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---|---
SubProject No. | SP5
SubProject Title | CoSSIB
Workpackage No. | WP5
Workpackage Title | Test and validation
Task No. | T5.5.1
Task Title | Test and validation plan
Authors (per company, if more than one company provide it together) | P. J. Feenstra, A.R.A van der Horst TNO; F. Bonnefoi, Cofiroute; N. Etienne, Sodit; S. Glaser, LCPC; A. Possani, DIBE; T. Schendzielorz, TUM; F. Visintainer, CRF; C. Torres, MIZAR

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Planned Date of submission according to TA: | 31/07/2008
Issue Date: | 05/08/2009
Project start date and duration | 01 February 2006, 48 Months
## Revision Log

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<thead>
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<th>Description</th>
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<tbody>
<tr>
<td>AV</td>
<td>Assistance Vehicle</td>
</tr>
<tr>
<td>AEV</td>
<td>Assistance and Emergency Vehicles</td>
</tr>
<tr>
<td>AMR</td>
<td>Anisotropic Magneto-Resistive</td>
</tr>
<tr>
<td>API</td>
<td>Application Programming Interface</td>
</tr>
<tr>
<td>BSCW</td>
<td>Basic Support for Cooperative Work</td>
</tr>
<tr>
<td>CoSSIB</td>
<td>Cooperative Safety Systems Infrastructure Based</td>
</tr>
<tr>
<td>CRF</td>
<td>Centro Ricerche FIAT</td>
</tr>
<tr>
<td>ECAID</td>
<td>Enhanced Cooperative Automatic Incident Detection</td>
</tr>
<tr>
<td>ESPOSYTOR</td>
<td>SAFESPOT SYSTEM MONITOR</td>
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<tr>
<td>EV</td>
<td>Emergency Vehicle</td>
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<tr>
<td>GD</td>
<td>Ghost Driver</td>
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<tr>
<td>GPS</td>
<td>Global Positioning System</td>
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<tr>
<td>H&amp;IW</td>
<td>Hazard and Incident Warning</td>
</tr>
<tr>
<td>HMI</td>
<td>Human Machine Interface</td>
</tr>
<tr>
<td>I2V</td>
<td>Infrastructure-to-Vehicle</td>
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<tr>
<td>ICT</td>
<td>Information Communication Technology</td>
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<tr>
<td>IRIS</td>
<td>Intelligent Cooperative Intersection Safety - System</td>
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<tr>
<td>LDM</td>
<td>Local Dynamic Map</td>
</tr>
<tr>
<td>LDP</td>
<td>LDM Data Player</td>
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<tr>
<td>LED</td>
<td>Light Emitting Diode</td>
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<tr>
<td>LIVIC</td>
<td>Laboratoire sur les Interactions Véhicules-Infrastructure-Conducteurs</td>
</tr>
<tr>
<td>MARS</td>
<td>Multi-Agent Real-Time Simulator</td>
</tr>
<tr>
<td>PC</td>
<td>Personal Computer</td>
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<tr>
<td>PND</td>
<td>Portable Navigation Device</td>
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<td>PRM</td>
<td>Priority Request Manager</td>
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<td>Planung Transport Verkehr AG</td>
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<tr>
<td>Pyro</td>
<td>Pyroelectric</td>
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<tr>
<td>RDep</td>
<td>Road Departure Prevention</td>
</tr>
<tr>
<td>RFID</td>
<td>Radio Frequency Identification</td>
</tr>
<tr>
<td>RQ</td>
<td>Requirement</td>
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<tr>
<td>RSU</td>
<td>Road Side Unit</td>
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<tr>
<td>SCOVA</td>
<td>Cooperative systems applications vehicle based</td>
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<tr>
<td>SDM</td>
<td>Safe Drive Map</td>
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<tr>
<td>SiVIC</td>
<td>Simulateur Véhicule Infrastructure Capteurs</td>
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<tr>
<td>SMA</td>
<td>Safety Margin Assistant</td>
</tr>
<tr>
<td>SMAEV</td>
<td>Safety Margin for Assistance and Emergency Vehicles</td>
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<tr>
<td>SP</td>
<td>Sub-project</td>
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<tr>
<td>SpA</td>
<td>Speed Alert</td>
</tr>
<tr>
<td>TBC</td>
<td>To Be Confirmed</td>
</tr>
<tr>
<td>TBD</td>
<td>To Be Determined</td>
</tr>
<tr>
<td>TLC</td>
<td>Traffic Light Controller</td>
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<tr>
<td>TNO</td>
<td>Nederlandse Organisatie Voor Toegepast Natuurwetenschappelijk Onderzoek</td>
</tr>
<tr>
<td>UC</td>
<td>Use Case</td>
</tr>
<tr>
<td>UDP</td>
<td>User Datagram Protocol (communication protocol)</td>
</tr>
<tr>
<td>VANET</td>
<td>Vehicle Ad hoc Network</td>
</tr>
<tr>
<td>VMS</td>
<td>Variable Message Sign</td>
</tr>
<tr>
<td>VTT</td>
<td>Valtion Teknillinen Tutkimuskeskus</td>
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<tr>
<td>WP</td>
<td>Work-package</td>
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<tr>
<td>WSN</td>
<td>Wireless Sensor Network</td>
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EXECUTIVE SUMMARY

The objective of work package 5 of SP 5 is to carry out tests on the prototypes in order to validate them against the specifications and requirements established in previous work performed in SAFESPOT. The result will be a set of operational applications ready for evaluation at the test sites and in virtual tests by driving simulators and traffic simulation. In the preceding work package, WP4 (Implementation and Prototypes), the infrastructure-based applications have been built. The present deliverable describes the test plans. The second deliverable to be produced within work package WP5 (Test and Validation) will describe the results. The succeeding work package (WP6) will evaluate the applications.

The approach adopted for the testing is the often-used V-model methodology for the development and implementation of ICT systems. In the initial phase, the requirements are defined. Next, a prototype is implemented. Finally, the prototype is validated, i.e., it is checked whether the requirements are met by the system developed. During the validation phase, first the modules are tested. Next, the applications that consist of a number of modules are tested. Finally, the applications together with components from other SPs are tested, i.e. a system test is carried out.

The work performed within the considered task of Test & validation plan consists in the definitions of tests for the five infrastructure-based applications. For each application, the module, the systems, the scenarios, the tools or test sites and the assessment criteria are defined.

The test plans are defined in such a way that the overlap between tests of different applications is minimized. Furthermore, effort is put in covering all functionalities. For each application, at least one complete system test is defined. If required, additional tests will be defined during the test phase. Due to this approach, the test phase continues after the delivery date of the present document. The project server will provide information on the current state of testing and reporting.
1 Introduction

The Test and Validation work package (WP 5.5) is the fifth WP within the COSSIB (COoperative Safety Systems Infrastructure Based) sub-project (SP 5). The objective of WP Test and Validation is to carry out tests on the prototypes in order to validate them against the specifications and requirements established. That is, testing procedures are set out. The validation will be carried out in one or more test-beds, either in laboratories, on tracks or at test sites. WP 5.5 is organized into 2 tasks:

1. Task 5.5.1: Test plan & validation plan
2. Task 5.5.2: Validation tests on tracks and sites.

The result of WP 5.5 is a set of operational applications ready for evaluation at the test sites and in virtual tests.

This deliverable describes the Test and Validation Plan (Task 5.5.1). It defines the test bed platform architecture and component for the tests. Furthermore, tests related to scenarios consistent with the requirements are defined. The Test and Validation plan includes assessment criteria, tools and methods to be used, including a compendium of all consortium equipment vital for the tests for each application.

In the WP Implementation and Prototypes (WP 5.4), the infrastructure-based applications have been built (see Figure 1). As mentioned, the objective of WP 5.5 is to validate the applications against the specifications and requirements established in Deliverables 5.3.1 through 5.3.5 and Deliverable D5.2.1 respectively. The detailed plans for testing are defined in this deliverable (D5.5.1). A second deliverable within the work package Test and Validation describes the results (D5.5.2). WP 5.6 evaluates the systems. A system includes the SP 5 application and components from other SPs (e.g. SP 2, SP 3 and SP 4).

![Figure 1 Work packages interaction and deliverables](image)

Safety applications that are based on vehicle-to-vehicle technology are addressed in a separate SP (SP 4, SCOVA). The work performed between
the associated test and validation WP of SP 4 follow the same organisation of the work within SP5.

The five SP 5 applications for which the plans are defined include:

1. Intelligent Cooperative Intersection Safety System (IRIS)
2. SPEed Alert (SPA)
3. Hazard and Incident Warning (H&IW)
4. Road DEparture Prevention (RDEP)
5. Safety Margins for Assistance and Emergency Vehicles (SMAEV)

In WP 5.5, the main goal is to test the SP 5 components and applications, i.e., the required components from other SP are only implicitly tested. The corresponding SP tests these additional components explicitly.

1.1 Contribution to the SAFESPOT Objectives

The main objective of the SAFESPOT project is to:

(1) show the feasibility and benefits of Co-operative Systems solutions
(2) improving road safety
(3) beyond the level that can be achieved with autonomous solutions (vehicle or infrastructure based).

This deliverable defines the plans for validating the feasibility of the developed solutions. It therefore directly addresses sub-objective (1). Moreover, the result of the validating process is to make the system ready for evaluation. The evaluation phase considers the degree in which the main objective is met. Therefore, this deliverable provides a contribution to the overall main objective.

1.2 Methodology

The approach adopted in the Test and validation plan relies on a standard framework which is common and harmonised within the whole SAFESPOT IP.

A well-known and often used methodology for the development and realisation of ICT systems is the V-model [1], [2]. The advantage of the V-model is that it facilitates the different abstractions that different stakeholders need: end-users can define their user requirements, system architects can design and specify a system architecture that fulfills the user requirements, sub-system designers can work on a sub-system design that complies with the specifications and so on. Another important advantage of the V-model is that the validation and verification activities are identified and specified from the start [5]. Figure 2 depicts a graphical representation of a part of the V-model that is of our interest i.e. that is used for test and validation in this deliverable.
The ‘route’ of a v-model starts at the left-side top of the ‘v’, it passes the bottom and then continues to right-side top.

- Requirements and specification are defined in the initial phase of the development. The definition starts with requirements and specification at the system level. Next, requirements and specifications are defined for the SP 5 (sub-) applications. These SP 5 (sub-) applications are an integration of different modules. These modules are specified at the end of this specification phase.

- The applications are implemented at the bottom in the v-model. In these phase software and hardware are built.

- The ‘right-sided leg’ addresses WP 5.5. Based on the module-, application- and system- test plans, the modules, applications and systems are tested subsequently. After the required modules have been tested, they are integrated to an SP 5 (sub-) application. Together with components from other SPs, complete systems are constructed, which are tested finally.

On the one hand, the test plans are defined in such a way that the overlap between tests of different applications is minimized, i.e., testing of equal functionalities is minimized. On the other hand, a specific effort is put in covering all functionalities. However, we note that full testing with all possible combinations and all possible conditions is practically impossible. Besides that full testing is not feasible, the number of tests is also constrained by the limitation in resources. This obvious limitation to the domain of the test planning is partially overcome by carrying out at least one complete system test. That is, testing the applications together with components of other SPs. If it is required also module and applications test are performed. In the situation that the system is operating according to the system requirements, it is assumed that the underlying components operate properly as well and the requirements at the other levels are met. Again if not, additional tests will be performed. Because of the adopted approach the test-phase continues after...
the due date of this deliverable. In the same way as the SP 4 approach, the project website reflects the current state of testing and reporting.

1.3 Deliverable structure

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Content</th>
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<tr>
<td>2</td>
<td>The report procedure for planning the tests, performing the tests and reporting the test.</td>
</tr>
<tr>
<td>3</td>
<td>Compendium of available consortium equipment.</td>
</tr>
<tr>
<td>4</td>
<td>The test and validation plans of the five COSSIB applications. For each application, first, a brief description is given of the objective, next the sub-applications and optionally the modules are described. Next, the plans for the applications are given.</td>
</tr>
<tr>
<td>5</td>
<td>Discussion about the plans and conclusions</td>
</tr>
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</table>

2 Report procedure

Within the SAFESPOT integrated project it was found to be important to have and apply a common standard to collect data in an homogeneous way. Therefore, a common format has been proposed. Two proposed forms are described in the next two sections. The third section describes the shared collaboration workspace that is used within the project.

