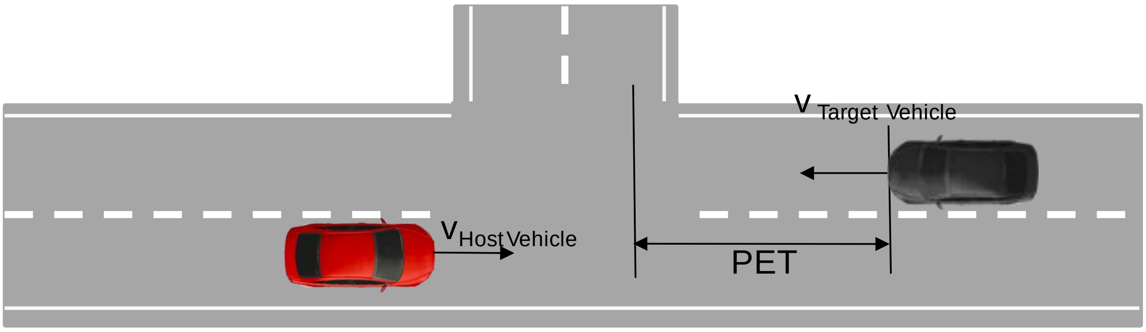

| | |
|---|---|
| Description | Host vehicle drives in its own lane while there is oncoming vehicle in the same lane. In the adjacent lane is another vehicle. Hence the host vehicle cannot evade into the initial lane. |
| Relevant functions | eDPP, LCCA, OCVA, CMS |
| Use case | UC_02_434_v0, UC_02_501_v2, UC_02_532_v1, UC_02_534_v1, UC_02_604_v0 |
| Vehicle parameters | $v_{host\ vehicle}$, $v_{target\ vehicle}$, $x_0$ |
| Number vehicles | 3 |
| Target objects required (only for real test) | at least 1 moving target (balloon car) and one static target; better: 2 moving targets |
| Environmental parameters | Road radius |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

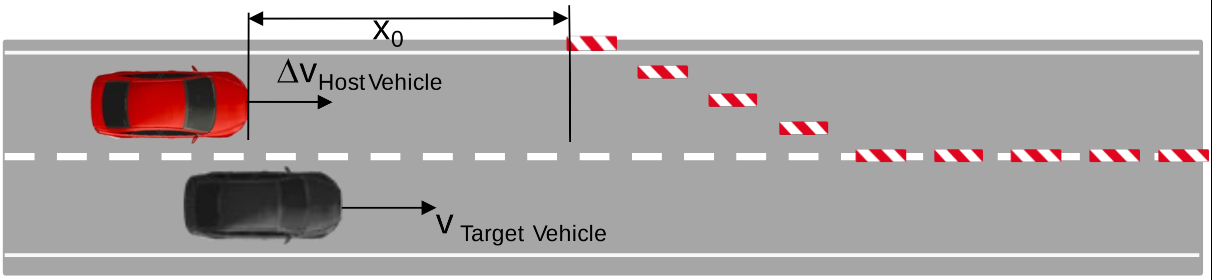
| Test Scenario | Head on collisions |
|---|---|
| Test Case | 2.4 |

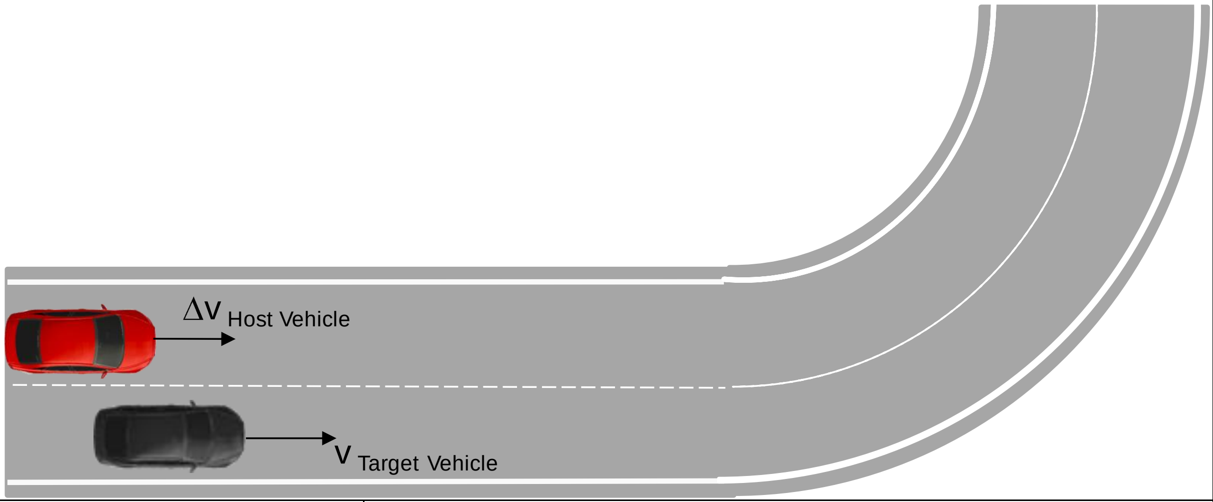
**Intended lane change with oncoming traffic**

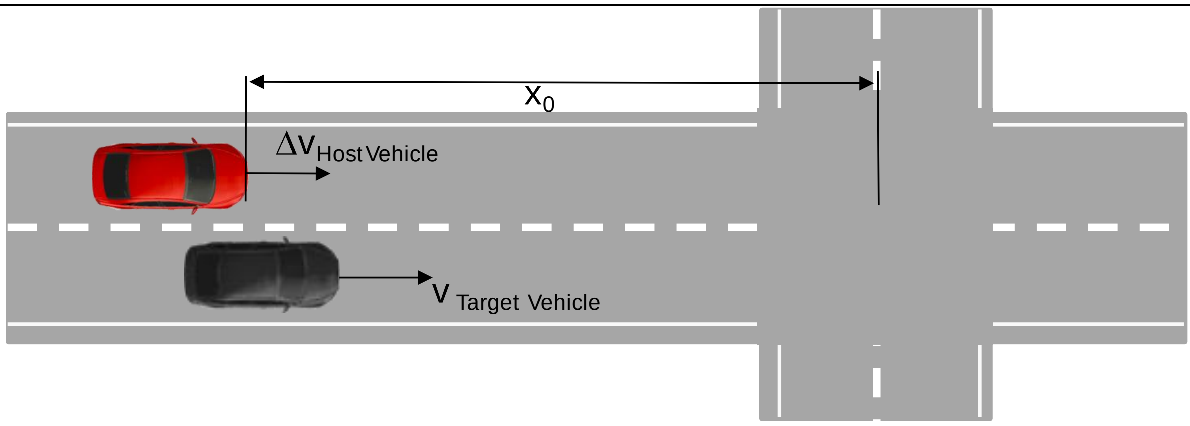


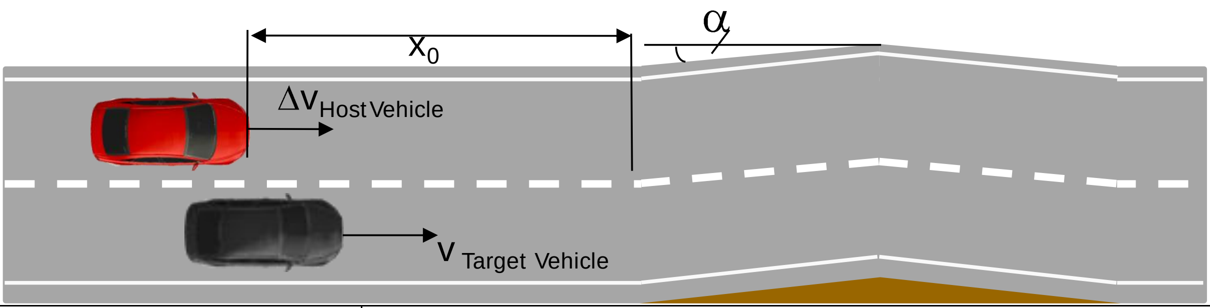

| | |
|---|---|
| Description | Host vehicle follows lead vehicle (at the same speed) and decides to overtake, but vehicle is approaching in the opposite direction. |
| Relevant functions | LCCA, OCVA, CMS |
| Use case | UC_02_501_v2 |
| Vehicle parameters | $v_{host\ vehicle}$, $v_{target\ vehicle}$, $x_0$ |
| Number vehicles | 3 |
| Target objects required (only for real test) | At least 1 moving target (balloon car) (It is extremely difficult to synchronize the different vehicles, so the leading vehicle could be static). |
| Environmental parameters | Road radius |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Head on collisions |
|---|---|
| Test Case | 2.5 |
| **Conflict with oncoming vehicle while left turn** | |
|  | |
| Description | Host vehicle performing a left turn, while an target vehicle is approaching |
| Relevant functions | CMS |
| Use case | UC_02_605_v1 |
| Vehicle parameters | $v_{host\ vehicle}$, $v_{target\ vehicle}$, Post Encroachment Time (PET) |
| Number vehicles | 2 |
| Target objects required (only for real test) | 1 moving target (balloon car) |
| Environmental parameters | Road radius |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | Post Encroachment Time (PET) represents a measure of the temporal difference between two road-users, who pass a common spatial point or area. |

| Test Scenario | Head on collisions |
|---|---|
| Test Case | 2.6 |
| **Road works** | |
|  | |
| Description | Host vehicle is driving in the opposite lane due to a overtaking manoeuvre. During this manoeuvre the host vehicle approaches road works. |
| Relevant functions | eDPP |
| Use case | UC_02_ 431_v0 |
| Vehicle parameters | $\Delta v_{host\ vehicle}$, $v_{target\ vehicle}$, x0 (distance to roadwork when vehicles are next to each other) |
| Number vehicles: | 2 |
| Target objects required (only for real test) | none (no intervention of eDPP) |
| Environmental parameters | Road radius |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

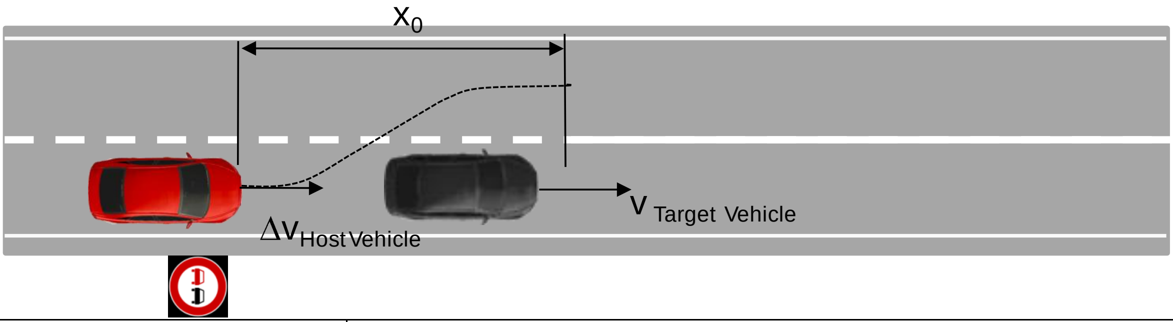
| Test Scenario | Head on collisions |
|---|---|
| Test Case | 2.7 |
| **Upcoming curve** | |
|  | |
| Description | Host vehicle is driving in the opposite lane due to an overtaking manoeuvre. There is a curve in front of the host vehicles. |
| Relevant functions | eDPP |
| Use case | UC_02_403_v0 |
| Vehicle parameters | $\Delta v_{\text{host vehicle}}$, $v_{\text{target vehicle}}$ |
| Number vehicles | 2 |
| Target objects required (only for real test) | none (no intervention of eDPP) |
| Environmental parameters | Road radius |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Head on collisions |
|---|---|
| Test Case | 2.8 |
| **Upcoming intersection** | |
|  | |
| Description | Host vehicle is driving in the opposite lane due to a overtaking manoeuvre. There is an intersection in front of the host vehicles. |
| Relevant functions | eDPP |
| Use case | UC_02_432_v0 |
| Vehicle parameters | $\Delta v_{host\ vehicle}$, $v_{target\ vehicle}$ , $x_0$ (distance to intersection when vehicles are next to each other) |
| Number vehicles | 2 |
| Target objects required (only for real test) | none (no intervention of eDPP) |
| Environmental parameters | Road radius |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

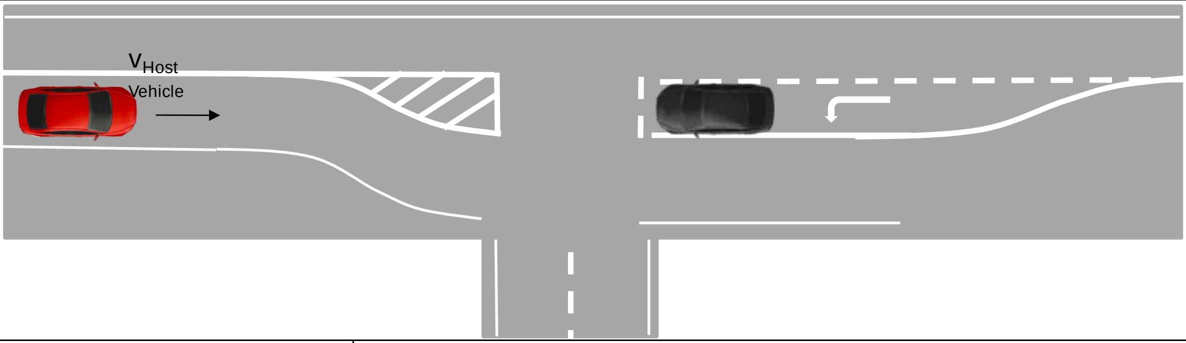
| Test Scenario | Head on collisions |
|---|---|
| Test Case | 2.9 |
| **Upcoming hill** | |
|  | |
| Description | Host vehicle is driving in the opposite lane due to an overtaking manoeuvre. There is a hill in front of the host vehicles. |
| Relevant functions | eDPP |
| Use case | UC_02_433_v0 |
| Vehicle parameters | $\Delta v_{host\ vehicle}$, $v_{target\ vehicle}$, $x_0$ (distance to hilltop when vehicles are next to each other) |
| Number vehicles | 2 |
| Target objects required (only for real test) | none (no intervention of eDPP) |
| Environmental parameters | Road radius, gradient of road |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