2.1 Test form

The Test Form was initially the proposed support tool to prepare tests for SP4; to describe test scenarios, to perform tests and to report results. For transversal applicability for others SPs involved in implementation (basically SP1-2-3-5), it was agreed to extend the method and process to all test activities within the SAFESPOT project.

The test form is a Microsoft Word document [12], which allows the user to define the tests in a unique way. Each test table consists of:

- a header that contains fields for example for, the related SP, WP prototype version etc.
- a Test Case Frame(s) that contains the test description and reports the results. This frame includes a Test Description field of what the test case should do, Expected Values/Results field do describe what the test case should prove and an Obtained Values/Results. The Obtained values Results is left out of the tables presented in this deliverable.

More information about the test form can be found in [11]).
2.2 Non compliancy management tracking form
The Non Compliance Management Tracking Form [10] is the proposed support tool to manage the Collection, the Submission and the Tracking and Fixing of technical problems arising during the SAFESPOT verification and validation activities. In case a problem is encountered during testing in a component which is not tested explicitly, this form could be used. More information about the Non compliancy management tracking form can be found at [9].

2.3 Verification and Validation on the BSCW area
Within the SAFESPOT project BSCW (Basic Support for Cooperative Work) Shared Workspaces are utilized. The BSCW shared workspace system is a tool for group collaboration. Each SP and WP have dedicated areas at this workspace. The test forms and the version management of the test forms are managed in here.

3 Compendium of test tools
This chapter describes the tools to use for the planned simulation tests as described in this deliverable.

3.1 VISSIM
VISSIM is a microscopic, behaviour-based multi-purpose traffic simulation program developed by PTV AG (Karlsruhe, Germany) and is part of the PTV-Vision suite of transportation planning and traffic engineering software programs [15]. It simulates urban and highway traffic, including pedestrians, cyclists and motorized vehicles. It allows the user to display and visualise complex traffic flows in a graphical way

3.2 ITS Modeller
The microscopic traffic simulator - ITS modeller - has been developed by TNO (Delft, Netherlands) to fulfil the need for a modelling environment in which intelligent cooperative vehicle-infrastructure systems can be modelled, tested and evaluated for their impact on traffic throughput, safety and environment [18]. The ITS modeller is built upon existing traffic simulation models, currently using Paramics.

3.3 MARS
MARS (Multi-Agent Real-time Simulator) is a sub-microscopic simulator developed by TNO (Delft, Netherlands). Sub-microscopic or nanoscopic simulations divide the vehicle/driver instance used by microscopic simulations again into its subparts, such as the engine, the wheels, but also the driver’s eyes, an internal world representation, etc.

MARS can handle complex traffic scenarios with multiple interacting road users. The multi-agent based framework decomposes the traffic simulation into a number of autonomous entities. These entities are controlled by their internal dynamics and communicate via abstract sensors and actuators. More information can be found in [14].
3.3.1 **MARS – LDP (LDM Data Player)**

LDP (LDM Data Player) is a data player that pushes dynamic data into the LDM to enable demonstration and testing of SAFESPOT applications [13]. These dynamic data are data from vehicles. The data reaches the LDP in two possible ways:

- it receives the data stream on-line from a simulation (on-line input as UDP message), or
- generates the stream from prerecorded data files (off-line) (off-line input from csv (.ldp) files)

The data can be generated by MARS or other tools (e.g. data loggers). Figure 3 shows how the LDP can be used.

![Diagram of LDP](image)

**Figure 3** LDP is a LDM client to feed dynamic data into the LDM

3.4 **ESPOSYTOR**

ESPOSYTOR is the common diagnostics and monitoring tool developed within the SAFESPOT project to support the implementation and testing activities of all SAFESPOT partners. It can be used both for the vehicles and the infrastructure [4].

ESPOSYTOR can visualize the environment around the ego vehicle or the test site under analysis, i.e., it shows a map with equipped vehicles and infrastructure elements. The visual data is updated dynamically. Furthermore, one can retrieve parameter and variable values, and messages send and received by these nodes. Figure 4 shows the main page of the ESPOSYTOR monitoring tool.
3.5 SiVIC
The SiVIC (Simulateur Véhicule-Infrastructure-Capteurs, Vehicle-Infrastructure-Sensors Simulator) platform is a software platform for complete simulations developed by LIVIC (Satory, France). It offers the same interactivity as a real vehicle: steering wheel angle, acceleration, braking, etc. This enables the possibility to integrate ADAS applications into SiVIC and test pre-defined driving situations [7].

4 Test & validation plans
In the next sections the test plans of the five COSSIB applications are defined. For each application, first, a brief description of the objective is given, next the different sub-applications are listed and thirdly, optionally the modules are listed. Finally the test plans for the applications are given.

Each test contains a listing of the requirement that are tested and a list of the associated use cases. A detailed description of the requirements and the use cases can be found in [8].

4.1 Intelligent Cooperative Intersection Safety System (IRIS)

4.1.1 Description
This application calculates and predicts the trajectories of the road users in proximity of urban intersections. Based on these trajectories, safety-critical situations are identified and a warning decision is taken.

The objective of IRIS is to identify potential red light violators, to support drivers turning right in being aware of pedestrians and cyclists as well as to assist left turning vehicles without a separate left-turn signal phase. Furthermore, the safe crossing of emergency vehicle is supported. The reader is referred to [16] for details.
4.1.2 Modules

IRIS consists of the following modules (see Figure 5 for a functional description):

- The Trajectory Prediction component predicts the trajectories of each vehicle stored in the LDM.

- The task of the Conflict Area Monitor component is to identify safety critical situations at an intersection by analyzing predicted trajectories and possible conflicts.

- The Vehicle Analyser component calculates conflict indicators. These indicators estimate the required time for a vehicle to stop. Furthermore, this module predicts whether a vehicle will be able to stop in time.

- The Threat Assessor module analyses the probability of a safety critical situation.

- Based on the assessed threat a decision on the appropriate warning strategy has to be taken. The Warning Decision Manager decides which warning and recommendation has to be displayed to the driver by the means of an in-vehicle HMI.
### 4.1.3 Test forms

#### Table 1 IRIS Simulation

<table>
<thead>
<tr>
<th>TEST FORM</th>
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<tr>
<td>Form Progressive Numb.</td>
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<tr>
<td>Functional Component</td>
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</table>

**Test Case 1: IRIS – Trajectory Prediction Test – simulation in VISSIM (or MARS)**

**Test Description**

**Prerequisite:**
- The LDM contains the detailed static description of the intersection such as allocations of stop lines, the reference tracks, signal groups and the assignment of the signal groups of the appropriate lanes. In addition, the data concerning moving objects need to be provided by the SP2 data platform.

- Furthermore, the intersection needs to be modelled in the simulation environment including all vehicles, cyclists and movements. The traffic is generated randomly.

- The simulated data need to be fed into the LDM.

**Description:**
- Based on the current situation, the IRIS Trajectory Prediction estimates the future trajectories of the vehicles at the intersection of each vehicle present in the LDM. This basic function is needed for all use cases of the IRIS Application (see list below)

**Tools:**
- VISSIM (or MARS)

**Requirements:**
- SP5_RQ01_36_v1.0: The system shall be able to calculate the trajectories of all vehicles approaching and passing critical points e.g. urban intersections.

- SP5_RQ03_36_v1.0: The system shall be able to calculate the trajectories of all cyclists approaching and passing the intersection.

- SP5_RQ04_36_v1.0: The system shall be able to predict the vehicle’s trajectories.

- SP5_RQ08_19_v1.0: The system shall take into account the actual and short-term forecast of the traffic light control status.

- SP5_RQ18_19_v1.0: The system shall be able to manage all vehicles in the vicinity of a critical point (e.g. the intersection) simultaneously.

- SP5_RQ19_36_v1.0: The system shall have nearly the same performance in case there are just two or 80 vehicles to manage.
- SP5_RQ41_19_v1.0: The LDM shall describe the static geometry of critical points (e.g. intersections) in a detailed, accurate and systematic way. The geometry shall comprise at least approaches, exits, lanes (also bicycle lanes), stop lines and pedestrian crossings as well as the topology of the lanes (left-turn, right-turn, straight ahead).
- SP5_RQ42_19_v1.0: The LDM shall provide a unique scheme for dynamic traffic information to refer to.
- SP5_RQ79_6_v1.1: The intended route on the intersection shall be known either in some direct manner, or indirectly through the status of vehicles indicator.

Use cases:
- SP5_UC22: Safe signalized intersection (crossing, turning)
- SP5_UC31: Safe signalized intersection (red light violation)
- SP5_UC52: Emergency vehicle is approaching a controlled intersection

<table>
<thead>
<tr>
<th>Expected Values / Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>The listed requirements are met, specifically for each vehicle present in the LDM the trajectory prediction is performed.</td>
</tr>
<tr>
<td>An assessment of the quality of the predicted trajectories compared to the real ones is provided.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Obtained Values / Results</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Status Test Case</th>
<th>To Be Done</th>
<th>Link to external annexed documentation (if any)</th>
</tr>
</thead>
</table>

**Test Case 2: IRIS – Identification of critical situations – simulated in VISSIM (or MARS)**

**Test Description**

**Prerequisite:**
- The LDM contains the detailed static description of the intersection such as allocations of stop lines, the reference tracks, signal groups and the assignment of the signal groups of the appropriate lanes. In addition, the data concerning moving objects need to be provided by the SP2 data platform.
- Furthermore, the intersection needs to be modelled in the simulation environment.
- The simulated data need to be fed into the LDM.

**Description:**
- Based on the prediction of the trajectories IRIS identifies safety critical situations. The trajectories are predicted from randomly generated traffic. The identification is stored in an internal log file for validation at a later stage.

**Tools:**
- VISSIM (or MARS)

**Requirements:**
- SP5_RQ08_19_v1.0: The system shall take into account the actual and short-term forecast of the traffic light control status.
- SP5_RQ18_19_v1.0: The system shall be able to manage all vehicles in the vicinity of a critical point (e.g. the intersection) simultaneously.
- SP5_RQ19_36_v1.0: The system shall have nearly the same performance in case there are just two or 80 vehicles to manage.
- SP5_RQ26_36_v1.0: The system shall receive the exact position of all pedestrians at the intersection from the LDM.
- SP5_RQ85_6_v1.1: When processing is needed for sensing, the processing time should be in the order of at most 0.1 second.
- SP5_RQ05_36_v1.0: The system shall be able to identify safety critical situations at the surrounding of a critical point e.g. an urban intersection.
### Use cases:

- SP5_UC22: Safe signalized intersection (crossing, turning)
- SP5_UC31: Safe signalized intersection (red light violation)

### Expected Values / Results

- The listed requirements are met. Specifically, each safety critical situation can be identified

### Obtained Values / Results

<table>
<thead>
<tr>
<th>Status</th>
<th>Test Case</th>
<th>Link to external annexed documentation (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>To Be Done</td>
<td></td>
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</tbody>
</table>
## Table 2 IRIS Test site

<table>
<thead>
<tr>
<th>SP</th>
<th>WP</th>
<th>Prototype Version</th>
<th>System Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>5</td>
<td>Compiled by / Company</td>
<td>TUM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Date</td>
<td>21/06/2009</td>
</tr>
<tr>
<td>HW Release</td>
<td>SW Release</td>
<td>Functional Component</td>
<td>IRIS</td>
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<tr>
<td>Form Progressive Numb.</td>
<td>2</td>
<td>Reference Document</td>
<td>D5.3.3</td>
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</table>

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Test Objective</th>
<th>Test Purpose</th>
<th>Test Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unitary</td>
<td>Verification</td>
<td>Correctness</td>
<td>Test site</td>
</tr>
</tbody>
</table>

### Test Case 1: IRIS – General technical tests – test site

**Test Description**

- Prerequisite:
  - The LDM contains the detailed static description of the intersection such as allocations of stop lines, the reference tracks, signal groups and the assignment of the signal groups of the appropriate lanes. In addition to that, the data concerning moving objects need to be provided by the SP2 data platform. The connection to the SINTECH router is set up and the routing software works properly.

- Description:
  - It is checked, whether in each test scenario the vehicles and vulnerable road user are present in the LDM. It will be checked, whether the traffic light status is in the LDM. In the case IRIS generates a warning, it will be checked, whether this warning is transmitted to the router via the SP5 message manager or not.
Red Light Violation: The violator is warned

- RSU
- TLC
- Critical Warning Zone
- Critical Warning (unicast)
  - SAFESPOT-Vehicle
  - Need to be marked at the road
  - Need to changed in LDM
- Critical Distance 5 - 20m
- Hamburgerstraße
- Gerichtsstraße
- West - East

Red Light Violation: The other road users are warned

- RSU
- TLC
- Critical Warning Zone
- Critical Distance
- Critical Warning (unicast)
  - SAFESPOT-Vehicle
  - Need to be marked at the road
  - Need to changed in LDM
- Critical Warning (broadcast)

Right Turning: cyclist warning

- VRU (cyclist)
  - (no warning possible)

Right Turning: pedestrian warning

- VRU (pedestrian)
  - (no warning possible)
Left Turning: oncoming vehicle warning

Emergency Vehicle

Test sites / intersections
- Germany: Dortmund (PG-LDM)
Map of the intersection used for the tests in the City of Dortmund

Requirements:
- SP5_RQ06_19_v1.0: The system shall be able to provide a priority level for each transmitted message. This is valid for V2I as well as for I2V communication.
- SP5_RQ07_19_v1.0: The system shall be able to determine the period of validity of the transmitted and received messages.
- SP5_RQ21_36_v1.0: The system must be an open system that will be able to host modules from various vendors.
- SP5_RQ26_36_v1.0: The system shall receive the exact position of all pedestrians at the intersection from the LDM.
- SP5_RQ28_19_v1.0: The short range communication shall be available at the intersection itself and its vicinity (minimum 150 m in each direction).
- SP5_RQ33_19_v1.0: All data transmitted from the vehicle to the infrastructure shall have a timestamp referring to the creation time of the data (and not to the transmission time point).
- SP5_RQ34_19_v1.0: The roadside sub-system must be able to address data directly to one vehicle distinctively (or a group of vehicles) or to broadcast to all vehicles in the vicinity of the RSU.
- SP5_RQ40_19_v1.0: Messages that are exchanged between vehicles and RSU have to be unified to insure system interoperability.
- SP5_RQ41_19_v1.0: The LDM shall describe the static geometry of critical points (e.g. intersections) in a detailed, accurate and systematic way. The geometry shall comprise at least approaches, exits, lanes (also bicycle lanes), stop lines and pedestrian crossings as well as the topology of the lanes (left-turn, right-turn, straight ahead).
- SP5_RQ42_19_v1.0: The LDM shall provide a unique scheme for dynamic traffic information to refer to.
- SP5_RQ44_19_v1.0: The system shall receive the position of the vehicles with an accuracy enabling to distinguish between two vehicles.
- SP5_RQ45_27_v1.0: In critical points the position of the vehicles shall be determined with a minimal accuracy of +/- 1m.
- SP5_RQ46_19_v1.0: The positioning of vehicles have to fulfil the accuracy up to a lane detection extend.
- SP5_RQ47_19_v1.0: In case of pedestrians and cyclists the system shall take into account demand signals (push buttons) or data from according road-side sensors.
- SP5_RQ49_19_v1.0: The RSU subsystem shall be able to receive at minimum the current vehicle position and speed.
- SP5_RQ50_36_v1.0: The system shall be able to transmit the warning / recommendation to equipped vehicles.
- SP5_RQS3_19_v1.0: The system shall receive in the vicinity of the urban intersection the position, speed and acceleration and driving direction with a frequency of 2/sec or shorter.
- SP5_RQ54_36_v1.0: The system shall receive in the vicinity of the urban intersection extended dynamic vehicle data like position of brake and acceleration pedal, angel of steering wheel.
- SP5_RQ56_19_v1.0: The system shall receive in the vicinity of the urban intersection the indicator state of the vehicles or alternatively / additionally – in case of an activated navigation system - their turning relations with respect to this intersection.
- SP5_RQ61_36_v1.0: The system must be able to receive data from the vehicles as well as the infrastructure.
- SP5_RQ79_6_v1.1: The intended route on the intersection shall be known. Either in some direct manner, or indirectly through the status of vehicles indicator.
- SP5_RQ80_6_v1.1: Information about emergency vehicles that need to ignore a red light shall be available.
- SP5_RQ86_6_v1.1: It shall be possible to give warnings to drivers. Preferably with a graphical identification of the type and location of potential conflicts.

Use cases:
- SP5_UC22: Safe signalized intersection (crossing, turning)
- SP5_UC31: Safe signalized intersection (red light violation)
- SP5_UC52: Emergency vehicle is approaching a controlled intersection

Use cases:

Expected Values / Results
The requirements are met. Specifically:
- successful interaction with the LDM
- successful interaction with the SP2 data platform
- successful reception of the IRIS message at the message manager and the SINTECH router, respectively

Obtained Values / Results

Test Case 2: IRIS – Trajectory Prediction Test – test site

Test Description

Prerequisite:
- The LDM contains the detailed static description of the intersection such as allocations of stop lines, the reference tracks, signal groups and the assignment of the signal groups of the appropriate lanes. In addition, the data concerning moving objects need to be provided by the SP2 data platform. The traffic equals the traffic that has been described in the previous test case.

Description:
- Based on the current situation, the IRIS Trajectory Prediction estimates the future trajectories of the vehicles at the intersection for each vehicle present in the LDM. This basic function is needed for all use cases of the IRIS Application (see list below). By the means of the following test scenarios, the prediction will be tested:
  - Red Light Violation: The violator is warned
  - Red Light Violation: The other road users are warned
  - Right Turning: cyclist warning
  - Right Turning: pedestrian warning
  - Left Turning: oncoming vehicle warning
Test sites / intersections
- Germany: Dortmund (PG-LDM) (Map of the intersection see test case above.)

Requirements:
- SP5_RQ04_36_v1.0: The system shall be able to predict the vehicle’s trajectories.
- SP5_RQ08_19_v1.0: The system shall take into account the actual and short-term forecast of the traffic light control status.
- SP5_RQ26_36_v1.0: The system shall receive the exact position of all pedestrians at the intersection from the LDM.
- SP5_RQ33_19_v1.0: All data transmitted from the vehicle to the infrastructure shall have a timestamp referring to the creation time of the data (and not to the transmission time point).
- SP5_RQ41_19_v1.0: The LDM shall describe the static geometry of critical points (e.g. intersections) in a detailed, accurate and systematic way. The geometry shall comprise at least approaches, exits, lanes (also bicycle lanes), stop lines and pedestrian crossings as well as the topology of the lanes (left-turn, right-turn, straight ahead).
- SP5_RQ42_19_v1.0: The LDM shall provide a unique scheme for dynamic traffic information to refer to.
- SP5_RQ44_19_v1.0: The system shall receive the position of the vehicles with an accuracy enabling to distinguish between two vehicles.
- SP5_RQ45_27_v1.0: In critical points the position of the vehicles shall be determined with a minimal accuracy of +/- 1m.
- SP5_RQ46_19_v1.0: The positioning of vehicles have to fulfill the accuracy up to a lane detection extend.
- SP5_RQ47_19_v1.0: In case of pedestrians and cyclists the system shall take into account demand signals (push buttons) or data from according road-side sensors.
- SP5_RQ49_19_v1.0: The RSU subsystem shall be able to receive at minimum the current vehicle position and speed.
- SP5_RQ53_19_v1.0: The system shall receive in the vicinity of the urban intersection the position, speed and acceleration and driving direction with a frequency of 2/sec or shorter.
- SP5_RQ54_36_v1.0: The system shall receive in the vicinity of the urban intersection extended dynamic vehicle data like position of brake and acceleration pedal, angle of steering wheel.
- SP5_RQ56_19_v1.0: The system shall receive in the vicinity of the urban intersection the indicator state of the vehicles or alternatively / additionally – in case of an activated navigation system - their turning relations with respect to this intersection.
- SP5_RQ57_19_v1.0: The system shall receive the position of the vehicles in the near vicinity of the urban intersection (<30m from stop line) with an accuracy enabling to assign the vehicle clearly to a lane.
- SP5_RQ79_6_v1.1: The intended route on the intersection shall be known. Either in some direct manner, or indirectly through the status of vehicles indicator.
- SP5_RQ84_6_v1.1: Localisation should be accurate to the level of a lane and with a 1 meter accuracy, this (in combination with the vehicles indicator makes it possible to determine whether a vehicle is about to turn

Use cases:
- SP5_UC22: Safe signalized intersection (crossing, turning)
- SP5_UC31: Safe signalized intersection (red light violation)

Expected Values / Results
- The listed requirements are met, specifically for each vehicle present in the LDM the trajectory prediction is performed.
- An assessment of the quality of the predicted trajectories compared to the real ones is provided.

Obtained Values / Results

Status Test Case 2 | To Be Done | Link to external annexed documentation (if any)
### Test Case 3: IRIS – Trajectory Prediction Test – test site

#### Test Description

**Prerequisite:**
- The LDM contains the detailed static description of the intersection such as allocations of stop lines, the reference tracks, signal groups and the assignment of the signal groups of the appropriate lanes. In addition to that, the data concerning moving objects need to be provided by the SP2 data platform.

**Description:**
- Based on the prediction of the trajectories, IRIS identifies safety critical situations. The identification is stored in an internal log file for validation at a later stage. For the test Scenarios see the Test Case 1 above.

**Test sites / intersections**
- Germany: Dortmund (PG-LDM) (Map of the intersection see test case above.)

**Requirements:**
- SP5_RQ05_36_v1.0: The system shall be able to identify safety critical situations at the surrounding of a critical point e.g. an urban intersection.

**Use cases:**
- SP5_UC22: Safe signalized intersection (crossing, turning)
- SP5_UC31: Safe signalized intersection (red light violation)

#### Expected Values / Results

The requirements are met. Specifically:
- Each safety critical situation is identified

#### Obtained Values / Results

**Status Test Case 3** | **To Be Done** | **Link to external annexed documentation (if any)**
4.2 Speed Alert (SpA)

4.2.1 Description

This application provides drivers with the recommended speed based on a real-time evaluation of parameters such as weather status, road surface conditions, road typology, traffic flow speed and other events like road works, traffic jam and deviations. The reader is referred to the SAFESPOT deliverable [6] for more information.

The application consists of three sub-applications.

- **SpA_01 Legal Speed Limit**: the goal is to warn drivers on excessive speed with respect to the legal speed limit.

- **SpA_02 Critical Speed Warning**: which also warn drivers on excessive speed, but the speed limit is now dynamic and takes into account the environment and traffic condition. This sub-application collaborates with the Hazard and Incident Warning Application.

- **SpA_03 Excessive Speed Alert**: the objective is now to define a speed limit with respect to the road; the road definition and the road status. Furthermore, it warns drivers near a black spot.

4.2.2 Modules

SpA is build-up around the following modules:

- The Event Manager Module that is in charge of monitoring the LDM, sends queries and generates appropriate threads for the sub-applications.

- The Vehicle Tracking Module is called when a new vehicle enters an area covered by an RSU. It is in charge of monitoring a vehicle and it sends messages regarding the specified speed. This speed can be the legal speed, a recommended speed or the speed associated with an H&IW event.

- The Gateway to the VMS can locally warn several drivers for specific conditions.

- The Critical Speed Module updates the LDM with the H&IW event information, it takes care that only one speed recommendation per road segment is given (to prevent overloading), and it retrieves a new event when the present event finishes (to deliver a new speed recommendation).

- The Speed Profile Evaluation module computes the speed profile when a static black spot is approached.

4.2.3 Test form

Test described for SpA are mainly focused on simulation. In fact, most of the tests focus on the internal validation of the SpA functionalities. However, for SpA_01 and SpA_02, some tests are designed in order to integrate and validate the whole processing of information. These tests will be extended to real test sites (mainly the France test site, Satory, closed track).
Table 3 SpA_01 Simulation

<table>
<thead>
<tr>
<th>Function Component</th>
<th>Reference Document</th>
<th>Test Purpose</th>
<th>Test Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>SpA_01</td>
<td>D5.3.1</td>
<td>Verification</td>
<td>Simulation</td>
</tr>
</tbody>
</table>

Test Case 1: Speed transition at a straight road

Test Description

Prerequisite:
- Functional LDM and VANET modules

Description:
The aim of this test is to prove the basic functionality of SpA_01. It warns the driver on excessive speed, regarding the legal speed limit. The road is a simple straight line with a modification of the speed limit at a given position.