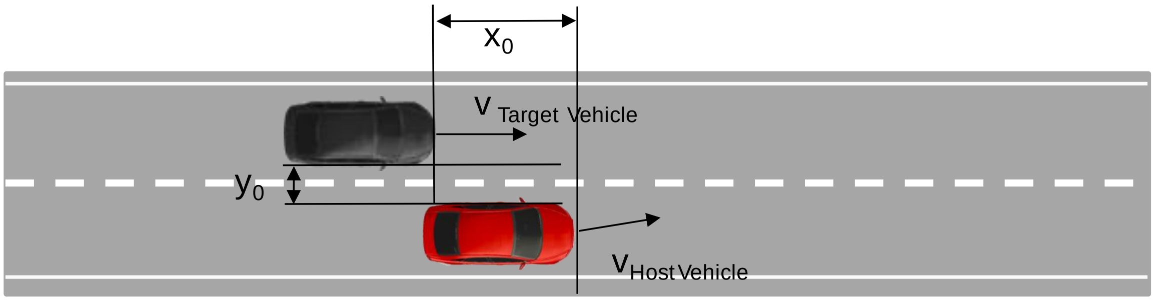
| Test Scenario | Head on collisions |
|---|---|
| Test Case | 2.10 |

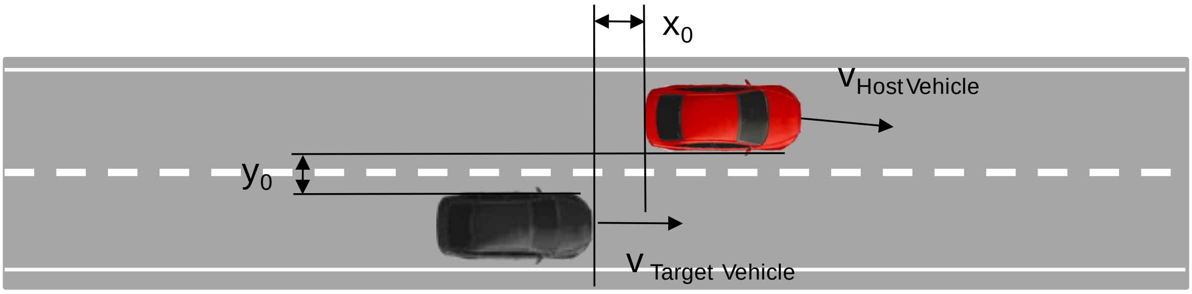
## Overtaking prohibition

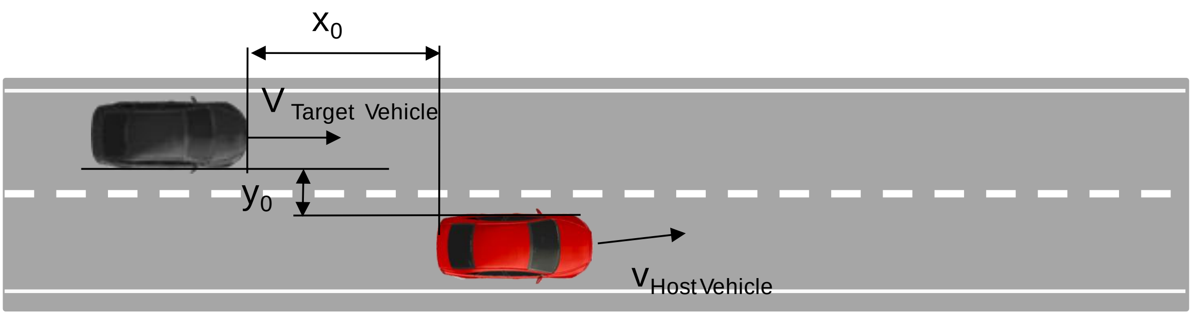



| | |
|---|---|
| Description | The driver in the host vehicle wants to overtake a slower vehicle in front of him. Due to this he/she conducts a lane change. But there is overtaking prohibition. |
| Relevant functions | eDPP, LCCA, OCVA, CMS |
| Use case | UC_02_434_v0, UC_02_501_v2, UC_02_532_v1, UC_02_534_v1, UC_02_604_v0 |
| Vehicle parameters | $\Delta v_{host\ vehicle}$, $v_{target\ vehicle}$, $x_0$ (distance between vehicles at start of overtaking), status turn indicator, kind of overtaking prohibition |
| Number vehicles | 2 |
| Target objects required (only for real test) | none |
| Environmental parameters | Road radius, kind of overtaking prohibition (lane marking sign) |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Head on collisions |
|---|---|
| Test Case | 2.11 |
| **Difficult traffic routing** | |
|  | |
| Description | The host vehicle follows the traffic routing. Due to the traffic routing a head on collision could be detected because of the opponent vehicle which waits for turning left |
| Relevant functions | eDPP, LCCA, OCVA, CMS |
| Use case | UC_02_506_v2, UC_02_535_v1 |
| Vehicle parameters | $v_{host\ vehicle}$ |
| Number vehicles | 2 |
| Target objects required (only for real test) | 1 (static balloon) |
| Environmental parameters | road/lane geometry |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

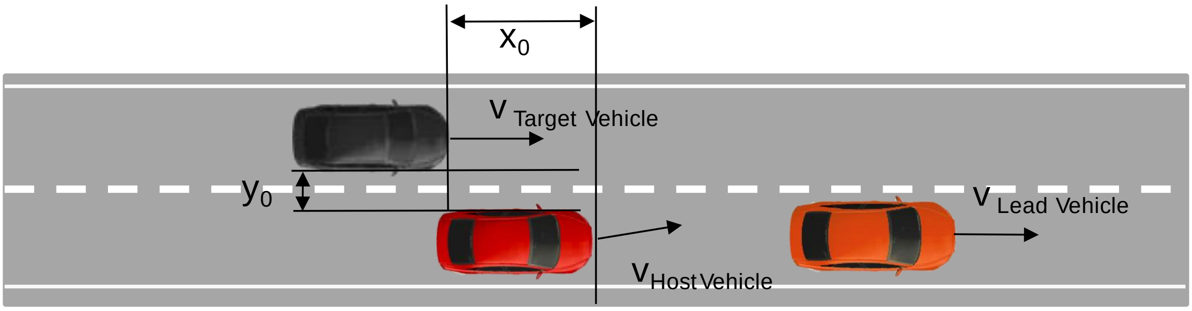
| Test Scenario | Lane change collisions |
|---|---|
| Test Case | 3.1 |
| **Vehicle in blind spot 1** | |
|  | |
| Description | The driver of the host vehicle wants to perform a lane change to the left lane (or drifts unintentionally towards the lane). But there is an opponent vehicle in blind spot. |
| Relevant functions | CS, LCCA, SIA |
| Use case | UC_03_404_v0, UC_03_507_v2, UC_03_533_v1, UC_06_503_v2, UC_06_535 |
| Vehicle parameters | $v_{hostvVehicle}$, $v_{target\ vehicle}$, $x_0$, $y_0$, status turn indicator |
| Number vehicles | 2 |
| Target objects required (only for real test) | (1 moving target (balloon car)) |
| Environmental parameters | Road radius |
| Road radius | ∞, 500 m |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Lane change collisions |
|---|---|
| Test Case | 3.2 |
| **Vehicle in blind spot 2** | |
|  | |
| Description | The driver of the host vehicle wants to perform a lane change to the right lane. But there is an opponent vehicle in blind spot. |
| Relevant functions | CS, LCCA, SIA |
| Use case | UC_03_404_v0, UC_03_507_v2, UC_03_533_v1 |
| Vehicle parameters | $v_{host\ vehicle}$, $v_{target\ vehicle}$, $x_0$, $y_0$, status turn indicator |
| Number vehicles | 2 |
| Target objects required (only for real test) | (1 moving target (balloon car)) |
| Environmental parameters | Road radius |
| Road radius | ∞, 500 m |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

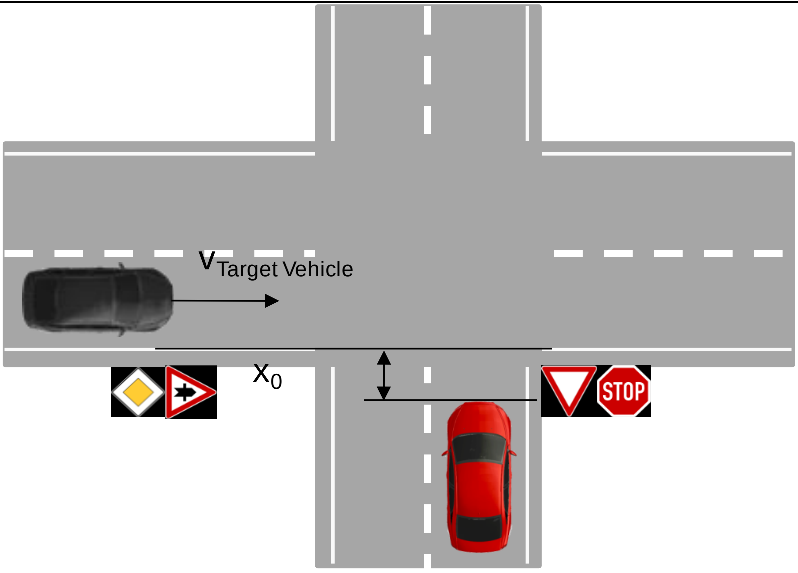
| Test Scenario | Lane change collisions |
|---|---|
| Test Case | 3.3 |
| **Fast approaching vehicle** | |
|  | |
| Description | The driver of the host vehicle wants to perform a lane change to the right lane. But there is a fast approaching opponent vehicle in the other lane. |
| Relevant functions | CS, LCCA, SIA |
| Use case | UC_03_435_v0, UC_03_511_v1, UC_06_450_V1 |
| Vehicle parameters | $v_{host\ vehicle}$, $v_{target\ vehicle}$, $y_0$, status turn indicator, $x_0$ (distance between two vehicles at start of manoeuvre/when crossing the lane) |
| Number vehicles | 2 |
| Target objects required (only for real test) | (1 moving target (balloon car)) |
| Environmental parameters | $v_{Host\ Vehicle}$, $v_{Target\ Vehicle}$, $x_0$, $y_0$, status turn indicator |
| Road radius | ∞, 500 m |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Lane change collisions |
|---|---|
| Test Case | 3.4 |

## Vehicle in blind spot 1 with lead vehicle

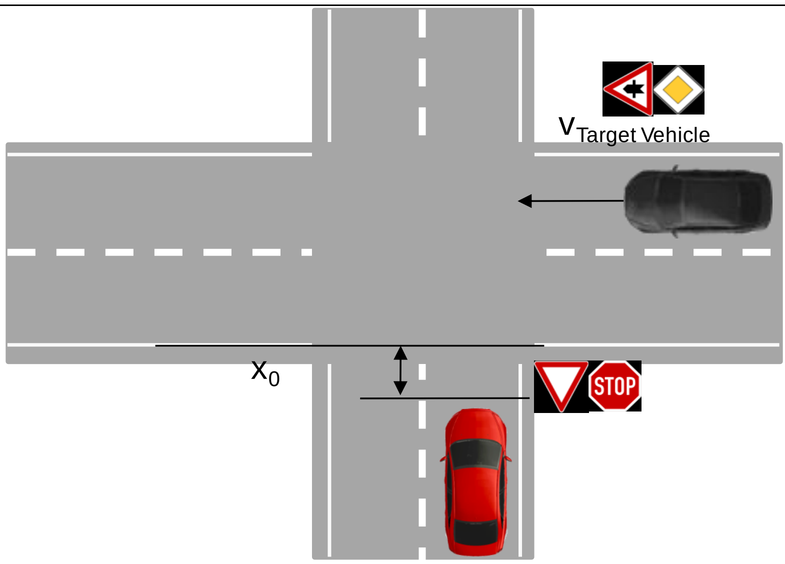



| | |
|---|---|
| Description | The HV is travelling in the left lane on a highway road with two lanes in the direction of travel. The HV approaches a lead vehicle. An OV is approaching in the left lane. The rear view mirrors are manipulated so that the HV driver cannot detect the OV. When the OV is approximately side by side with the HV, the HV driver is instructed to overtake the LV. The function provides 1) warning and 2) intervention (steering). In this test case, either full function or function with 1) disabled is tested (see “environmental parameters” below). |
| Relevant functions | LCCA |
| Use Case | **UC_06_511_v1** |
| Vehicle parameters | $v_{host\ vehicle}$, $v_{target\ vehicle}$, $v_{lead\ vehicle}$, $x_0$, $y_0$ |
| Number of lanes | 2 |
| Target(s) | 2 moving targets |
| Environmental parameters | Road radius,<br>1: Warning is given<br>2: Warning is not given (to simulate that driver misses warning) |
| Road Radius | ∞ |
| Assessment | ☐ Technical ☒ User-related ☐ Impact |
| Comment | Test environment: Simulator or test track |