- The driver enters an area that is covered by a road-side unit (RSU), the vehicle transmits its beaconing message.
- The RSU detects the vehicle, and starts managing it.
- If the vehicle speed is higher than the speed limit, a warning is sent from the RSU.
- The vehicle receives the message and displays the warning to the driver.
- Vehicles entering the area are chosen randomly, as is their speed.

Specific test conditions:
- The vehicle type is identified using simple classes: passenger car or truck (which may have a specific speed limit)
- The nominal road speed ranges from 90km/h; 110km/h and 130 km/h.
- The modification of the speed in the middle of the road section decrease to 50km/h, 90km/h and 110km/h respectively.
Requirements:
- RQ02_36_v1.0 (Message Management) The system shall be able to decide if and to whom a message has to be send.
- RQ06_19_v1.0 (Priority Level of Message) The system shall be able to provide a priority level for each transmitted message. This is valid for V2I as well as for I2V communication.
- RQ12_33_v1.0 (Data exchange) The system shall be able to transmit information towards several supporters (e.g. VMS, radio, PND).
- RQ16_36_v1.0 (Query from the LDM) The system shall be able to query needed data from the LDM.
- RQ17_36_v1.0 (Receive data from the LDM) The system shall be able to receive and handle the LDM data.
- RQ18_19_v1.0 (Simultaneity) The system shall be able to manage all vehicles in the vicinity of a critical point (e.g. the intersection) simultaneously.
- RQ19_36_v1. (Scalability) The system shall have nearly the same performance in case there are just two or 80 vehicles to manage.
- RQ20_19_v1.0 (Time of Warning Generation) The system shall generate and transmit warning information to the drivers timely enough, so that the reaction time left to the drivers is appropriate.
- RQ24_19_v1.0 (Robustness of System) The system has to be robust enough in order to operate under different extreme weather conditions (heat, cold, snow, etc.).
- RQ29_27_v1.0 (Range of Communication) The short range communication shall be available at the critical points and their vicinity (minimum 600 m).
- RQ31_27_v1.0 (Simultaneous Communication) The system shall be able to communicate with all vehicles in the vicinity of the intersection (minimum radius <= 600 m) simultaneously.
- RQ48_36_v1.0 (Environmental Data) The system shall receive data from environmental sensors about weather (rain, snow, fog...).
- RQ49_19_v1.0 (Position and speed of vehicles) The RSU subsystem shall be able to receive at minimum the current vehicle position and speed.
- RQ50_36_v1.0 (Transmission of warnings) The system shall be able to transmit the warning / recommendation to equipped vehicles.
- RQ68_10_v1.0 (Road status) The system shall acquire data on the weather conditions in the ‘critical area’ (extent TBD) of the obstacle or accident, i.e. wet/dry road surface, rain, fog, ice, which may affect stopping distances and visibility.
- RQ69_10_v1.0 (V Warning) The system shall send appropriate warnings to equipped vehicles within the critical (e and a) zones to permit them to reduce speed and/or change lane and avoid a (secondary) collision.
### User Needs:

SP5_UN38: Give to the driver a continuous access to the information of speed limit.

SP5_UN39: Infrastructure can warn the driver in case of excessive speed

### Use cases:

SP5_UC32: Prevention of Driver Excessive Speed

<table>
<thead>
<tr>
<th>Expected Values / Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>The requirements are met, specifically:</td>
</tr>
<tr>
<td>- The vehicle transmits its beaconing message.</td>
</tr>
<tr>
<td>- The RSU detects the vehicle</td>
</tr>
<tr>
<td>- In case of speeding, the vehicle is specifically warned, otherwise, the vehicle on-board system knows the legal speed limit</td>
</tr>
<tr>
<td>- The legal speed limit in the first area is consistent with the speed limit in the RSU LDM</td>
</tr>
<tr>
<td>- The time elapsed between the crossing of the new area and the reception of the new speed limit, is not higher than 1s</td>
</tr>
<tr>
<td>- The time between the start of the over speeding and the reception of the message from the RSU is not higher than 1s</td>
</tr>
<tr>
<td>- The vehicle type is identified using simple classes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Obtained Values / Results</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Status Test Case 1</th>
<th>To Be Done</th>
<th>Link to external annexed documentation (if any)</th>
</tr>
</thead>
</table>

### Test Case 2: Speed transition at a straight road with different weather conditions

#### Test Description

**Prerequisite:**

- Functional LDM and VANET modules

**Description:**

The aim of this test is to ensure that the SpA_01 application can handle accurately the weather condition and the associated speed limit. In this test case, the road network is more complex AND accounts for various road types (urban, interurban and highway)

The network is generated with traffic that initially can have over speed problems. Various weather conditions are tested (rain, fog). The test scenario is the same as test case 1:
- The driver enters an area covered by a road side unit, the vehicle transmits its beaconing message
- The RSU detects the vehicle, and starts managing it.
- If the vehicle speed is higher than the speed limit, a warning is sent from the RSU.
- The vehicle receives the message and displays the warning to the driver.

**Specific test conditions:**

- The road types in the simulation have various speed limits: ranging from 50km/h to 130km/h
- The distribution of vehicles at the road are chosen randomly (see previous case)
- Vehicles entering the area covered by the road side unit have a defined road trip
- The weather condition ranges from normal weather to fog situations. the SpA_01 application must then adjust legal speed accordingly to the situation (for instance, the legal speed on a highway must drop from 130km/h to 110km/h, more details are given in D5.3.1)
### Tools:
- LDM Data player
- Internally developed tools for the vehicle

### Requirements:
- **RQ02_36_v1.0 (Message Management)** The system shall be able to decide if and to whom a message has to be send.
- **RQ06_19_v1.0 (Priority Level of Message)** The system shall be able to provide a priority level for each transmitted message. This is valid for V2I as well as for I2V communication.
- **RQ12_33_v1.0 (Data exchange)** The system shall be able to transmit information towards several supporters (e.g. VMS, radio, PND).
- **RQ16_36_v1.0 (Query from the LDM)** The system shall be able to query needed data from the LDM.
- **RQ17_36_v1.0 (Receive data from the LDM)** The system shall be able to receive and handle the LDM data.
- **RQ18_19_v1.0 (Simultaneity)** The system shall be able to manage all vehicles in the vicinity of a critical point (e.g. the intersection) simultaneously.
- **RQ19_36_v1.** (Scalability) The system shall have nearly the same performance in case there are just two or 80 vehicles to manage.
- **RQ20_19_v1.0 (Time of Warning Generation)** The system shall generate and transmit warning information to the drivers timely enough, so that the reaction time left to the drivers is appropriate.
- **RQ24_19_v1.0 (Robustness of System)** The system has to be robust enough in order to operable under different extreme weather conditions (heat, cold, snow, etc.).
- **RQ29_27_v1.0 (Range of Communication)** The short range communication shall be available at the critical points and their vicinity (minimum 600 m).
- **RQ31_27_v1.0 (Simultaneous Communication)** The system shall be able to communicate with all vehicles in the vicinity of the intersection (minimum radius <= 600 m) simultaneously.
- **RQ48_36_v1.0 (Environmental Data)** The system shall receive data from environmental sensors about weather (rain, snow, fog…).
- **RQ49_19_v1.0 (Position and speed of vehicles)** The RSU subsystem shall be able to receive the current vehicle position and speed.
- **RQ50_36_v1.0 (Transmission of warnings)** The system shall be able to transmit the warning / recommendation to equipped vehicles.
- **RQ68_10_v1.0 (Road status)** The system shall acquire data on the weather conditions in the ‘critical area’ (extent TBD) of the obstacle or accident, i.e. wet/dry road surface, rain, fog, ice, which may affect stopping distances and visibility.
- **RQ69_10_v1.0 (V Warning)** The system shall send appropriate warnings to equipped vehicles within the critical (e and a) zones to permit them to reduce speed and/or change lane and avoid a (secondary) collision.

### User Needs:
- **SP5_UN38**: Give to the driver a continuous access to the information of speed limit.
- **SP5_UN39**: Infrastructure can warn the driver in case of excessive speed.

### Use cases:
- **SP5_UC32**: Prevention of Driver Excessive Speed

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<table>
<thead>
<tr>
<th>Expected Values / Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two results are expected:</td>
</tr>
<tr>
<td>- Reorganization of the weather condition and the associated speed limit</td>
</tr>
<tr>
<td>- A warning in case of over speed, where the speed limit is a function of the weather and the road type</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Obtained Values / Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status Test Case 2</td>
</tr>
<tr>
<td>Link to external annexed documentation (if any)</td>
</tr>
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</table>
### Table 4 SpA_02 Simulation

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
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<td>WP</td>
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<td>HW Release</td>
<td>SW Release</td>
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<td>LCPC (S. Glaser)</td>
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<td>8/01/2009</td>
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<th>Test Objective</th>
<th>Test Purpose</th>
<th>Test Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unitary</td>
<td>Verification</td>
<td>Correctness</td>
<td>Simulation</td>
</tr>
</tbody>
</table>

**Test Case 1: Evaluation of safety distance and speed associated**

**Test Description**

**Prerequisite:**
- Functional LDM and VANET modules

**Description:**
The aim of this test is to prove the basic functionality of SpA_02: the definition of safe area with speed associated accordingly to warnings generated by H&IW.
The test addresses the definition of the three different areas before arriving at the incident area and addresses the associated speed with consideration of the available friction or class of friction.

Test values:
- The event from H&IW (randomly generated according to the use cases, in the black section) is defined in the H&IW use cases. Given the type of event, the application firstly defines the speed per area.
- The second step aims to define the impact area. The application determines where to warn the driver given the final speed, the road friction and a minimal deceleration.
- Third step of the application is to associate an entrance speed for each area (low warning, medium warning high warning) as defined in D5.3.1. In this step the application defines the reference speed for the vehicle required in order to decelerate safely. SpA_02 define three levels of braking: -0.1g, -0.3g and -0.5g.

Tools:
LDM Data player
H&IW data player

Requirements:
- SP5_RQ06_19_v1.0: The system shall be able to provide a priority level for each transmitted message. This is valid for V2I as well as for I2V communication
- SP5_RQ20_19_v1.0: The system shall generate and transmit warning information to the drivers timely enough, so that the reaction time left to the drivers is appropriate.
- SP5_RQ69_10_v1.0: The system shall send appropriate warnings to equipped vehicles within the critical (c and a) zones to permit them to reduce speed and/or change lane and avoid a (secondary) collision.
- RQ68_10_v1.0 (Road status) The system shall acquire data on the weather conditions in the 'critical area' (extent TBD) of the obstacle or accident, i.e. wet/dry road surface, rain, fog, ice, which may affect stopping distances and visibility.
- RQ60_96_v1.0 (Lack of Friction) The system shall receive information about the lack of friction of a road segment.
- RQ49_19_v1.0 (Position and speed of vehicles) The RSU subsystem shall be able to receive at minimum the current vehicle position and speed.

User needs:
- SP5_UN33: Oncoming vehicle: Be warned of an accident in the vicinity, especially in low visibility condition
- SP5_UN35: Oncoming vehicle: Getting recommendation on lane to follow and speed recommendations

Use cases:
- Same as H&IW event uses

<table>
<thead>
<tr>
<th>Expected Values / Results</th>
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</thead>
<tbody>
<tr>
<td>The requirements are met, specifically: The application determines the road area of impact and the associated speed corresponding to requirement. The application only aims at defining the critical speed.</td>
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<th>Obtained Values / Results</th>
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<table>
<thead>
<tr>
<th>Test Case 2: Generation of Safe Area under several H&amp;IW events</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Test Description</th>
</tr>
</thead>
</table>

Prerequisite:
- Functional LDM and VANET modules

Description:
The aim of this second test is to ensure a robust behaviour of the application while dealing with multiple incidents on a larger road network. The SpA coordinator must manage the birth and death of multiple H&IW events, especially when the areas of effect of two or more events are intersected. Main test will be then carried out on the management for the end of an event that affect several other events. Events generated are done accordingly with H&IW applications.
Test values:
- Multiple events from H&IW application are generated on the road networks. The single tests remain the same as described in test case 1.
- The application handles multiple speed limitation.