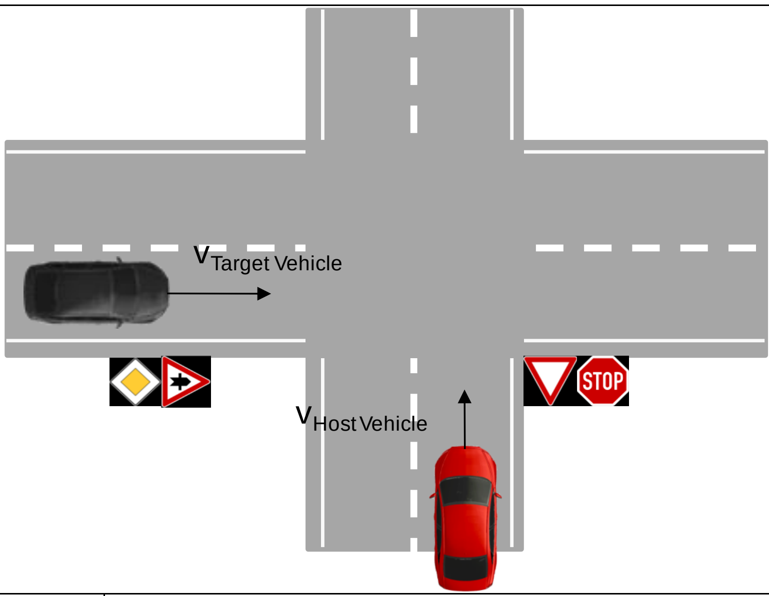
| Test Scenario | Cross traffic collisions |
|---|---|
| Test Case | 4.1 |
| **Crossing traffic stand still 1** | |
|   | |
| Description | The host vehicle stands still at intersection. There is crossing traffic from the lefts side. |
| Relevant functions | CS, ESA, CMS |
| Use case | UC_04_436_v1 |
| Vehicle parameters | $V_{target\ vehicle}$, $x_0$ (distance to intersection) |
| Number vehicles | 2 |
| Target objects required (only for real test) | No |
| Environmental parameters | traffic sign, V2V communication available or not in crossing vehicle |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

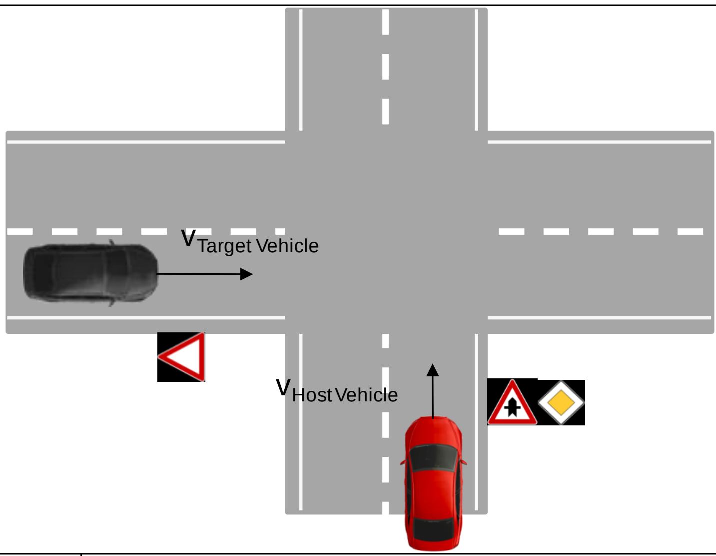
| Test Scenario | Cross traffic collisions |
|---|---|
| Test Case | 4.2 |

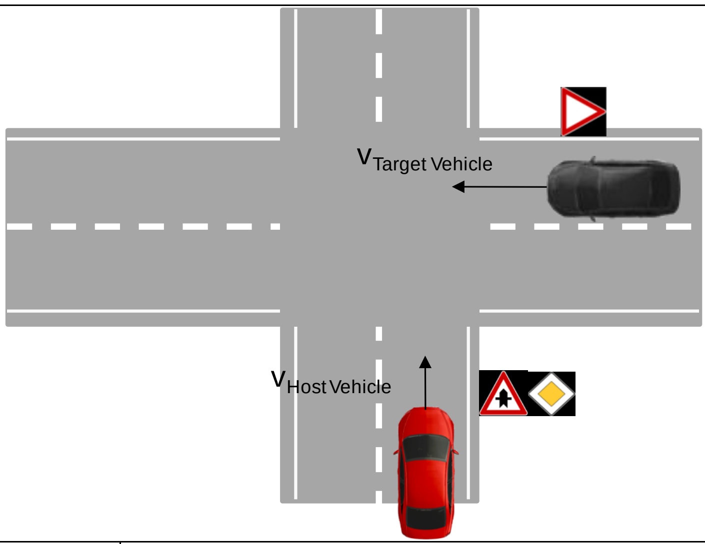
## Crossing traffic (stand still) 2




| | |
|---|---|
| Description | The host vehicle stands at intersection. There is crossing traffic from the right side. |
| Relevant functions | CS, ESA, CMS |
| Use case | UC_04_436_v0 |
| Vehicle parameters | $V_{target\ vehicle}$, $x_0$ (distance to intersection) |
| Number vehicles | 2 |
| Target objects required (only for real test) | No |
| Environmental parameters | traffic sign , V2V communication available or not in crossing vehicle |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

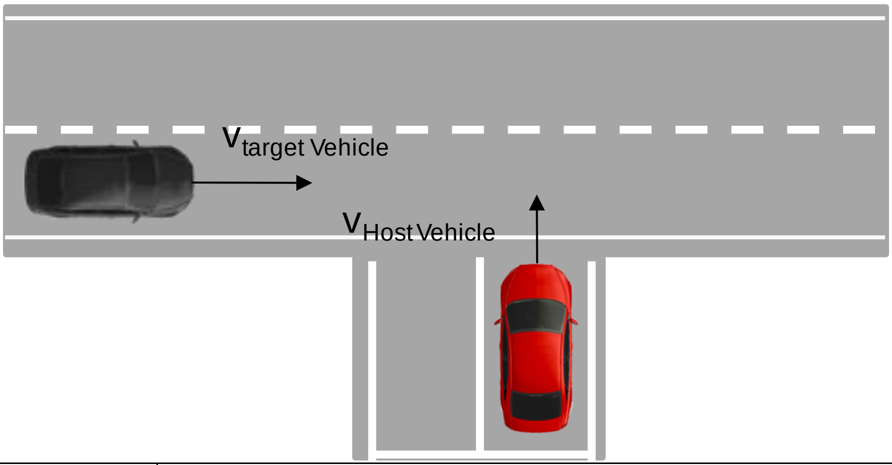
| Test Scenario | Cross traffic collisions |
|---|---|
| Test Case | 4.3 |
| **Crossing traffic (moving) 1** | |
|  | |
| Description | The host vehicle approaches an intersection. There is another vehicle, which has the right of way, crossing from the left side. |
| Relevant functions | CS, ESA, CMS |
| Use case | UC_04_436_v0 |
| Vehicle parameters | $v_{host\ vehicle}$, $v_{target\ vehicle}$, Post Encroachment Time (PET, see test scenario 2.5) |
| Number vehicles | 2 |
| Target objects required (only for real test) | 1 moving target (balloon car) |
| Environmental parameters | traffic sign |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Cross traffic collisions |
| --- | --- |
| Test Case | 4.4 |
| **Crossing traffic (moving) 2** | |
|  | |
| Description | The host vehicle, which has the way of right, approaches an intersection. There is also another vehicle crossing from the left side. |
| Relevant functions | CS, ESA, CMS |
| Use case | UC_04_436_v0, UC_04_607_v2 |
| Vehicle parameters | $v_{host\ vehicle}$, $v_{crossing\ vehicle}$, Post Encroachment Time (PET, see test scenario 2.5) |
| Number vehicles | 2 |
| Target objects required (only for real test) | 1 moving target (balloon car) |
| Environmental parameters | traffic sign |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

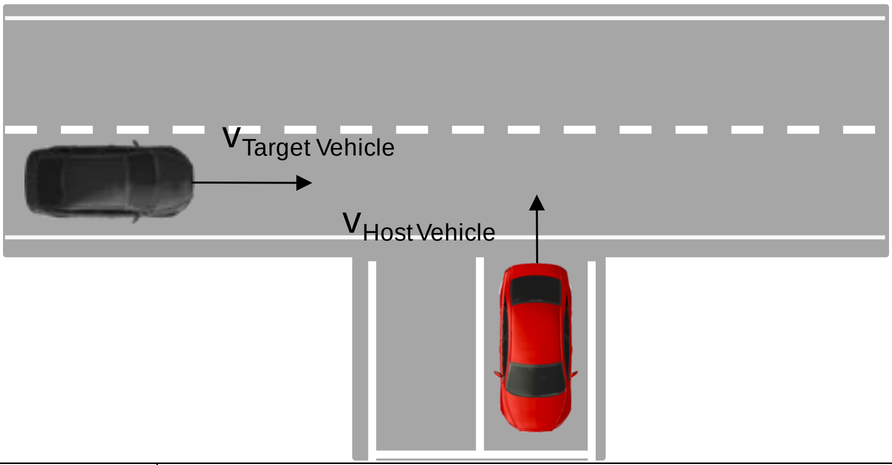
| Test Scenario | Cross traffic collisions |
|---|---|
| Test Case | 4.5 |
| **Crossing traffic (moving) 3** | |
|   | |
| Description | The host vehicle, which has the way of right, approaches an intersection. There is also another vehicle crossing from the right side. |
| Relevant functions | CS, ESA, CMS |
| Use case | UC_04_436_v0, UC_04_607_v2 |
| Vehicle parameters | $v_{host\ vehicle}$, $v_{target\ vehicle}$, Post Encroachment Time (PET, see scenario 2.5)? |
| Number vehicles | 2 |
| Target objects required (only for real test) | 1 moving target (balloon car) |
| Environmental parameters | traffic sign |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

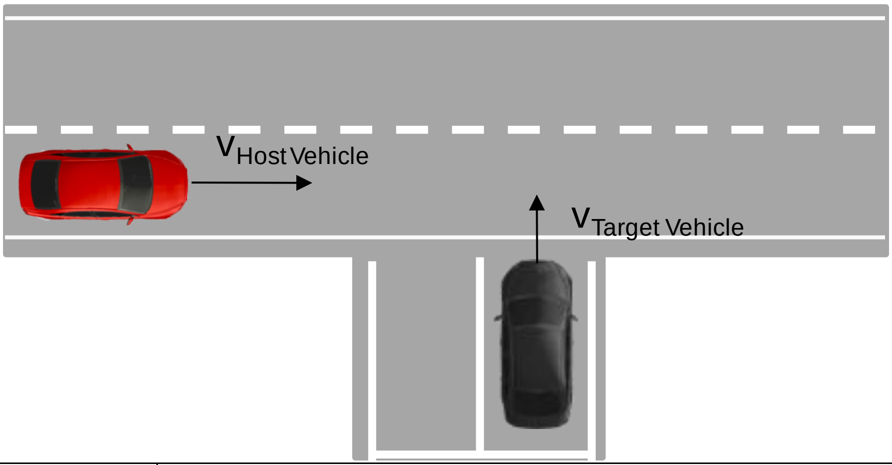
| Test Scenario | Cross traffic collisions |
|---|---|
| Test Case | 4.6 |

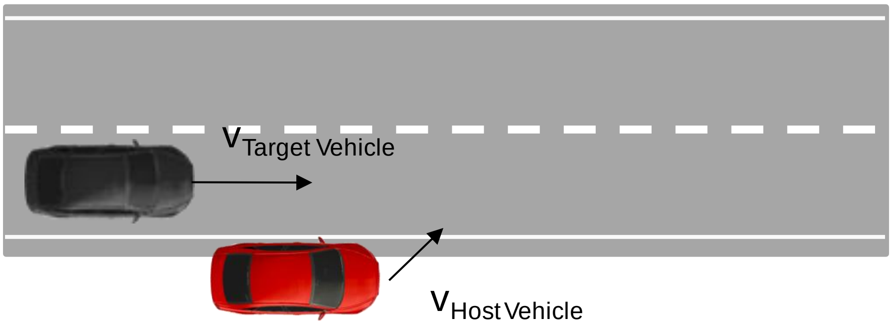
**Parking 1**




| | |
|---|---|
| Description | Driver of the host vehicle leaves the parking lot. But there is crossing traffic from the lefts side. |
| Relevant functions | CS |
| Use case | UC_04_437_v1 |
| Initial value | $v_{host\ vehicle}$, $v_{target\ vehicle}$, $x_0$ (distance to target vehicle when crossing lane border) |
| Number vehicles | 2 |
| Target objects required (only for real test) | 1 moving target (balloon car) |
| Environmental parameters | Road radius |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