Tools:
LDM Data player
H&IW data player

Requirements:
- SP5_RQ02_36_v1.0: The system shall be able to decide if and to whom a message has to be send.
- RQ29_27_v1.0 (Range of Communication) The short range communication shall be available at the critical points and their vicinity (minimum 600 m).
- RQ31_27_v1.0 (Simultaneous Communication) The system shall be able to communicate with all vehicles in the vicinity of the intersection (minimum radius <= 600 m) simultaneously.
- RQ18_19_v1.0 (Simultaneity) The system shall be able to manage all vehicles in the vicinity of a critical point (e.g. the intersection) simultaneously.
- RQ19_36_v1.0 (Scalability) The system shall have nearly the same performance in case there are just two or 80 vehicles to manage.
- RQ06_19_v1.0 (Priority Level of Message) The system shall be able to provide a priority level for each transmitted message. This is valid for V2I as well as for I2V communication

User needs:
No user needs

Use cases:
same as H&IW event used

Expected Values / Results
The requirements are met, specifically two results are expected:
- The application deals with several incidents, especially if these incidents impact the same road sections.
- The application manages the end of an event

Obtained Values / Results

<table>
<thead>
<tr>
<th>Status Test Case</th>
<th>To Be Done</th>
<th>Link to external annexed documentation (if any)</th>
</tr>
</thead>
</table>
## Table 5 SpA_03 Simulation

<table>
<thead>
<tr>
<th>Test Case 1: Basic Validation of SpA_03</th>
</tr>
</thead>
</table>

**Test Description**

The aim of this test is to prove the basic functionality of SpA_03: the definition of a speed profile with respect to the road geometry and the road surface condition. The application warns the driver on excessive speed, regarding the computed speed profile. The road presents a simple geometry with a straight line a clothoid and a curve. The radius of the curve can be set at different values.

- The driver enters an area covered by a road side unit, the vehicle transmits its beaconing message
- The RSU detects the vehicle, and starts managing it.
- If the vehicle speed is higher than the speed limit, a warning is sent from the RSU
- The vehicle receives the message and displays the warning to the driver

Requirements:
- RQ34_19_v1.0 (Directly address a Vehicle) The roadside sub-system must be able to address data directly to one vehicle distinctively (or a group of vehicles) or to broadcast to all vehicles in the vicinity of the RSU.
- RQ35_19_v1.0 (Time of Data Delay 2) In the roadside sub-system the delay between generation of warnings and transmission of this data to the vehicles shall be smaller than 50 ms.
- RQ36_27_v1.0 (Time of Connection) The time needed to set-up a connection between an incoming vehicle and the roadside communication system should be smaller than 0.8 seconds.
- RQ41_19_v1.0 (Static Map contents) The LDM shall describe the static geometry of critical points (e.g., intersections) in a detailed, accurate and systematic way. The geometry shall comprise at least approaches, exits, lanes (also bicycle lanes), stop lines and pedestrian crossings as well as the topology of the lanes (left-turn, right-turn, straight ahead).
- RQ46_19_v1.0 (Position of Vehicles 3) The positioning of vehicles have to fulfill the accuracy up to a lane detection extend.
- RQ49_19_v1.0 (Position and speed of vehicles) The RSU subsystem shall be able to receive at minimum the current vehicle position and speed.
- RQ50_36_v1.0 (Transmission of warnings) The system shall be able to transmit the warning / recommendation to equipped vehicles.

User needs:
SP5_UN39: Infrastructure can warn the driver in case of excessive speed.

Use cases:
SP5_UC41 : Prevention of lack of adherence
SP5_UC45 : Sudden reduce Visibility

Expected Values / Results

Obtained Values / Results

Status Test Case1 To Be Done Link to external annexed documentation (if any)

Test Case 2: Road surface condition interaction with SpA

Test Description

Prerequisite:
- Functional LDM and VANET modules

Description:
The aim of this test is to verify that the SpA_03 application can handle the environmental variations and that it defines the associated speed. In this test case, the road is the same as defined in test case 1.

Various weather conditions are injected during the simulation, as rain (various densities) or fog.
Tools:
LDM Data player
SiVIC simulator and SP2 weather monitoring

Requirements:
- RQ48\_36\_v1.0 (Environmental Data) The system shall receive data from environmental sensors about weather (rain, snow, fog…).
- RQ60\_36\_v1.0 (Lack of Friction) The system shall receive information about the lack of friction of a road segment.

User Needs:
- SP5\_UN39: Infrastructure can warn the driver in case of excessive speed.
- SP5\_UN49: Be warned in case of low adherence road
- SP5\_UN51: The system transmits warning information towards the driver approaching the risky site that signals a slippery bend or a puddle road.

Use cases:
SP5\_UC41 : Prevention of lack of adherence
SP5\_UC45 : Sudden reduce Visibility

<table>
<thead>
<tr>
<th>Expected Values / Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>The requirements are met, specifically two results are expected:</td>
</tr>
<tr>
<td>- the speed advice is varied in accordance with the weather status</td>
</tr>
<tr>
<td>- a warning of over speeding is provided, which is a function of the weather condition</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Obtained Values / Results</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Status Test Case 2</th>
<th>To Be Done</th>
<th>Link to external annexed documentation (if any)</th>
</tr>
</thead>
</table>
4.3 Hazard and Incident Warning (H&IW)

4.3.1 Description

The aim of this application is to warn drivers in case of a dangerous event on the road. The selected events are the most relevant in term of safety, e.g. accidents, presence of unexpected obstacles on the road, presence of a vehicle driving in the wrong direction, dangerous overtaking and also weather conditions like snow, rain or fog.

The application consists of three sub-applications:

- **Obstacle on the road** (H&IW_01): which alerts drivers to the presence of static or semi-static objects detected on the road (e.g. a vehicle involved in an accident, a queue, a slow moving vehicle, or a pedestrian on the road). Warnings will be given to approaching vehicles to allow them to reduce speed or change lane in time to avoid a collision.

- **Wrong way driving** (H&IW_02): this sub-application warns drivers of the potential danger caused by a vehicle travelling in the same lane as themselves but in the wrong direction, either due to an overtaking manoeuvre or ‘ghost driving’ (i.e. travelling against the flow on a motorway).

- **Abnormal weather conditions** (H&IW_03): the aim of this sub-application is to be able alert drivers to the presence of a hazard due to weather conditions (e.g. rain, ice or fog) which result in reduced friction or low visibility.

The reader is referred to [17] for more details.

4.3.2 Modules

The H&IW application consists of a number of modules:

- The Black spot monitor is responsible for setting the conditions which need to be met for the recognition of an event, i.e. the presence of a hazard or incident within black spot. This module is implemented by the `eventCaching()` function.

- The Scenario Manager module obtains information, which enables further characterization of the Event and Scenario, respectively. They are implemented through the `scenarioAnalysis()` function.

  This module is also responsible for the execution of following modules:
o The objective of the Threat Assessor module is to evaluate the degree of risk of an accident occurring, i.e. the criticality of the scenario identified by the Black spot analyser. This module is implemented by the `riskEval()` function.

o The task of the Decision manager module is to determine which safety warnings are to be implemented and where. It is implemented by the `safetyMarginComputation()` function.

o The Warning system actuator module is responsible for activating the warning systems, i.e. providing the commands for switching on/off the signals or sending message displays to the roadside devices and broadcasting messages. It is implemented by the `warningStrategyRealisation()` function.
### 4.3.3 Test form

Table 6 H&IW_01 and H&IW_02 Simulation

<p>| | | | | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>SP</td>
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<td>WP</td>
<td>5</td>
<td>Prototype Version</td>
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<td></td>
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<td>Function Configuration</td>
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<td>H&amp;IW_01</td>
<td>H&amp;IW_02</td>
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<tr>
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<th>Test Objective</th>
<th>Test Purpose</th>
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<tbody>
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<td>Unitary</td>
<td>Verification</td>
<td>Correctness</td>
<td>Simulation</td>
<td></td>
</tr>
</tbody>
</table>

**Test Case 1: Basic functionality test for H&IW_01 and H&IW_02 #1: Event Notification to BlackSpot Monitor**

**Test Description**

Prerequisite:
- Information about an event inside the “traffic event” table of LDM.
  - [trafficevent.eventcause = 35 (ghost driver)]
  - [trafficevent.eventcause = 28 (animal)]
  - [trafficevent.eventcause = 30 (pedestrian)]
  - [trafficevent.eventcause = 35 (obstruction on road)]
- Simulation of [motorvehicle speed > 20 km/h]
- Sensor source simulator: WSN (Wireless Sensor Network), RFID sensors, Thermal imaging cameras (provided by VTT).
- Synchronization of the clock and Positioning:
  - connect GPS receiver to Positioning PC (Application PC)
  - SP3 Positioning SW (responsible to acquire PPS signal from GPS and synchronize PC time)
  - Start NTP Server on Positioning PC
  - Start NTP Client on RSU PC and on ROUTER VANET PC
  - In order to check synchronization it is possible to compare Beacon sending time from RSU to beacon receiving time from Vehicle using the file log vanet_msg_incoming.
- DataReceiver from SP2
- RSU with OS Linux and Windows

Description:
The goal of this test is verify the correctness in the communication between the BlackSpotMonitor (application responsible for detecting H&IW events) and the LDM after the detection of each H&IW event. This basic function is needed for all use cases of the H&IW 01 and 02.
- The H&IW sub-application is by means of a trigger launched by the LDM communicates with the BlackSpotMonitor.
- The BlackSpotMonitor creates a log that shows the state of the message  (Correct message received from LDM, Error connection with LDM, Error message received from LDM)

Extended Description
- The test start with the simulation of:
  - Vehicle that goes in the wrong way (Ghost Driver)
  - Pedestrian on Motorway
  - Accident as Obstacle, Slow moving vehicles, or traffic jams as an obstacle
- The simulator of the relative application generates a corresponding message regarding the presence of an event
  - For case Ghost Driver detected by WSN and RFID
  - For case Pedestrian on Motorway detected by VTT
  - For case Obstacle by WSN
- The LDM sends the corresponding message to the BlackSpotMonitor depending on the case
- The Black Spot Monitor receives this message.

Test lab location:
CRF Centro di Ricerche FIAT lab

Test tools:
TBD

Requirements:
- SP5_RQ02_36_v1.0: The system shall be able to decide if and to whom a message has to be send.
- SP5_RQ07_19_v1.0: The system shall be able to determine the period of validity of the transmitted and received messages.
- SP5_RQ16_36_v1.0: The system shall be able to query needed data from the LDM.
- SP5_RQ17_36_v1.0: The system shall be able to receive and handle the LDM data.

Use Cases:
- SP5_UC34_v1.0 (Ghost Driver)
- SP5_UC17 (Pedestrian on Motorway)
- SP5_UC13 (Accident as Obstacle)
- SP5_UC14 (Traffic jams as obstacles (slow moving vehicles))
- SP5_UC15 (Traffic jams as an obstacle results of an accident, with poor visibility)

Expected Values / Results
The listed requirements are met, specifically,
- The reception of the correct message in the BlackSpotMonitor for all the UC simulated.
- Detection of the obstacle with the associated position
- A log that shows the message reception of the corresponding UC.

Note: For SP5_UC13, SP5_UC14, SP5_UC15, the message event will be the same.
Obtained Values / Results

<table>
<thead>
<tr>
<th>Status</th>
<th>Test Case 1</th>
<th>To Be Done</th>
<th>Link to external annexed documentation (if any)</th>
</tr>
</thead>
</table>

Test Case 2: Basic functionality test for H&IW_01 and H&IW_02 #2: Send and Reception of the Message HMI

**Test Description**

**Prerequisite:**
In the table traffic event of LDM there is the information regarding the presence of an event corresponding to H&IW_02 or H&IW_01
- [motorvehicle speed > 20 km/h]
- [trafficevent.eventcause = 35]
- Sensor source: WSN and RFID sensors
- Simulator of WSN, RFID and VTT messages.
- DataReceiver from SP2
- RSU with OS Linux and Windows
- The BlackSpotMonitor have received the message from LDM.
- All the test before have to be successful
- Vanet unit inside RSU and Vanet in the vehicle
- 1 vehicle

**Description:**
The goal of this test is to verify the correct operation of the generation of the SendHmiEventMessage and the Reception of the RSUHmiMsg in the vehicle.

**Extended Description:**
This is an IV communication test and has to be tested for all the use cases, to do this test it is necessary to do a simulation of all the cases in order to generate an event. After the reception of the corresponding notification message from the Black Spot Monitor the corresponding message has to be sent to the vehicle by means of Vanet. The Vanet has to be able to display a log of the correct receipt of this message and the correctness of it.

**Test lab location:**
- CRF Centro di Ricerche FIAT lab

**Test tools:**
TBD

**Requirements:**
- SP5_RQ02_36_v1.0: The system shall be able to decide if and to whom a message has to be send.
- SP5_RQ07_19_v1.0: The system shall be able to determine the period of validity of the transmitted and received messages.
- SP5_RQ16_36_v1.0: The system shall be able to query needed data from the LDM.
- SP5_RQ17_36_v1.0: The system shall be able to receive and handle the LDM data.
<table>
<thead>
<tr>
<th>Use Cases</th>
<th>Expected Values / Results</th>
<th>Obtained Values / Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>- SP5_UC34_v1.0 (Ghost Driver)</td>
<td>To HmiMessage that correspond to the use cases is received in the vehicle.</td>
<td>Status Test Case 2 To Be Done</td>
</tr>
<tr>
<td>- SP5_UC17 (Pedestrian on Motorway)</td>
<td>The messages arrive in the vehicle with the correct information of the obstacle and its position</td>
<td>Link to external annexed documentation (if any)</td>
</tr>
<tr>
<td>- SP5_UC13 (Accident as Obstacle)</td>
<td>The log will show a message of correct message reception.</td>
<td></td>
</tr>
<tr>
<td>- SP5_UC14 (Traffic jams as obstacles (slow moving vehicles))</td>
<td>Note: For SP5_UC14, SP5_UC15, SP5_UC13 the message event will be the same.</td>
<td></td>
</tr>
<tr>
<td>SP</td>
<td>WP</td>
<td>Prototype Version</td>
</tr>
<tr>
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<td>Compiled by / Company</td>
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<td></td>
<td></td>
<td>Reference Document</td>
</tr>
<tr>
<td>HW Release</td>
<td>SW Release</td>
<td>Functional Component</td>
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<tr>
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<table>
<thead>
<tr>
<th>Test Type</th>
<th>Test Objective</th>
<th>Test Purpose</th>
<th>Test Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unitary</td>
<td>Verification</td>
<td>Correctness</td>
<td>Simulation</td>
</tr>
</tbody>
</table>

### Test Case 1: Basic functionality test for H&IW_01 (Obstacle) #1: Accident/Vehicle as obstacle

**Test Description**

**Prerequisite:**
The LDM must contain information about the presence of an Accident and/or a Vehicle as an obstacle, i.e.:
- LdmObject.attribute: [motorvehicle.speed < 2km/h] i.e. the vehicle is an obstacle
  source: from vehicle beaconing
  and/or
  - LdmObject.attribute: [trafficevent.eventcause = 2] i.e. traffic accident
  source: from RSU sensors/gateway

**Description:**
- (simulated) A vehicle B has an accident (or is stopped, or is slowly moving) in the vicinity of an RSU.
- the H&W_01 sub-application detects these events through its BlackSpotMonitor (responsible for detecting event related to H&IW)
  - then the ScenarioManager is launched to compute the Safety margin and associated RsuHmiMsg (this uses the functions: scenarioanalysis() - riskEval() - safetyMarginComputation() - warningStrategyRealisation())
- the warning strategy realisation start broadcasting RsuHmiMsgs (which should be received by vehicle A).

**Extended description:**
- the application retrieves additional information from the LDM about weather and traffic status to adapt the warning message, i.e. the warning destination area should be reduced or extended depending on the weather and traffic status (this uses the function scenarioAnalysis() of object ScenarioManager)
- then it generates the appropriate RsuHIMessage and triggers the SendHMIPeriodicMessage from SP5_MessageManager (i.e. the SP5 interface with Vanet) and it triggers the display on possible VMS through the SP5ApplicationCoordinator.
  (example RsuHmiMsg := status=0 comfort textMessage= "Caution: stopped vehicle ahead") depending on the destination, vehicle speed and location, the message could be with other status and other text message - details given on the specification document of H&W.
Tools:
Standard H&IW log files analysis and SAFESPOT UDP messages observation.
In addition, Esposytor, TNO ITS Modeller and CRF Vanet2Udp2Vanet player can be used for further integration analysis.

Requirements:
- **SP5_RQ02_36_v1.0 / Message Management:** The system shall be able to decide if and to whom a message has to be send.
- **SP5_RQ05_36_v1.0 / Identify Safety Critical Situations:** The system shall be able to identify safety critical situations at the surrounding of a critical point e.g. an urban intersection.
- **SP5_RQ09_19_v1.0 / Message Management 2:** The system must not send warnings concerning severe dangerous situations (that might cause drivers to extreme driving actions), which does in fact not happen.
- **SP5_RQ12_33_v1.0 / Data exchange:** The system shall be able to transmit information towards several supporters (e.g. VMS, radio, PND)
- **SP5_RQ16_36_v1.0 / Query from the LDM:** The system shall be able to query needed data from the LDM.
- **SP5_RQ17_36_v1.0 / Receive data from the LDM:** The system shall be able to receive and handle the LDM data.
- **SP5_RQ18_19_v1.0 / Simultaneity:** The system shall be able to manage all vehicles in the vicinity of a critical point (e.g. the intersection) simultaneously.

Extended test requirements:
- **SP5_RQ20_19_v1.0 / Time of Warning Generation:** The system shall generate and transmit warning information to the drivers timely enough, so that the reaction time left to the drivers is appropriate.
- **SP5_RQ22_10_v1.0 / R/S Warning:** The system shall provide a roadside warning in fewer than 2 sec (TBC) in the critical zones to permit vehicles to reduce speed and/or change lane in order to avoid a (secondary) collision.

Use cases:
- **SP5_UC13_v1.0 / Accident as an obstacle**

<table>
<thead>
<tr>
<th>Expected Values / Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>The requirements are met, specifically,</td>
</tr>
<tr>
<td>- These are pure qualitative functional tests; only functionalities are tested – no quantitative criteria. The purpose is to test the functional environment of the H&amp;IW and H&amp;IW_01 functionalities. The test sequentially starts with the first module. If generates an output the test continuous with the next module until the total sub-application generates an output from input to output.</td>
</tr>
<tr>
<td>- This leads to 8 tests: 2 eventType (vehicle as obstacle and accident) x 2 LDM implementations (Navteq and TeleAtlas) x 2 descriptions (basic description and extended description).</td>
</tr>
<tr>
<td>- The VANET component sends the RsuHMImessage (extended) the vehicle display the text/icon</td>
</tr>
</tbody>
</table>
- Some TBD quantitative requirements involving the H&IW processing durations (i.e. RQ 20 and 22) could be tested in extended tests.

### Obtained Values / Results

<table>
<thead>
<tr>
<th>Status Test Case 1</th>
<th>To Be Done</th>
<th>Link to external annexed documentation (if any)</th>
</tr>
</thead>
</table>

#### Test Case 2: Basic functionality test for H&IW_01(Obstacle) #2: Road Works as an obstacle

**Test Description**

**Prerequisite:**
- The LDM contains information about the presence of road-works
- [TrafficEvent.element.RoadWork] i.e. road-works presence
  - source: RSU/Gateway (Navteq LDM - not fully compliant yet...) (TeleAtlas?)

**Description:**
- the H&IW_01 module detects this event through its BlackSpotMonitor thread
  - responsible for detecting event related to H&IW
- the ScenarioManager thread is launched to compute the Safety margin and associated RsuHmiMsg (it uses functions: riskEval() - safetyMarginComputation() - warningStrategyRealisation())

**Extended description:**
- the application retrieves additional information form the LDM about weather and traffic status to adapt the warning message, i.e. the warning destination area is reduced or extended depending on weather and traffic status (fct scenarioAnalysis() of object ScenarioManager)
- then it generates the appropriate RsuHmiMessage and triggers the SendHMIPeriodicMessage from SP5_MessageManager (i.e. the SP5 interface with Vanet) and triggers the display on possible VMS through the SP5ApplicationCoordinator.
  - (example: RsuHmiMsg := status=0 comfort textMessage = "Caution: Road-works ahead") depending on the destination vehicle speed and location, the message could have an other status and other text message
- The warning messages sent to vehicle A contains “lane merging” indications at the icon displayed onboard, if accurate positioning of the vehicles and a detailed LDM (lane level positioning) are available.

**Tools:**
Standard H&IW log files analysis and SAFESPOT UDP messages observation.
In addition, Esposytor, TNO ITS Modeller and CRF Vanet2Udp2Vanet player can be used for further integration analysis.
Requirements:
- SP5_RQ02_36_v1.0 / Message Management: The system shall be able to decide if and to whom a message has to be send.
- SP5_RQ05_36_v1.0 / Identify Safety Critical Situations: The system shall be able to identify safety critical situations at the surrounding of a critical point e.g. an urban intersection.
- SP5_RQ09_19_v1.0 / Message Management 2: The system must not send warnings concerning severe dangerous situations (that might cause drivers to extreme driving actions), which does in fact not happen.
- SP5_RQ12_33_v1.0 / Data exchange: The system shall be able to transmit information towards several supporters (e.g. VMS, radio, PND).
- SP5_RQ16_36_v1.0 / Query from the LDM: The system shall be able to query needed data from the LDM.
- SP5_RQ17_36_v1.0 / Receive data from the LDM: The system shall be able to receive and handle the LDM data.
- SP5_RQ18_19_v1.0 / Simultaneity: The system shall be able to manage all vehicles in the vicinity of a critical point (e.g. the intersection) simultaneously.

Extended test requirements:
- SP5_RQ20_19_v1.0 / Time of Warning Generation: The system shall generate and transmit warning information to the drivers timely enough, so that the reaction time left to the drivers is appropriate.
- SP5_RQ22_10_v1.0 / R/S Warning: The system shall provide a roadside warning in fewer than 2 sec (TBC) in the critical zones to permit vehicles to reduce speed and/or change lane in order to avoid a (secondary) collision.

Use cases:
- UC: SP5_UC16_v1.0: Deviations for road-works

Expected Values / Results

The requirements are met, more specifically:
- These are pure qualitative functional tests; only functionalities are tested – no quantitative criteria. The purpose is to test the functional environment of the H&IW and H&IW_01 functionalities. The test sequentially starts with the first module. If generates an output the test continuous with the next module until the total sub-application generates an output from input to output.
  - This leads to 2 tests: 1 eventType x 1 LDM implementation x 2 (classic/ext version)
  - The VANET component sends the RsuHMImessage (extended) the vehicle display the text / icon

Some quantitative (TBD) requirements involving the H&IW processing durations (i.e. RQ 20 and 22) could be tested in extended tests

Obtained Values / Results

| Status Test Case 2 | To Be Done | Link to external annexed documentation (if any) |
Table 8 H&IW_02 Simulation

<table>
<thead>
<tr>
<th>SP</th>
<th>WP</th>
<th>Prototype Version</th>
<th>System Configuration</th>
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</thead>
<tbody>
<tr>
<td>5</td>
<td>5</td>
<td>Compiled by / Company: COFIROUTE</td>
<td>Date: 10/03/2009</td>
</tr>
<tr>
<td>HW Release</td>
<td>SW Release</td>
<td>Functional Component: H&amp;IW_02_v0.1</td>
<td>Reference Document: D5..3.5</td>
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</tbody>
</table>

| Form Progressive Numb. | 8 |

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Test Objective</th>
<th>Test Purpose</th>
<th>Test Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unitary</strong></td>
<td>Verification</td>
<td>Correctness</td>
<td><strong>Simulation</strong></td>
</tr>
</tbody>
</table>

**Test Case 1: Basic functionality test for H&IW_02: Wrong Way Driving**

**Test Description**

Prerequisite: The “H&IW_02 Wrong Way Driving Sub-application” relies on the detection of vehicles by roadside sensors (RFID or wireless sensors cf.D5.3.2) or vehicles beacons/data messages. This test aims to prove the basic functionalities of H&IW_02, and require a working LDM.

Description:

A vehicle (vehicle A) enters an area monitored by a SAFESPOT RSU, driving in the wrong direction (i.e., “a ghost driver”). For the simulation of vehicle beacons/data, RFID data and/or wireless sensors, two solutions are possible: 1) playing an on-site recorded sensor/beacon sequence, or 2) using a dedicated simulator (which can be a simple V2V/sensor message sequence). This implies the use of a working data fusion module.

- The H&IW_02 application detects the presence of the vehicle on the LDM (the information is coming from a vehicle or RSU sensors) through its BlackSpotMonitor.

- A Scenario Manager is launched (a parallel thread) and computes the safety Margin and the associated RsuHmiMessage (this uses the functions: scenarioAnalysis() - riskEval() - safetyMarginComputation() - warningStrategyRealisation()).