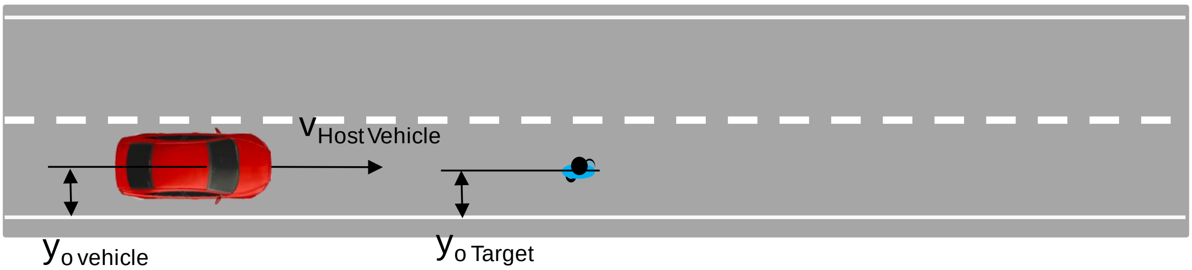
| Test Scenario | Cross traffic collisions |
|---|---|
| Test Case | 4.7 |
| **Parking 1b (Reverse)** | |
|   | |
| Description | Driver of the host vehicle leaves the parking lot. In reverse. But there is crossing traffic from the left side. |
| Relevant functions | CS |
| Use case | UC_04_437_v1 |
| Vehicle parameters | $v_{host\ vehicle}$, $v_{target\ vehicle}$, $x_0$ (distance to oncoming vehicle when crossing lane border) |
| Number vehicles | 2 |
| Target objects required (only for real test) | 1 moving target (balloon car) |
| Environmental parameters | Road radius |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Cross traffic collisions |
|---|---|
| Test Case | 4.8 |
| **Parking 3: unparking vehicle and steer assist** | |
| <br> | |
| Description | Opponent vehicle drives on main road, unparking car leaves the parking lot and is on collision course. The driver reacts by applying an inappropriate steering torque. |
| Relevant functions | ESA |
| Use case | UC_04_608_v2 |
| Vehicle parameters | $v_{host\ vehicle}$, $v_{target\ vehicle}$, $x_0$ (distance to target vehicle when crossing lane border), steering torque applied by driver |
| Number vehicles | 2 |
| Target objects required (only for real test) | 1 moving target (balloon car) |
| Environmental parameters | Road radius |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

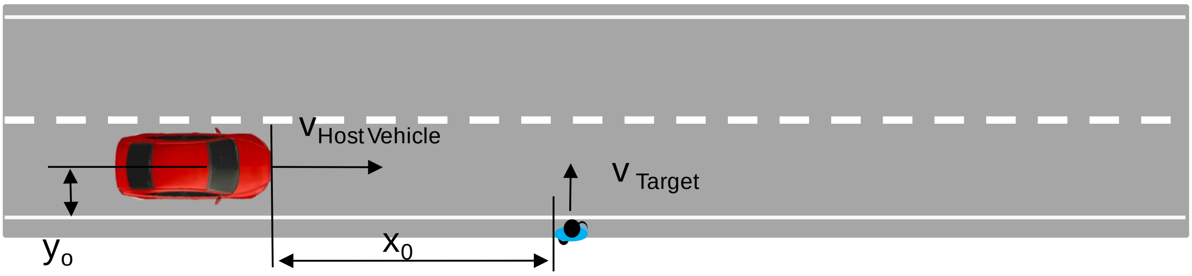
| Test Scenario | Cross traffic collisions |
|---|---|
| Test Case | 4.9 |
| **Parking 4** | |
|  | |
| Description | Driver of the host vehicle wants to leave the parking lot. But there is crossing traffic from the lefts side. |
| Relevant functions | CS, ESA, CMS |
| Use case | UC_04_437_v1, UC_04_607_v1 |
| Vehicle parameters | $v_{host\ vehicle}$, $v_{target\ vehicle,}$, $x_0$ (distance between vehicles at start of maneuver) |
| Number vehicles | 2 |
| Target objects required (only for real test) | 1 moving target (balloon car) |
| Environmental parameters | Road radius |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| | |
|---|---|
| Test Scenario | Collisions with vulnerable road users |
| Test Case | 5.1 |

## Standstill pedestrian

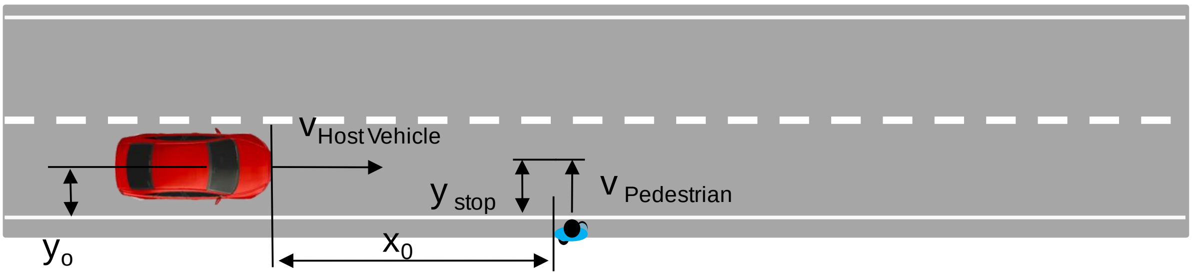



| | |
|---|---|
| Description | Host vehicle approaches a pedestrian, who stands in the middle of the road. |
| Relevant functions | CS, ESA |
| Use case | UC_05_405_v1, UC_05_609v2 |
| Vehicle parameters | $v_{host\ vehicle}$, $y_o$, $y_{o\ target}$ |
| Number vehicles | 1 |
| Target objects required (only for real test) | Pedestrian dummy (stationary) |
| Environmental parameters | Road radius, size of pedestrian |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

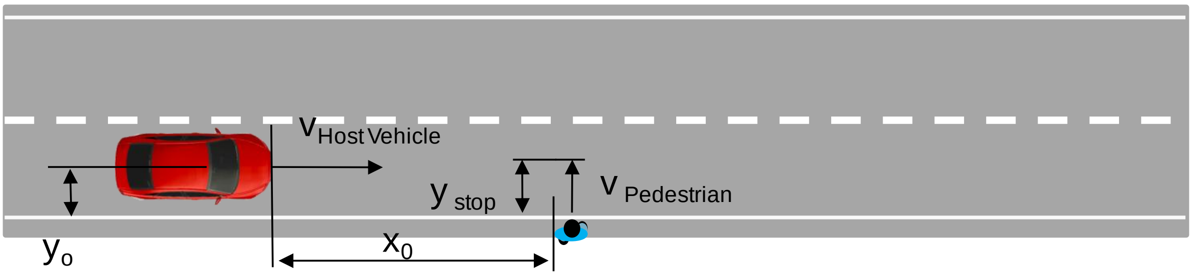
| Test Scenario | Collisions with vulnerable road users |
|---|---|
| Test Case | 5.2 |
| **Moving pedestrian (crossing)** | |
|   | |
| Description | Host vehicle approaches a pedestrian, who crossed the road. |
| Relevant functions | CS, ESA |
| Use case | UC_05_405_v1, UC_05_609v2 |
| Vehicle parameters | $v_{host\ vehicle}$, $v_{target}$, $y_0$, $x_0$ (distance to pedestrian when crossing border) |
| Number vehicles | 1 |
| Target objects required (only for real test) | Pedestrian dummy (moving) |
| Environmental parameters | Road radius, pedestrian‘s moving direction |
| Road radius | $\infty$ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Collisions with vulnerable road users |
|---|---|
| Test Case | 5.3 |

## Stopped pedestrian

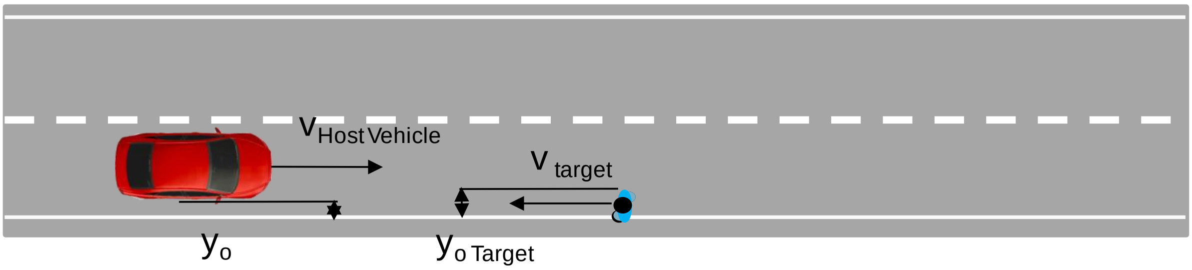



| | |
|---|---|
| Description | Host vehicle approaches a pedestrian, who moves on the road and then stops on the road. |
| Relevant functions | CS, ESA |
| Use case | UC_05_405_v0, UC_06_610_V1 |
| Vehicle parameters | $v_{host\ vehicle}$, $v_{pedestrian}$, $y_0$, $y_{stop}$, $x_0$ (distance to pedestrian when crossing border) |
| Number vehicles | 1 |
| Target objects required (only for real test) | Pedestrian dummy (moving) |
| Environmental parameters | Road radius |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

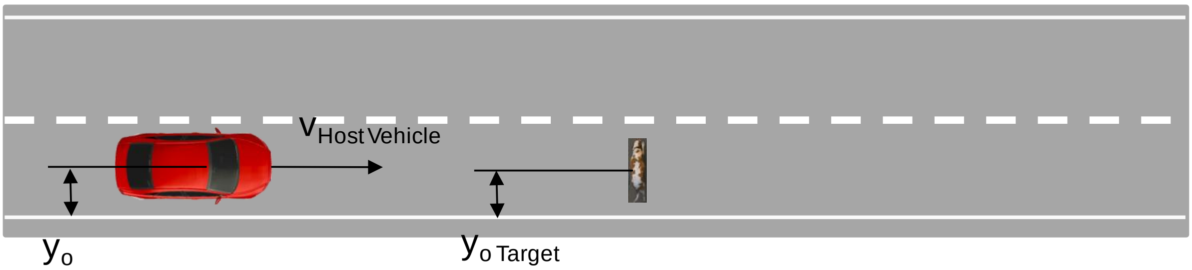
| Test Scenario | Collisions with vulnerable road users |
|---|---|
| Test Case | 5.31 |
| **Stopped pedestrian – steering assist** | |
|  | |
| Description | Host vehicle approaches a pedestrian, who moves on the road and then stops on the road. The driver steers to avoid the pedestrian, but with an inappropriate torque. |
| Relevant functions | CMS |
| Use case | UC_06_610_V1 |
| Vehicle parameters | $v_{host\ vehicle}$ , $y_{stop}$, $v_{target}$, $y_o$ , applied torque, $x_0$ (distance to pedestrian when starting to apply torque) |
| Number vehicles | 1 |
| Target objects required (only for real test) | Pedestrian dummy (moving) |
| Environmental parameters | Road radius |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Collisions with vulnerable road users |
|---|---|
| Test Case | 5.4 |

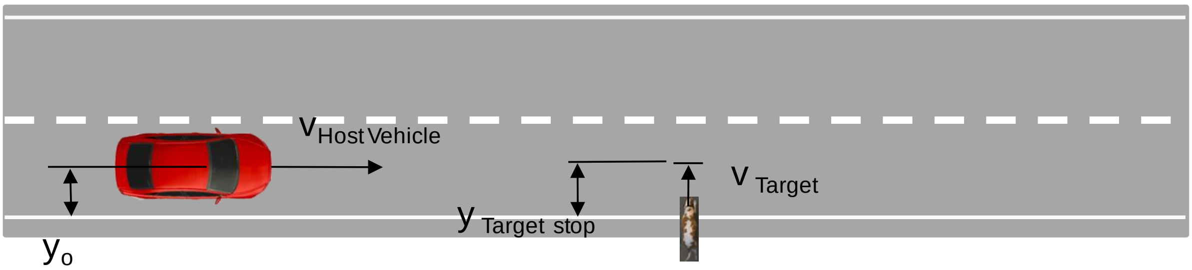
## Moving pedestrian (oncoming)




| | |
|---|---|
| Description | Host vehicle approaches a pedestrian, who walks on the road (e.g. rural road without sidewalk). |
| Relevant functions | CS |
| Use case | UC_05_405_v1 |
| Initial value | $v_{host\ vehicle}$, $v_{target}$, $y_o$, $y_{o\ target}$ |
| Number vehicles | 1 |
| Target objects required (only for real test) | Pedestrian dummy (moving) |
| Environmental parameters | Road radius |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

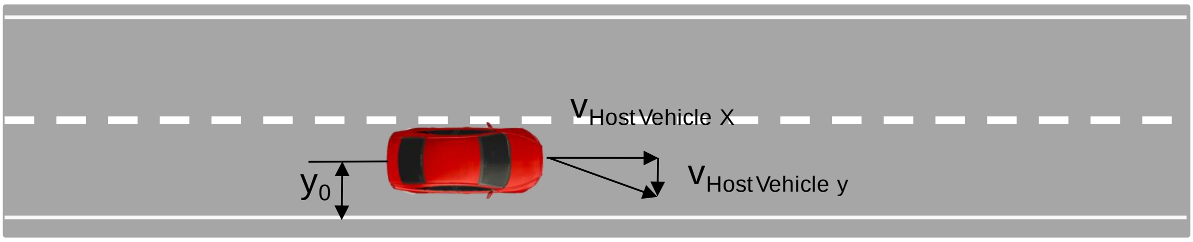
| Test Scenario | Collisions with vulnerable road users |
|---|---|
| Test Case | 5.5 |
| **Standstill animal** | |
|  | |
| Description | Host vehicle approaches an animal, which stands in the middle of the road respectively lane. |
| Relevant functions | CS |
| Use case | UC_05_438_v1 |
| Vehicle parameters | $v_{host\ vehicle}$, $y_{o\ vehicle}$, $y_{o\ animal}$ |
| Number vehicles | 1 |
| Target objects required (only for real test) | Animal dummy (stationary) |
| Environmental parameters | Road radius |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Collisions with vulnerable road users |
|---|---|
| Test Case | 5.6 |
| | **stopped animal** |
| Description | Host vehicle approaches an animal, (or a herd of animals) , which moves on the road and then stops on the road. |
| Relevant functions | CS |
| Use case | UC_05_438_v1 |
| Vehicle parameters | $v_{host\ vehicle}$, $v_{target}$, $y_{target\ stop}$, $y_o$ |
| Number vehicles | 1 |
| Target objects required (only for real test) | Animal dummy (moving) |
| Environmental parameters | Road radius |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |



| Test Scenario | Unintended lane departure-accidents |
|---|---|
| Test Case | 6.1 |

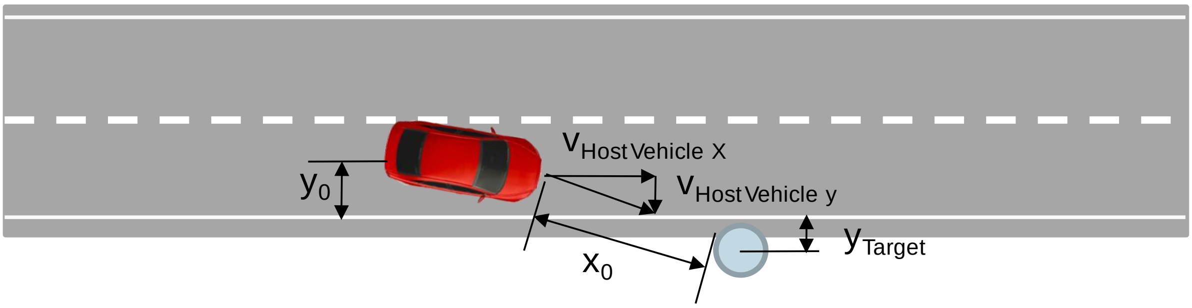
## Unintended lane departure (right)



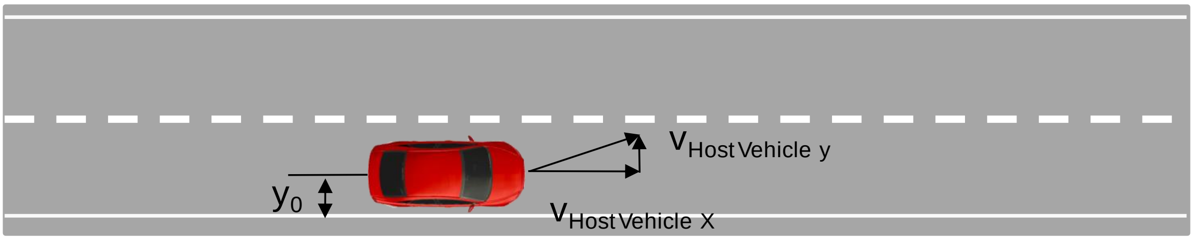

| | |
|---|---|
| Description | Unintended lane departure of the host vehicle to the right side. |
| Relevant functions | CS, RORP |
| Use case | UC_06_454_v0, UC_06_503_v2, UC_06_536_v1, UC_06_510_v2, UC_06_535, UC_06_536_v1 |
| Vehicle parameters | $v_{host\ vehicle\_x}$ , $v_{host\ vehicle\ y}$ , $y_0$ , status turn indictor, lane marking |
| Number vehicles | 1 |
| Target objects required (only for real test) | none |
| Environmental parameters | Road radius, lane marking |
| Road radius | ∞, 500 m |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

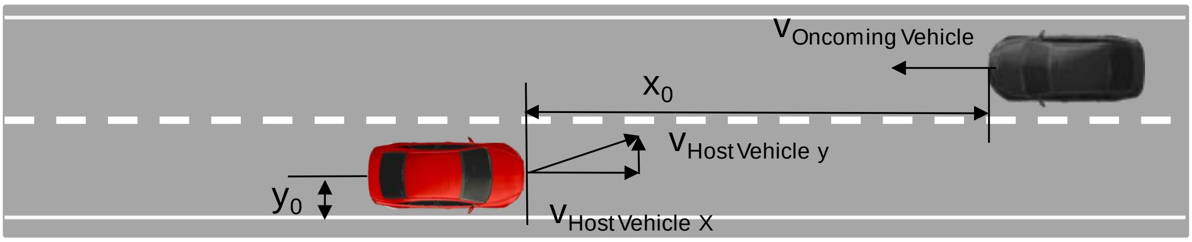
| Test Scenario | Unintended lane departure-accidents |
|---|---|
| Test Case | 6.2 |

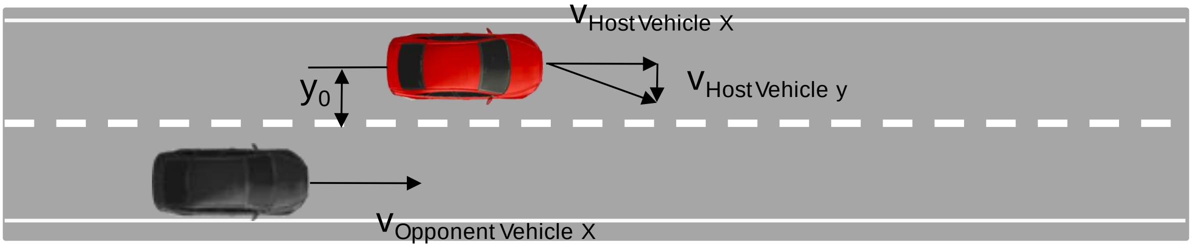
## Unintended lane departure to obstacle (right)

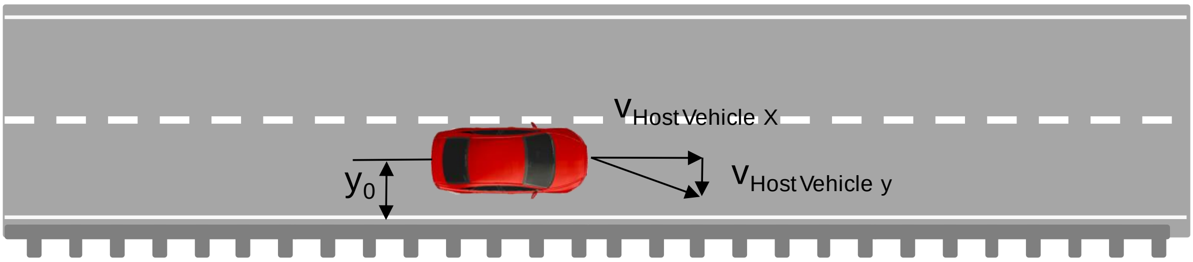


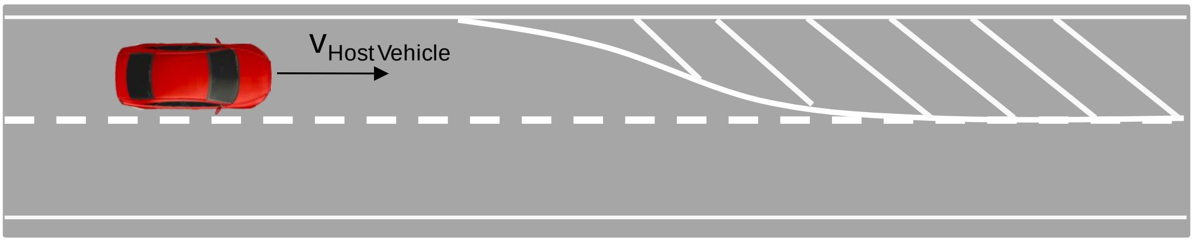

| | |
|---|---|
| Description | Unintended lane departure of the host vehicle to the right side and approaches a obstacle |
| Relevant functions | CMS |
| Use case | UC_06_610_v1 |
| Vehicle parameters | $v_{host\ vehicle\_x}$ , $v_{host\ vehicle\ y}$ ,$y_0$ , status turn indictor, $x_0$ (longididunal distance to obstacle when leaving road), $y_{obstacle}$ |
| Number vehicles | 1 |
| Target objects required (only for real test) | none |
| Environmental parameters | Road radius, lane marking |
| Road radius | ∞, 500 m |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Unintended lane departure-accidents |
|---|---|
| Test Case | 6.3 |
| **Unintended lane departure (left)** | |
|   | |
| Description | Unintended lane departure of the host vehicle to the left side. |
| Relevant functions | CS, RORP |
| Use case | UC_06_451_v0, UC_06_452_v0, UC_06_503_v2, UC_06_510_v2 |
| Vehicle parameters | $v_{host\ vehicle\ x}$ , $v_{host\ vehicle\ y}$, $y_0$ , status turn indictor |
| Number vehicles | 1 |
| Target objects required (only for real test) | none |
| Environmental parameters | Road radius, lane marking |
| Road radius | ∞, 500 m |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Unintended lane departure-accidents |
|---|---|
| Test Case | 6.4 |
| **Unintended lane departure with oncoming traffic (left)** | |
|  | |
| Description | Unintended lane departure of the host vehicle to the left lane, in which an oncoming vehicle is. |
| Relevant functions | CS, RORP, CMS |
| Use case | UC_06_452_v0, UC_06_453_v0, UC_06_535, UC_02_606_V4 |
| Vehicle parameters | $v_{host\ vehicle\ x}$ , $v_{host\ vehicle\ y}$ ,$y_0$ , status turn indictor , $v_{target\ vehicle,}$ $x_0$ (distance to oncoming vehicle when crossing the lane). |
| Number vehicles | 2 |
| Target objects required (only for real test) | 1 moving target (balloon car) |
| Environmental parameters | Road radius, lane marking |
| Road radius | ∞, 500 m |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

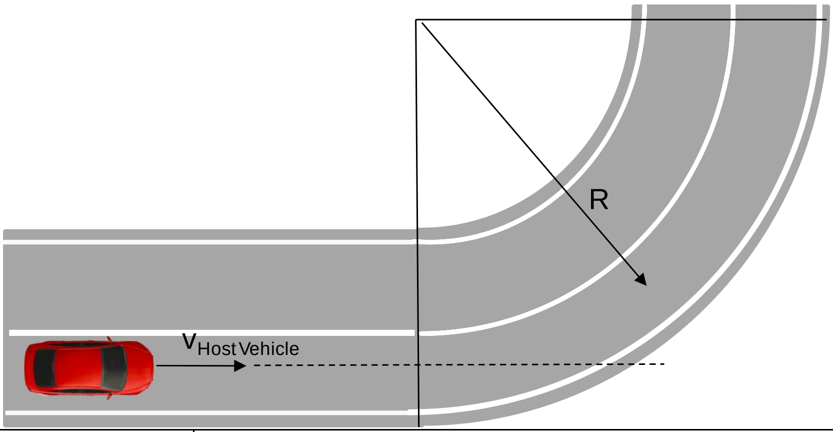
| Test Scenario | Unintended lane departure-accidents |
|---|---|
| Test Case | 6.5 |
| **Unintended lane departure + opponent vehicle** | |
|  | |
| Description | The HV (a car) is travelling in the left lane on a straight motorway road with two lanes in the direction of travel. A distraction is provided to the test driver (message typing task) while the road is gradually displaced (y1 or y2 m) to the left to make the HV drift out of the lane and into the right lane. In the right lane, an opponent vehicle is approaching. |
| Relevant functions | RORP |
| Use Case: | **UC_06_503_v2 (Event 2)**, **UC_06_535 (Event 2)** |
| Initiate value: | $v_{host\ vehicle\ x}$ , $v_{host\ vehicle\ y}$ , $y_0$ , $v_{target\ vehicle}$ |
| Number of lanes | 2 |
| Target(s) | 1 moving target (sedan-type passenger car) |
| Environmental parameters: | Road radius, lane marking |
| Road Radius: | ∞ |
| Assessment | ☐ Technical ☒ User-related ☐ Impact |
| Comment | Test environment simulator |

| Test Scenario | Unintended lane departure-accidents |
|---|---|
| Test Case | 6.6 |
| **Barrier** | |
|  | |
| Description | The host vehicle drifts unintended to the right road side, where the road is bordered by a barrier. |
| Relevant functions | CS, RORP, CMS |
| Use case | UC_06_454_v0 |
| Vehicle parameters | $v_{host\ vehicle\ x}$ , $v_{host\ vehicle\ y}$ , $y_0$, status turn indictor |
| Number vehicles | 1 |
| Target objects required (only for real test) | none |
| Environmental parameters | Road radius |
| Road radius | ∞, 500 m |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Unintended lane departure-accidents |
|---|---|
| Test Case | 6.7 |
| **End of Lane** | |
|  | |
| Description | The driver of the host vehicle does not react on a lane. |
| Relevant functions | CS, RORP |
| Use case | |
| Vehicle parameters | $v_{host\ vehicle}$, status turn indictor |
| Number vehicles | 1 |
| Target objects required (only for real test) | none |
| Environmental parameters | Road radius |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Unintended lane departure-accidents |
|---|---|
| Test Case | 6.8 |