Extended description:

- The application retrieves additional information from the LDM about weather and traffic status to adapt the warning message, i.e., the warning destination area should be reduced or extended depending on the weather and traffic status. (this uses the function scenarioAnalysis() of the object ScenarioManager).

- Then it generates the appropriate RsuHMIMessage and triggers the SendHMIPeriodicMessage from SP5_MessageManager (i.e., the SP5 interface with Vanet) and it triggers the display of an possible VMS through the SP5ApplicationCoordinator.

- The application operates with or without equipped vehicles. This leads to at least three tests:

  - The “Ghost driver” and the approaching vehicle (vehicle C) are both equipped: data are coming from vehicle A beacons, and information is provided onboard both the vehicles.
  - The “Ghost driver” is equipped but the approaching vehicle is not. Data are coming from the vehicle A beacons, and information is shown both onboard of vehicle A and on the VMS.
The “Ghost Driver” is not equipped, nor is the incoming vehicle C. Data are coming from RSU sensors. The VMS provides information for the approaching vehicle, and a dedicated flashing light is used for the ghost driver.

- Also, Vehicle B can act as a sensor for the RSU.

Tools:
Standard H&IW log files analysis and SAFESPOT UDP messages observation.
In addition, Esposytor, can be used.
Also, and CRF Vanet2Udp2Vanet player can be used for further integration analysis.

Requirements:
- SP5_RQ71_10_v1.0: The system shall detect a vehicle travelling in the wrong direction on a motorway with the location accurate to x metres (TBD).
- SP5_RQ72_10_v1.0: The system shall detect the speed, lane and trajectory of a vehicle travelling the wrong way on a motorway.
<table>
<thead>
<tr>
<th>Status Test Case1</th>
<th>To Be Done</th>
<th>Link to external annexed documentation (if any)</th>
</tr>
</thead>
</table>

Use cases:
- SP5_UC34

Expected Values / Results

The requirements are met.
- These are pure qualitative functional tests; only functionalities are tested – no quantitative criteria. The purpose is to test the functional environment of the H&I/W and H&I/W_02 functionalities. The test sequentially starts with the first module. If generates an output the test continuous with the next module until the total sub-application generates an output from input to output.
- During the three different tests, relevant messages will be sent to either: vehicles, VMS and/or flashing lights.
- The VANET component sends the RsuHMImessage (extended) the vehicle display the text / icon

Obtained Values / Results
### Table 9 H&IW_03 Simulation

<table>
<thead>
<tr>
<th>SP</th>
<th>WP</th>
<th>Prototype Version</th>
<th>System Configuration</th>
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<tbody>
<tr>
<td>HW Release</td>
<td>SW Release</td>
<td>Compiled by / Company</td>
<td>COFIROUTE</td>
</tr>
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<td>Form Progressive Numb.</td>
<td>9</td>
<td>Functional Component</td>
<td>H&amp;IW_03_v0.1</td>
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<tr>
<td>Date</td>
<td>10/03/2009</td>
<td>Reference Document</td>
<td>D5.3.5</td>
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#### Test Form

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Test Objective</th>
<th>Test Purpose</th>
<th>Test Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unitary</td>
<td>Verification</td>
<td>Correctness</td>
<td>Simulation</td>
</tr>
</tbody>
</table>

#### Test Case 1: Basic functionality test for H&IW_03: Abnormal road Condition

**Test Description**

- **Prerequisite:**
  - This test aims to prove the basic functionalities of H&IW_03, and requires a working LDM.
  - The H&IW applications are designed to work in close cooperation with the SP5 Speed Alert Application. This is particularly true for “H&IW_03 Abnormal road condition” sub-application, as it may not generate Critical warnings but only Comfort or Safety warnings. Critical warnings can be generated (if necessary) by the SpA application. Therefore, a full functional test of H&IW_03 should include a cooperation with SpA, which should issue warnings (with higher priority) when the vehicle speed is not appropriate.

- **Description:**
  - The RSU detects the abnormal road condition status either form vehicle messages, or roadside sensors. The first version (vehicle sensors) is not tested at the SAFESPOT test sites. Therefore, only the RSU sensors have to be simulated. A simple writing of weather information on the LDM is sufficient for the functional test.
  - The H&W_03 application detects the presence of abnormal road conditions on the LDM through its BlackSpotMonitor.
  - A Scenario Manager is launched (a parallel thread) and computes the safety Margin and the associated RsuHmiMessage (this uses the functions: scenarioAnalysis() - riskEval() - safetyMarginComputation() - warningStrategyRealisation()).
  - The warningStrategyRealisation() issues a warning for the VMS when it is available, and starts broadcasting periodic RSUHMImessage messages on the vanet.

- **Extended description:**
  - the SpA detects the RSUHmiMessage concerning Abnormal road condition status, and triggers a stronger warning to incoming vehicles.

- **Tools:**
  - TBD

- **Requirements:**
  - SP5_RQ02_36_v1.0: The system shall be able to decide if and to whom a message has to be send.
  - SP5_RQ06_19_v1.0: The system shall be able to provide a priority level for each transmitted message. This is valid for V2I as well as for I2V communication.
- SP5_RQ07_19_v1.0: The system shall be able to determine the period of validity of the transmitted and received messages.
- SP5_RQ09_19_v1.0: The system must not send warnings concerning severe dangerous situations (that might cause drivers to extreme driving actions), which does in fact not happen.
- SP5_RQ19_36_v1.0: The system shall have nearly the same performance in case there are just two or 80 vehicles to manage.
- SP5_RQ20_19_v1.0: The system shall generate and transmit warning information to the drivers timely enough, so that the reaction time left to the drivers is appropriate.
- SP5_RQ24_19_v1.0: The system has to be robust enough in order to operate under different extreme weather conditions (heat, cold, snow, etc.).
- SP5_RQ29_27_v1.0: The short range communication shall be available at the critical points and their vicinity (minimum 600 m).
- SP5_RQ32_19_v1.0: In the vehicle sub-system the delay between determination of position and velocity of the vehicle and transmission of this data to the roadside shall be smaller than 50 ms.
- SP5_RQ34_19_v1.0: The roadside sub-system must be able to address data directly to one vehicle distinctively (or a group of vehicles) or to broadcast to all vehicles in the vicinity of the RSU.
- SP5_RQ35_19_v1.0: In the roadside sub-system the delay between generation of warnings and transmission of this data to the vehicles shall be smaller than 50 ms.
- SP5_RQ36_27_v1.0: The time needed to set-up a connection between an incoming vehicle and the roadside communication system should be smaller than 0.8 seconds.
- SP5_RQ48_36_v1.0: The system shall receive data from environmental sensors about weather (rain, snow, fog...).
- SP5_RQ50_36_v1.0: The system shall be able to transmit the warning/recommendation to equipped vehicles.
- SP5_RQ51_19_v1.0: In vehicle assistance HMI shall present warnings to the driver in an intelligent way without distracting him. Example: Use of different actuators to smooth signalizes hazards.
- SP5_RQ61_36_v1.0: The system must be able to receive data from the vehicles as well as the infrastructure.

Use cases:
- SP5_UC41

<table>
<thead>
<tr>
<th>Expected Values / Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>The requirements are met, specifically:</td>
</tr>
<tr>
<td>- These are pure qualitative functional tests; only functionalities are tested – no quantitative criteria. The purpose is to test the functional environment of the H&amp;IW and H&amp;IW_03 functionalities. The test sequentially starts with the first module. If generates an output the test continuous with the next module until the total sub-application generates an output from input to output.</td>
</tr>
<tr>
<td>- The VANET component sends the RsuHMImessage (extended) the vehicle display the text/icon</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Obtained Values / Results</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Status Test Case</th>
<th>To Be Done</th>
<th>Link to external annexed documentation (if any)</th>
</tr>
</thead>
</table>
Table 10 H&IW_01 Test site

<table>
<thead>
<tr>
<th>SP</th>
<th>WP</th>
<th>Prototype Version</th>
<th>System Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW</td>
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<td>Compiled by / Company</td>
<td></td>
</tr>
<tr>
<td>Release</td>
<td>5 Release</td>
<td>COFIROUTE (case 1, 2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MIZAR (case 3, 4, 5)</td>
<td>Date 10/03/2009</td>
</tr>
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<td>Form Progressive Numb.</td>
<td>10</td>
<td>Functional Component</td>
<td>Reference Document</td>
</tr>
<tr>
<td>Test Type</td>
<td>Test Objective</td>
<td>Test Purpose</td>
<td>Test Environment</td>
</tr>
<tr>
<td></td>
<td>Unitary</td>
<td>Verification</td>
<td>Performance</td>
</tr>
</tbody>
</table>

Test Case 1: Basic performance test for H&IW_01 (Obstacle) #1: Accident/Vehicle as obstacle

Test Description

Prerequisite:
- Functional correctness validation simulation tests of H&IW_01_v0.1 should have been performed and assessed on the LDM of the test site (Navteq or TeleAtlas)
- Integration of other SAFESPOT component of the architecture, both in vehicle and infrastructure, and corresponding test should have been performed and validated.

Deployment
- One RSU and two equipped vehicles are required for this test.
- One equipped vehicle (B) is stopped within the range of the RSU preferably downstream the RSU (this is the Accident/Vehicle as obstacle). The other equipped vehicle (A) passes within the range of the RSU. It moves from upstream to downstream the RSU, in the direction of the road where the stopped vehicle VB is located (i.e. at the considered road section).
- No specific sensors are required for this test. Accurate positioning and lane level details at the LDM are required for the extended version test. In addition, weather sensors at the RSU and/or at the vehicles are required in the extended version (note that RSU gateway to a legacy system can act as a weather sensor). Finally, VMS can be connected to the RSU to inform non-equipped vehicles.
Description:
The test consist on comparing a prepared table containing estimated time and position of when/where a warning from H&IW_01 should appear at a SAFESPOT equipped vehicle. This table is prepared for each test site (otherwise, it will contain too many entries).

- First, the stopped vehicle (B) sends its beacons.
- The H&IW_01 sub-application detects a stopped vehicle (an obstacle) through its BlackSpotMonitor function.
- Then the ScenarioManager function is launched to compute the Threat level.
- Then vehicle A enters the range of the RSU and sends its beacons.
- The H&IW application sends the generic H&IW warning corresponding to the threat level (Comfort, Safety, Emergency) depending on its type, speed, road attributes and obstacle position.
- If the vehicle A does not adapt its speed to stay in the "comfort" situation, the different Safety and Emergency warnings will follow.

Test 1: vehicle A passes trough the coverage area of the event, with the maximum legal speed authorized at the road. The vehicle A does not adapt its speed and sees the three levels of warnings. First, the Comfort warning, then the Safety warning, this is shown 3 seconds before crossing the obstacle with constant speed, plus the estimated time to stop. The emergency warning is shown one second plus time to stop before crossing the event. Obviously, the vehicle A does not drive on the lane where the obstacle is located!

Test 2: vehicle A slows down (to around 20 km/h) so it stays in the comfort situation. The driver should intuitively choose the exact speed reduction. The exact speed reduction expected by the H&IW application depends on many factors and will be calculated according to the specification of H&IW prior to the test.

Extended description:
- the application retrieves additional information from the LDM about weather and traffic status to adapt the warning message, i.e. the warning destination area should be reduced or extended depending on the weather and traffic status (this imply function scenarioAnalysis() of object ScenarioManager).
- then it generates the appropriate RsuHMImessage and triggers the SendHMI PeriodicMessage from SP5_MessageManager (i.e. the SP5 interface with Vanet) and it triggers the display on possible VMS through the SP5ApplicationCoordinator.
- The warning messages sent to vehicle A contains “lane merging” indications at the icon displayed onboard, if accurate positioning of the vehicles and a detailed LDM (lane level positioning) are available.

Related Test sites:
from vehicle beacons:
- Netherlands/A16 (TeleAtlas)
- West/A86 (Navteq)
- Livic TBC (Navteq)
- CG22 TBC (Navteq)
from rsu:
- Italy/Brescia-Prodova (Navteq)

Tools:
The timing values can be determined by analysing H&IW log files and observing SAFESPOT UDP messages.
In addition, Esposytor, can be used.