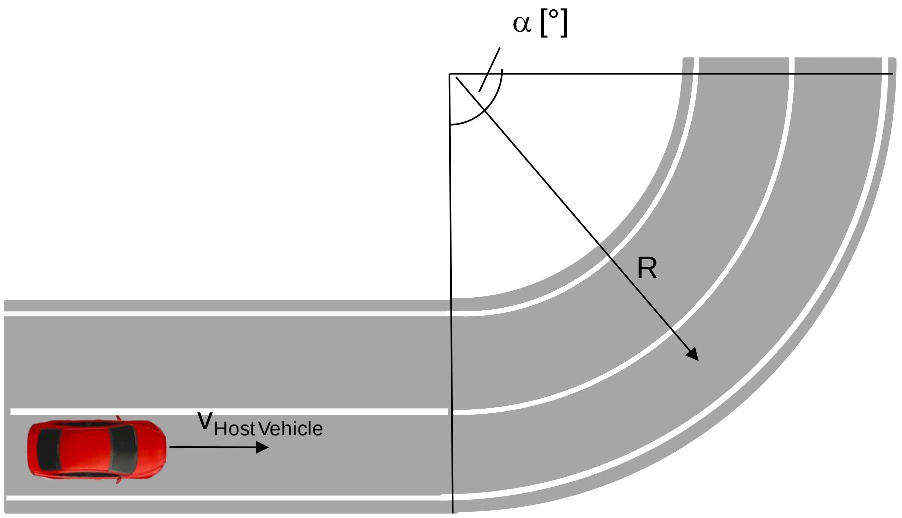
## Lane departure in curve



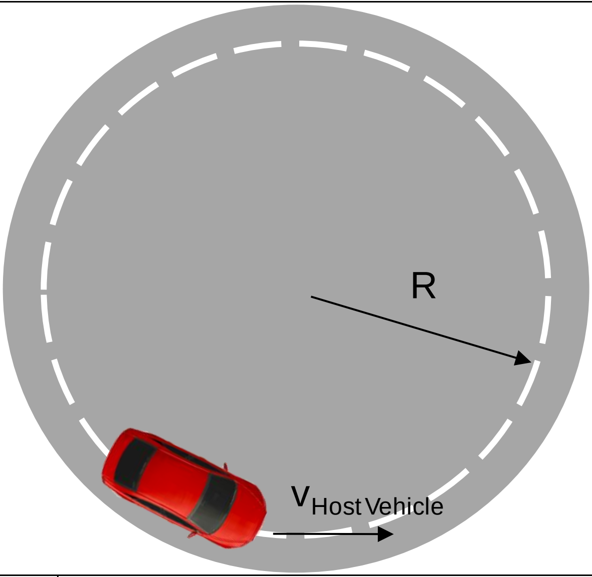

| | |
|---|---|
| Description | Lane departure in curve. |
| Relevant functions | RORP |
| Use case | UC_06_509_v2 |
| Vehicle parameters | $v_{host\ vehicle\ x}$ |
| Number vehicles | 1 |
| Target objects required (only for real test) | none |
| Environmental parameters | Road radius |
| Road radius | 30, 50, 80 m |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

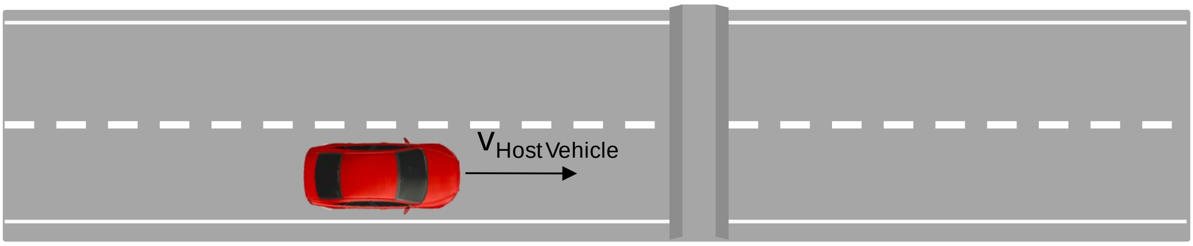
| Test Scenario | Excessive speed accidents |
|---|---|
| Test Case | 7.1 |

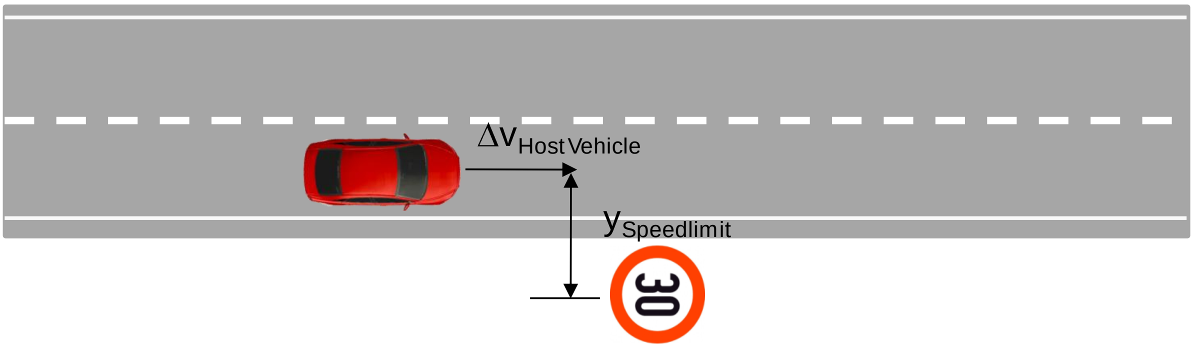
**Speed curve**




| | |
|---|---|
| Description | Host vehicle approaches with a too high (unsafe) velocity a curve. |
| Relevant functions | CSC |
| Use case | UC_07_406_v1, UC_07_456_v0 |
| Vehicle parameters | $v_{host\ vehicle}$ |
| Number vehicles | 1 |
| Target objects required (only for real test) | none |
| Environmental parameters | road radius, curve angle |
| Road radius | 10, 30, 50, 80, 180, 250 m |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

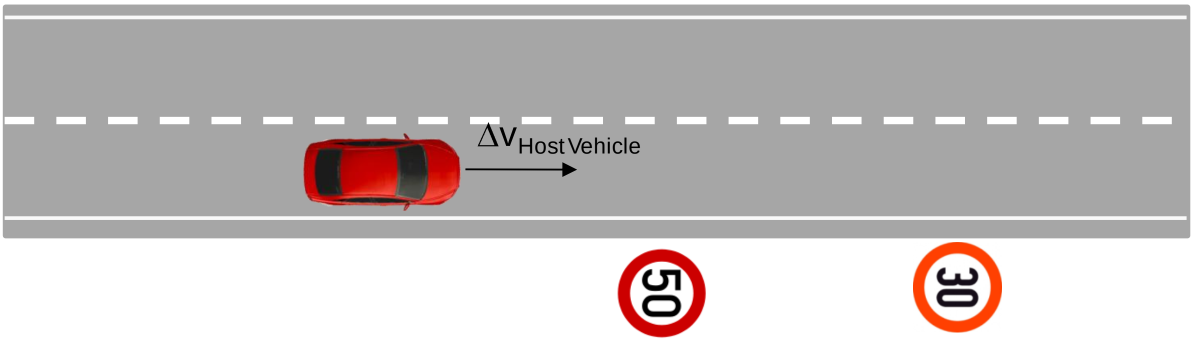
| Test Scenario | Excessive speed accidents |
|---|---|
| Test Case | 7.2 |
| **Unsteady circling** | |
|  | |
| Description | Instationary circling. The host vehicle accelerates slowly up to the physically possible velocity. |
| Relevant functions | CSC |
| Use case | UC_ 07_406_v1, UC_ 07_456_v0 |
| Vehicle parameters | $v_{host\ vehicle}$, $a_{host\ vehicle}$ |
| Number vehicles | 1 |
| Target objects required (only for real test) | |
| Environmental parameters | Road radius |
| Road radius | 20, 40, 60, 100 m |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Excessive speed accidents |
|---|---|
| Test Case | 7.3 |
| **Approaching zone, which required a lower speed (e.g. speed bump)** | |
|  | |
| Description | Host vehicle approaches a zone without traffic signs, which required a lower speed (e.g. speed bump) |
| Relevant functions | CS |
| Use case | UC_07_455_v0 |
| Vehicle parameters | $v_{host\ vehicle}$ |
| Number vehicles | 1 |
| Target objects required (only for real test) | speed bump |
| Environmental parameters | Geometric of zone (e.g. speed bump) |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | Best test for detection is the real traffic |

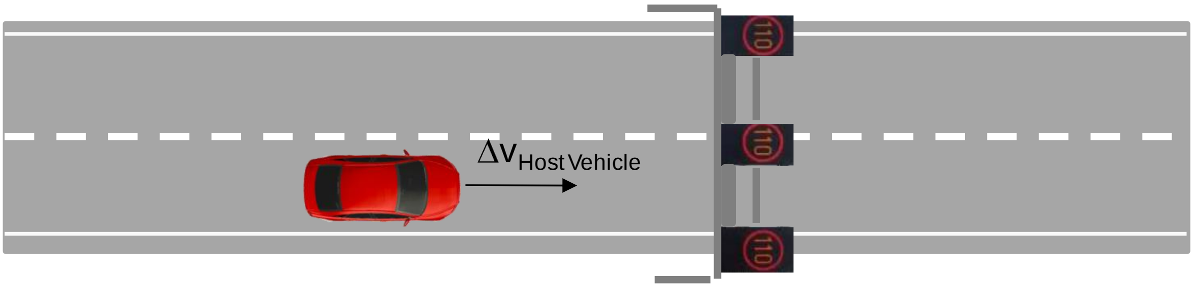
| Test Scenario | Traffic rule violations |
|---|---|
| Test Case | 8.1 |
| **Approaching speed limit** | |
|  | |
| Description | Host vehicle approaches a speed limit with different relative velocities. The lateral distance to the speed limit is variable. |
| Relevant functions | CS, SC |
| Use case | UC_08_457_v1 |
| Vehicle parameters | $\Delta v_{host\ vehicle}$ |
| Number vehicles | 1 |
| Target objects required (only for real test) | speed limit signs |
| Environmental parameters | Road radius, number of speed limits signs (1, 2), $y_{speedlimit}$, speed limit |
| Road radius | ∞, 500 m |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

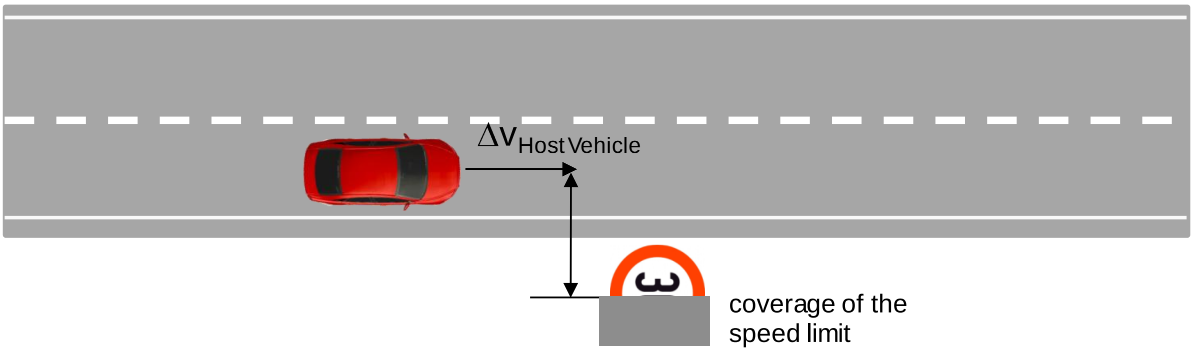
| Test Scenario | Traffic rule violations |
|---|---|
| Test Case | 8.2 |

## Approaching series of speed limits



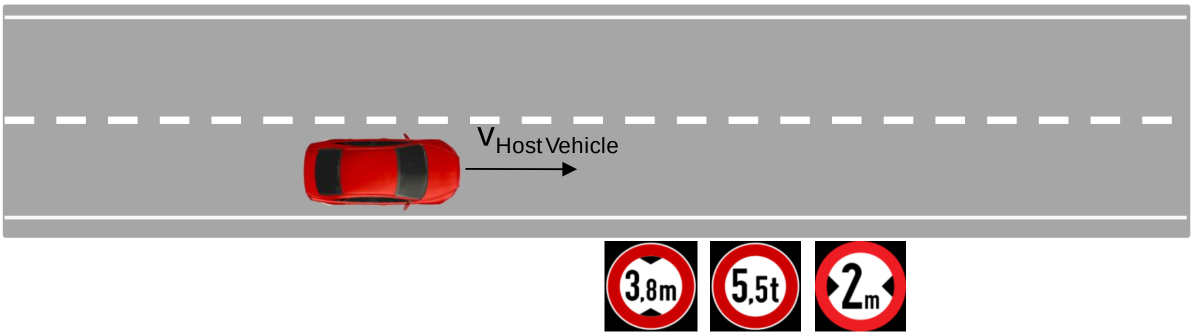

| | |
|---|---|
| Description | Host vehicle approaches a series of speed limit with different relative velocities. The lateral distance of the speed limits is fixed. |
| Relevant functions | CS, SC |
| Use case | UC_08_457_v1 |
| Vehicle parameters | $\Delta v_{host\ vehicle}$ |
| Number vehicles | 1 |
| Target objects required (only for real test) | speed limit signs |
| Environmental parameters | road radius, speed limits |
| Road radius | $\infty$ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Traffic rule violations |
|---|---|
| Test Case | 8.3 |
| **Approaching dynamic speed limit** | |
|   | |
| Description | Host vehicle approaches a dynamic speed limit, which is mounted over the street. |
| Relevant functions | CS, SC |
| Use case | UC_08_457_v1 |
| Vehicle parameters | $\Delta v_{host\ vehicle}$ |
| Number vehicles | 1 |
| Target objects required (only for real test) | dynamic speed limit signs |
| Environmental parameters | road radius, speed limit |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | Difficult to test. Best test real traffic. |

| Test Scenario | Traffic rule violations |
|---|---|
| Test Case | 8.4 |
| **Approaching covered speed limit** | |
|  | |
| Description | Host vehicle approaches a speed limit, which is (partly) covered. Therefore the whole speed limit sign is not visible. |
| Relevant functions | CS, SC |
| Use case | UC_08_457_v1 |
| Vehicle parameters | $\Delta v_{host\ vehicle}$ |
| Number vehicles | 1 |
| Target objects required (only for real test) | speed limit signs |
| Environmental parameters | road radius, speed limits, covering of the speed limit |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Traffic rule violations |
|---|---|
| Test Case | 8.5 |

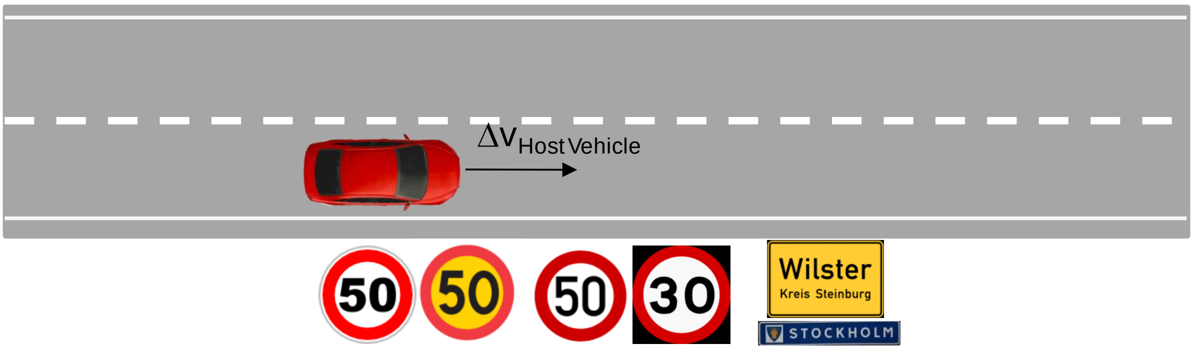
## Approaching similar speed limit signs




| | |
|---|---|
| Description | Host vehicle approaches different traffic signs, which looks similar to a speed limit sign. |
| Relevant functions | CS, SC |
| Use case | UC_08_457_v1 |
| Vehicle parameters | $v_{host\ vehicle}$ |
| Number vehicles | 1 |
| Target objects required (only for real test) | different traffic signs |
| Environmental parameters | road radius, traffic signs |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Traffic rule violations |
|---|---|
| Test Case | 8.6 |

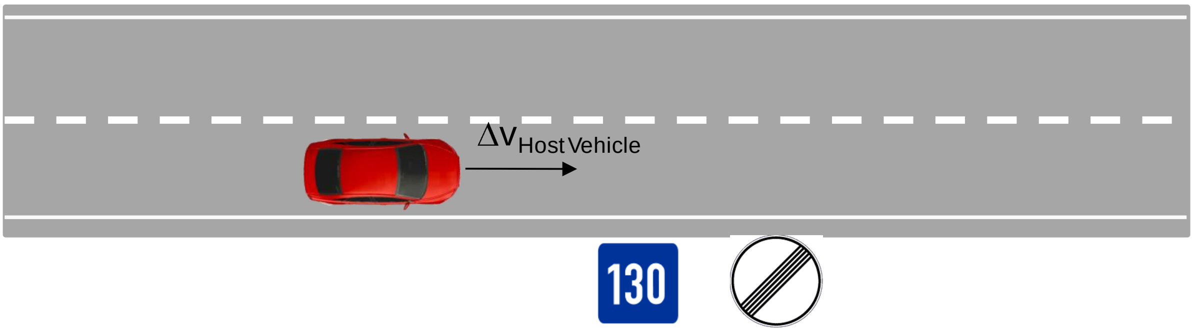
## Approaching speed limit (country)




| | |
|---|---|
| Description | Host vehicle approaches different speed limit signs, which are from different countries. |
| Relevant functions | CS, SC |
| Use case | UC_08_457_v1 |
| Vehicle parameters | $\Delta v_{host\ vehicle}$ |
| Number vehicles | 1 |
| Target objects required (only for real test) | 1 stationary target (balloon car) |
| Environmental parameters | road radius, speed limit (country) |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Traffic rule violations |
|---|---|
| Test Case | 8.7 |

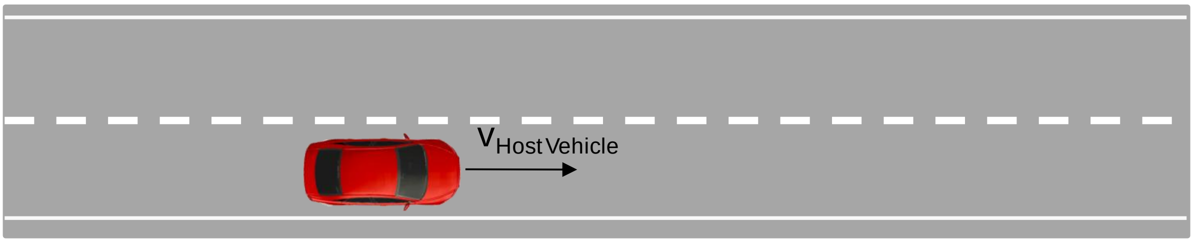
## Exit speed limit




| | |
|---|---|
| Description | Host vehicle approaches the end of speed limit. |
| Relevant functions | CS, SC |
| Use case | UC_08_457_v1 |
| Vehicle parameters | $\Delta v_{host\ vehicle}$ |
| Number vehicles | 1 |
| Target objects required (only for real test) | traffic sign |
| Environmental parameters | road radius, speed limit, traffic sign |
| Road radius | $\infty$ |
| Assessment | ☒ Technical ☐ User-related ☐ Impact |
| Comment | |

| Test Scenario | Verification test |
|---|---|
| Test Case | 9.1 |

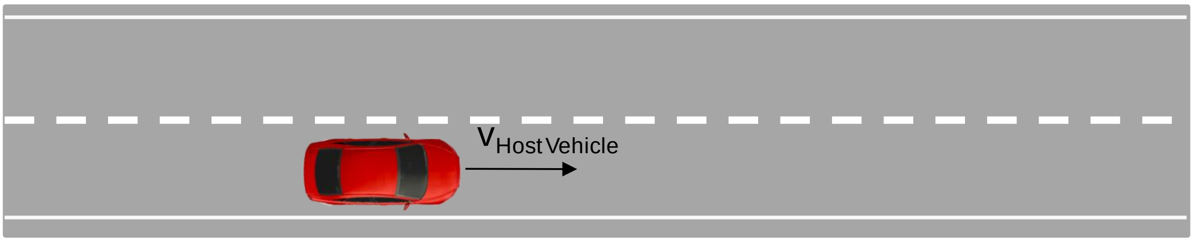
## Speed range



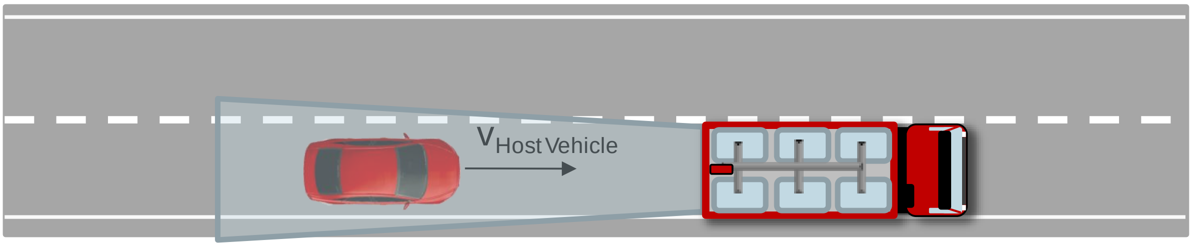

| | |
|---|---|
| Description | Check, whether function works over the specified speed range. |
| Relevant functions | All |
| Use Case | |
| Vehicle parameters | $v_{host\ vehicle}$, function status |
| Number vehicles | 1 |
| Target objects required (only for real test) | none |
| Environmental parameters | road radius |
| Road radius | 0 m |
| Assessment | ☒ Technical ☐ User-related ☒ Impact |
| Comment | |

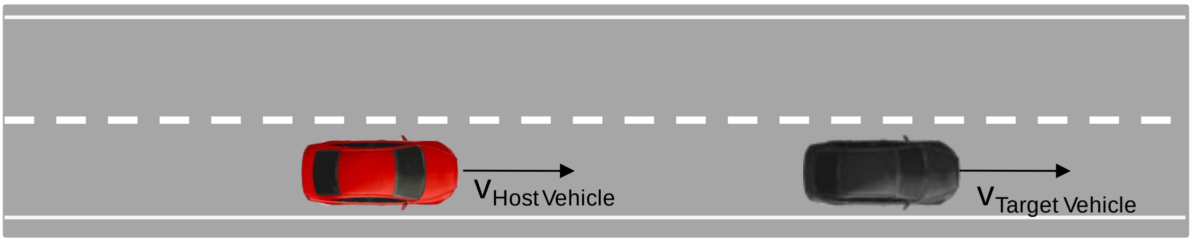
| Test Scenario | Verification test |
|---|---|
| Test Case | 9.2 |

## Braking capacity



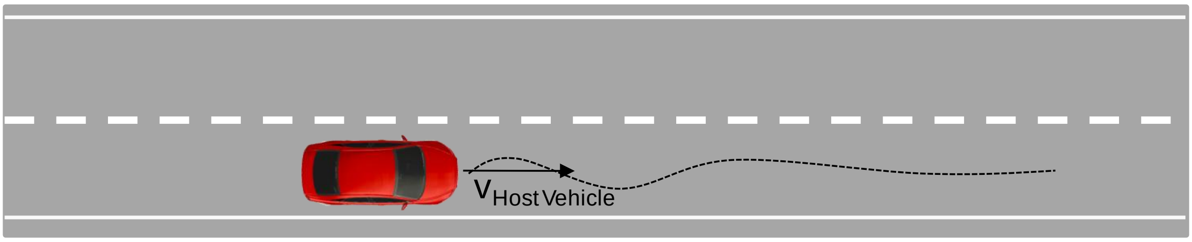

| | |
|---|---|
| Description | Check of the braking capacity of the vehicle (dependent on road condition – dry, wet, black ice). |
| Relevant functions | All |
| Use Case | |
| Vehicle parameters | $v_{host\ vehicle}$, function status |
| Number vehicles | 1 |
| Target objects required (only for real test) | None |
| Environmental parameters | road radius |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☒ Impact |
| Comment | |

| Test Scenario | Verification test |
|---|---|
| Test Case | 9.3 |
| **Weather conditions** | |
|  | |
| Description | Check, whether the function operates in different weather (rain, fog, snow) and lighting conditions (day/night) and road conditions (dry, wet, black ice, covered with snow/ice). |
| Relevant functions | All |
| Use Case | |
| Vehicle parameters | $v_{host\ vehicle}$, function status |
| Number vehicles | 1 |
| Target objects required (only for real test) | rain |
| Environmental parameters | road radius, rain |
| Road radius | ∞ |
| Assessment | ☒ Technical ☐ User-related ☒ Impact |
| Comment | Rain is not specified |

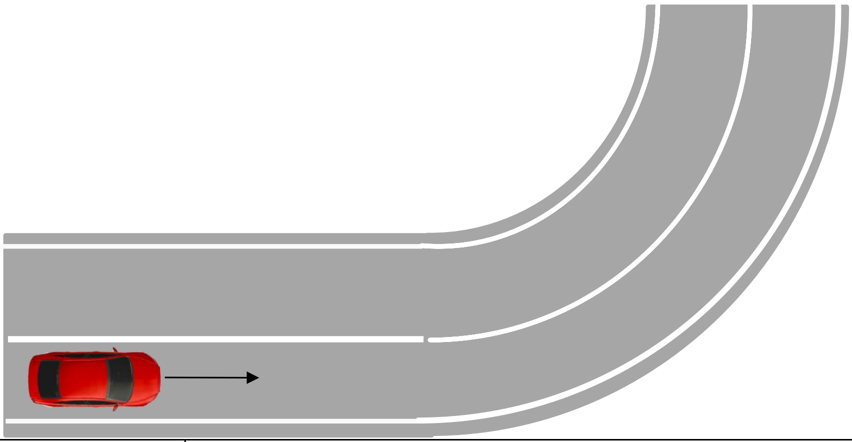
| Test Scenario | Simulation test |
|---|---|
| Test Case | 10.1 |
| **Car following** | |
|  | |
| Description | Driver of the host vehicle follows the target vehicle. The driver of the target vehicle gets instruction to varying the velocity. The driver of the host vehicle should only flow the lead vehicle. |
| Relevant functions | All functions related to use case category “Rear-end conflict” |
| Use Case | UC_01_401_v2, UC_01_531_v1 |
| Initiate values | $v_{host\ vehicle}$, $v_{target\ vehicle}$ |
| Number vehicles | 2 |
| Target objects required (only for real test) | none |
| Environmental parameters | road radius |
| Road radius | various |
| Assessment | ☐ Technical ☐ User-related ☒ Impact |
| Comment | |

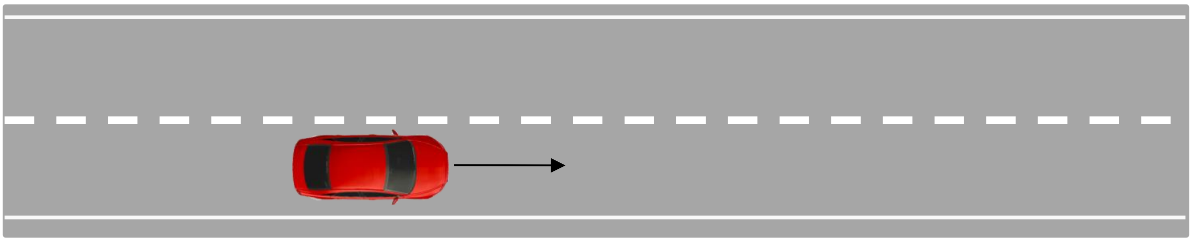
| Test Scenario | Simulation test |
|---|---|
| Test Case | 10.2 |

## Lane keeping



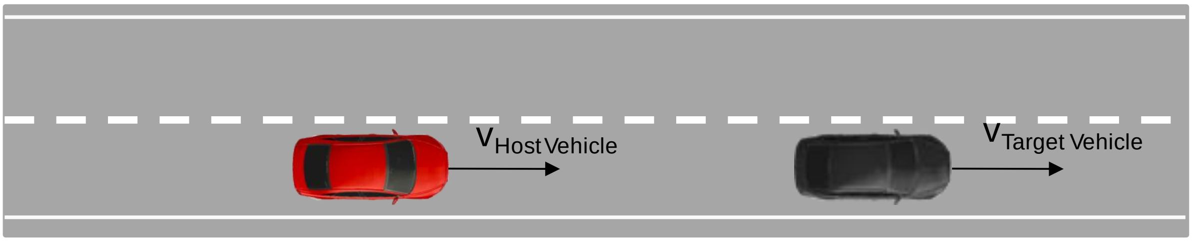

| | |
|---|---|
| Description | Driver of the host vehicle drives in the lane, while the lane keeping behavior is observed. |
| Relevant functions | All functions which are intended for lane change scenarios |
| Use Case | UC_06_454_v0, UC_06_503_v2, UC_06_536_v1, UC_06_510_v2, UC_06_535, UC_06_536_v1 |
| Initiate values | $v_{host\ vehicle}$ |
| Number vehicles | 1 |
| Target objects required (only for real test) | none |
| Environmental parameters | road radius, lane width |
| Road radius | various |
| Assessment | ☐ Technical ☐ User-related ☒ Impact |
| Comment | |

| Test Scenario | Simulation test |
|---|---|
| Test Case | 10.3 |
| **Curve driving** | |
|  | |
| Description | Driver of the host vehicle negotiates on a track different curves. |
| Relevant functions | All functions which are intended scenarios, which are related to curves driving |
| Use Case | UC_ 07_406_v1, UC_ 07_456_v0, |
| Initiate values | $v_{host\ vehicle}$ |
| Number vehicles | 1 |
| Target objects required (only for real test) | none |
| Environmental parameters | road radius, curve angle |
| Road radius | various |
| Assessment | ☐ Technical ☐ User-related ☒ Impact |
| Comment | |

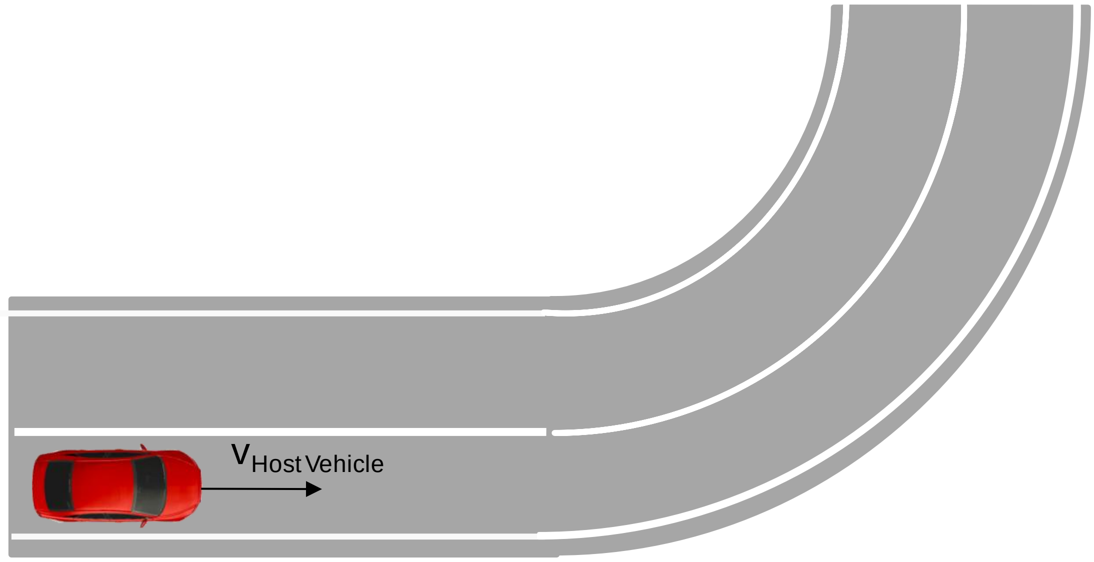
| Test Scenario | Fuel consumption |
|---|---|
| Test Case | 11.1 |
| **Fuel consumption** | |
|  | |
| Description | Test on fuel consumption on a defined track. The driver should not get any instruction except the route, he should drive. |
| Relevant functions | CS, SC, CSC |
| Use Case | |
| Initiate values | $v_{host\ vehicle}$ |
| Number vehicles | 1 |
| Target objects required (only for real test) | none |
| Environmental parameters | none |
| Road radius | not relevant |
| Assessment | ☐ Technical ☐ User-related ☒ Impact |
| Comment | similar velocity course to driving cycle test (e.g. NEFZ) |

| Test Scenario | Fuel consumption |
|---|---|
| Test Case | 11.2 |

## Car following

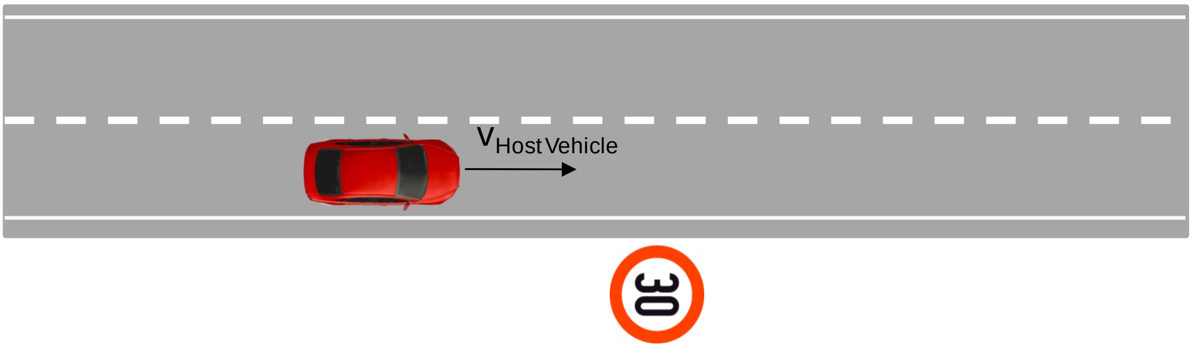



| | |
|---|---|
| Description | Test on fuel consumption in car following scenario. |
| Relevant functions | CS, SC |
| Use Case | UC_01_401_v2, UC_01_531_v1 |
| Initiate values | $v_{target\ vehicle}$, function status |
| Number vehicles | 2 |
| Target objects required (only for real test) | none |
| Environmental parameters | road radius |
| Road radius | various |
| Assessment | ☐ Technical ☐ User-related ☒ Impact |
| Comment | Target vehicle drives a similar velocity course like it is done in driving cycle test (e.g. NEFZ); Driver of the host vehicle should follow the target vehicle. |

| Test Scenario | Fuel consumption |
|---|---|
| Test Case | 11.3 |
| **Curve** | |
|  | |
| Description | Test on fuel consumption. The host vehicle negotiates different curves. |
| Relevant functions | CS, SC, CSC |
| Use Case | UC_ 07_406_v1, UC_ 07_456_v0, |
| Initiate values | $v_{host\ vehicle}$ , function status |
| Number vehicles | 1 |
| Target objects required (only for real test) | None |
| Environmental parameters | road radius, curve angle |
| Road radius | Varied |
| Assessment | ☐ Technical ☐ User-related ☒ Impact |
| Comment | The driver get no instructions how to drive the curve, only initial velocity is set |

| Test Scenario | Fuel consumption |
|---|---|
| Test Case | 11.4 |

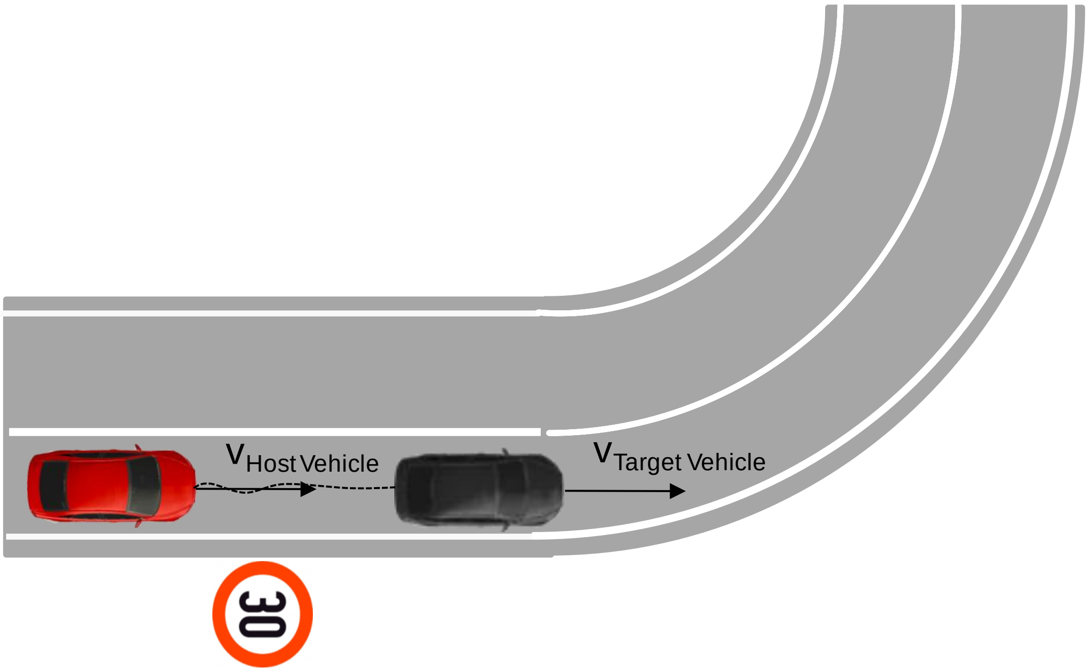
## Speed limit




| | |
|---|---|
| Description | Test on fuel consumption. Host vehicle approaches a speed limit with different relative velocities. |
| Relevant functions | CS, SC, CSC |
| Use Case | UC_07_455_v0, UC_08_457_v1 |
| Initiate values | $v_{host\ vehicle}$, function status |
| Number vehicles | 1 |
| Target objects required (only for real test) | speed limit signs |
| Environmental parameters | raod radius, speed limit |
| Road radius | ∞ |
| Assessment | ☐ Technical ☐ User-related ☒ Impact |
| Comment: | The driver get no instructions how to drive, only initial velocity is set |

| Test Scenario | Combined test |
|---|---|
| Test Case | 12.1 |

## Combined test




| | |
|---|---|
| Description | Combined test of different test case (e.g. test for fuel consumption and simulator test). Should be conducted as a small filed test. |
| Relevant functions | All function (especially CS, CSC; SC) |
| Use Case | Different use cases |
| Initiate values | $v_{host\ vehicle}$, $v_{target\ vehicle}$ , function status |
| Number vehicles | 1 |
| Target objects required (only for real test) | speed limit signs |
| Environmental parameters | road radius, curve angle, speed limit |
| Road radius | various |
| Assessment | ☐ Technical ☒ User-related ☒ Impact |
| Comment | Test in real traffic is preferred, but tests are also possible on a test track or in a simulator. Test route is defined based on test environment. The driver only gets the instruction to drive in normal way. Speed limits, curve radius, curve angle, existence and distance to a processor are varied during the test drive. By these test it is intended to create normal driving situation. No critical situation should be analysed. |