Requirements:

**H&IW functions**
- SP5_RQ02_36_v1.0 / Message Management: The system shall be able to decide if and to whom a message has to be send.
- SP5_RQ05_36_v1.0 / Identify Safety Critical Situations: The system shall be able to identify safety critical situations at the surrounding of a critical point e.g. an urban intersection.
- SP5_RQ06_19_v1.0 / Priority Level of Message: The system shall be able to provide a priority level for each transmitted message. This is valid for V2I as well as for I2V communication.
- SP5_RQ07_19_v1.0 / Validity of Messages: The system shall be able to determine the period of validity of the transmitted and received messages.
- SP5_RQ09_19_v1.0 / Message Management 2: The system must not send warnings concerning severe dangerous situations (that might cause drivers to extreme driving actions), which does in fact not happen.
- SP5_RQ12_33_v1.0 / Data exchange: The system shall be able to transmit information towards several supporters (e.g. VMS, radio, PND).
- SP5_RQ16_36_v1.0 / Query from the LDM: The system shall be able to query needed data from the LDM.
- SP5_RQ17_36_v1.0 / Receive data from the LDM: The system shall be able to receive and handle the LDM data.

**LDM functionalities**
- SP5_RQ49_19_v1.0 / Position and speed of vehicles: The RSU subsystem shall be able to receive at minimum the current vehicle position and speed.
- SP5_RQ68_10_v1.0 / Road status: The system shall acquire data on the weather conditions in the ‘critical area’ (extent TBD) of the obstacle or accident, SP5_RQ65_10_v1.0 / Obstacle description.
- The system shall provide other details of the obstacle where possible: type of object (accident, queue, rocks, dropped load, etc), lanes affected, speed (for moving object), precise location etc. i.e. wet/dry road surface, rain, fog, ice, which may affect stopping distances and visibility.

**TIMING and Performance**
- SP5_RQ18_19_v1.0 / Simultaneity: The system shall be able to manage all vehicles in the vicinity of a critical point (e.g. the intersection) simultaneously.
- SP5_RQ20_19_v1.0 / Time of Warning Generation: The system shall generate and transmit warning information to the drivers timely enough, so that the reaction time left to the drivers is appropriate.
- SP5_RQ22_10_v1.0 / R/S Warning: The system shall provide a roadside warning in fewer than 2 sec (TBC) in the critical zones to permit vehicles to reduce speed and/or change lane in order to avoid a (secondary) collision.
- SP5_RQ35_19_v1.0 / Time of Data Delay 2: In the roadside sub-system the delay between generation of warnings and transmission of this data to the vehicles shall be smaller than 50 ms.

**MESSAGES EXCHANGE and Filtering**
- SP5_RQ34_19_v1.0 / Directly address a Vehicle: The roadside sub-system must be able to address data directly to one vehicle distinctively (or a group of vehicles) or to broadcast to all vehicles in the vicinity of the RSU.
- SP5_RQ50_36_v1.0 / Transmission of warnings: The system shall be able to transmit the warning / recommendation to equipped vehicles.
- SP5_RQ69_10_v1.0 / V Warning: The system shall send appropriate warnings to equipped vehicles within the critical (e and a) zones to permit them to reduce speed and/or change lane and avoid a (secondary) collision.
- SP5_RQ73_19_v1.0 / Filter for relevant data: The vehicle subsystem should be able to filter the relevant information to the driver.
- SP5_RQ51_19_v1.0 / HMI: In vehicle assistance HMI shall present warnings to the driver in an intelligent way without distracting him. Example: Use of different actuators to smoothly signalizes hazards.
- SP5_RQ48_36_v1.0 / Environmental Data: The system shall receive data from environmental sensors about weather (rain, snow, fog...).
- SP5_RQ52_36_v1.0 / Static Vehicle Data: The system shall receive static vehicle data like width, length, type of vehicle, mass.
- SP5_RQ60_36_v1.0 / Lack of Friction: The system shall receive information about the lack of friction of a road segment.
- Use cases:
  SP5_UC13_v1.0: Accident as an obstacle

<table>
<thead>
<tr>
<th>Expected Values / Results</th>
</tr>
</thead>
</table>

The requirements are met, specifically:
- The VANET component sends the RsuHMImessage and the vehicle display the text / icon
- Test 1 will validate the warning sequence. The expected sequence is: Comfort, Safety, Emergency
- Test 2 should validate the ability to stay in what H&IW considers as a Comfort situation.
- The time shift between the specification and the implementation/deployment will be measured.

The expected time measures are based on the “Safety Margin” definition of H&IW, which describe where and when a warning (Safety or Critical) message should be received. It mainly describes the time left to the driver to react for each warning type.

NB: The overall SAFESPOT system, including H&IW, will introduce delays due to computation and transmission that will reduce the time left to the driver to react. Therefore, different runs should be achieved to calibrate H&IW (mainly by adding average system delay into the Safety Margin Computation of H&IW).

Test 1 and Test 2 should be performed for different vehicle speeds corresponding to different road environments and situations (30km/h, 50km/h, 90km/h etc...) and with different speed recommendations corresponding to different obstacles (road blocked, speed limited to 30km/h or 50km/h).

This lead to different expected measures on the generated warnings, mainly in terms of destination areas, transmission dates and durations.

The following figure shows an example of expected warning destination areas for a vehicle driving at 90km/h, and with an obstacle speed limitation to 50km/h:
An example of expected measures for test 1 are shown in the table below.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>VEHICLE SPEED</th>
<th>ROAD WORK</th>
<th>EXPECTED MEASURES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>km/h</td>
<td>brespeed adapt.</td>
<td>speed limitation</td>
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<tr>
<td>1.1 Obstacle Warning</td>
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<td>7</td>
<td>30km/h</td>
</tr>
<tr>
<td>1.2 Obstacle Warning</td>
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<td>7</td>
<td>30km/h</td>
</tr>
<tr>
<td>1.3 Obstacle Warning</td>
<td>50</td>
<td>7</td>
<td>30km/h</td>
</tr>
<tr>
<td>2.1 Obstacle Warning</td>
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<td>2.2 Obstacle Warning</td>
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<td>50km/h</td>
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<td>2.3 Obstacle Warning</td>
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<td>7</td>
<td>50km/h</td>
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<td>2.4 Obstacle Warning</td>
<td>90</td>
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<tr>
<td>2.5 Obstacle Warning</td>
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<td>7</td>
<td>50km/h</td>
</tr>
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</table>

**Obtained Values / Results**

**Status Test Case 1**: To Be Done

**Link to external annexed documentation (if any)**

### Test Case 2: Basic performance test for H&IW_01(Obstacle) #2: Road Works as an obstacle

#### Test Description

**Prerequisite:**
- Functional
  - the functional unitary correctness validation simulation tests of H&IW_01_v0.1 have been performed and assessed at the LDM of the test site (Navteq or TéléAtlas)
- Integration of other SAFESPOT component of the architecture, both in vehicle and infrastructure, and corresponding test have been performed and validated.

**Deployment**
- One RSU and one equipped vehicle are required for this test.
- An area at the road contains road works or something similar, downstream the RSU.
- The RSU is equipped with a Gateway able to provide information about the road works location to the RSU.
- The equipped vehicle is within the range of the RSU from upstream to downstream of the RSU, in the direction of the road where the “test road works” is located (i.e. in the considered road section).
- No specific sensors are required for this test (except the RSU Gateway). Precise positioning and lane level details of the LDM are required for the extended version tests. In addition, weather sensors at the RSU and/or at the vehicles are required in extended version (note that RSU gateway to a legacy system can act as a weather sensor). Finally, VMS can be connected to the RSU to manage non-equipped vehicles.
Description:
The test consist on comparing a prepared table containing estimated time and position on when/where a warning from H&IW_01 should appears at an SAFESPOT equipped vehicle. This table is be prepared for each test site (otherwise it will contains too many entries).

- First the RSU Gateway transmits information about roadwork presence to the RSU.
- the H&IW_01 sub-application detects the roadwork (an obstacle) through its BlackSpotMonitor function.
- then the ScenarioManager function is launched to compute the Threat level.
- Then the vehicle enters in the range of the RSU, sending its beacons.
- The H&IW application sends the generic H&IW warning that corresponds to the threat level (Comfort, Safety, Emergency) depending on it’s type, speed, road attributes and obstacle position.
- If the vehicle does not adapt its speed to stay into the “comfort” situation, the different Safety and Emergency warnings will follow.

Test 1: vehicle passes thru the coverage area of the event, with the maximum legal speed authorized at the road. The vehicle does not adapt its speed and sees the three levels of warnings. The Safety warning is shown 3 seconds plus the estimated time to stop before crossing the obstacle with constant speed. The emergency warning is shown one second plus time to stop before crossing the event. Obviously, the vehicle does not drive on the lane where the obstacle is located!

Test 2: The vehicle slows down (to around 20 km/h) so it stays in the comfort situation. The exact speed reduction should be intuitively chosen by the driver. The exact speed reduction expected by the H&IW application depends on many factors and will be calculated according to the specification of H&IW prior to the test.

Extended description:
- The application retrieves additional information from the LDM about the weather and traffic status to adapt the warning message, i.e. the warning destination area should be reduced or extended depending on the weather and traffic status (using the function scenarioAnalysis() of the object ScenarioManager).
- Then it generates the appropriate RsuHMIErrorMessage and triggers the SendHMIErrorMessage from SP5_MessageManager (i.e. the SP5 interface with Vanet) and it triggers the display on possible VMS through the SP5 ApplicationCoordinator.
- The warning messages sent to vehicle A contains “lane merging” indications at the icon displayed onboard, if accurate positioning of the vehicles and a detailed LDM (lane level positioning) are available,

Test sites:
- from rsu : West/ A86 (Navteq)
Requirements:
- same as “H&IW_01 Test Site : Test Case 1: Basic performance test for H&IW_01 (Obstacle) #1: Accident/ Vehicle as obstacle”

Use cases:
- UC : SP5_UC16_v1.0: Deviations for road-works

Expected Values / Results

The requirements are met, specifically:
- The VANET component sends the RsuHMImessage and the vehicle displays the text / icon
- In test 1 the warning sequence is: Comfort, Safety, Emergency
- In Test 2 the H&IW stays in the Comfort situation.

Those test should enable to measure the shift, in term of time, between the specification and the implementation/deployment.

See the expected values of H&IW_01 Test Case 1 for more details.

Status Test Case 2  To Be Done  Link to external annexed documentation (if any)

Test Case 3: Test #1: Obstacle (stopped vehicle) Torino-Caselle- WSN

Test Description

Prerequisite:
- The successful results of all the previous tests
- Synchronization of the clock and Positioning have to be done
- Installation of the WSN system in Torino Casella ( test area)
- 10 Wireless Sensors + Gateway
- Base Board with a Local Detection Algorithm installed (FW_LDA)
- Main PC (ECW-281B-ATOM)
- SP2 applications(Data Fusion Module)
- SP5 applications installed inside Main PC
- Vanet Router dedicated gateway PC connected to main PC
- 2 FIAT BRAVO (CRF) called Vehicle A and Vehicle B (with Vanet)

Functional Description
This test aims to verify the correctness of the detection of an obstacle and the communication of a warning message to approaching SAFESPOT vehicles.

The components will communicate according to the following sequence:
1. The vehicles drive in a normal way
2. A stopped vehicle is in the area of detection. (The test is performed in a period that there is no traffic.)
3. The sensors detects the presence of a stopped vehicle
4. The communication to the Data Fusion is done and the event is written in the LDM
5. The trigger generates the notification that an obstacle is detected
6. The Black Spot Monitor receive this message
7. The SP5 application analyse the risk of the event and takes the decision of to end the message to the router Vanet (SP5_MessageManager (SP5 interface with Vanet))
8. The second vehicle (B) passes the area TBD seconds later
9. The vehicle is able to see the message with the visualization tool

Test site:
Torino Caselle

Related Test:
- Nether-lands A16 TeleAtlas
- France - West/A86 - Navteq

Requirements:
- SP5_RQ02_36_v1.0: The system shall be able to decide if and to whom a message has to be send.
- SP5_RQ07_19_v1.0: The system shall be able to determine the period of validity of the transmitted and received messages.
- SP5_RQ16_36_v1.0: The system shall be able to query needed data from the LDM.
- SP5_RQ17_36_v1.0: The system shall be able to receive and handle the LDM data.

Use cases:
- SP5_UC13 (Accident as Obstacle)
- SP5_UC14 (Traffic jams as obstacles (slow moving vehicles))
- SP5_UC15 (Traffic jams as an obstacle results of an accident, with poor visibility)

### Expected Values / Results

The requirements are met, specifically:
- The WSN detects the obstacle and its position
- Communication between the components

### Obtained Values / Results

<table>
<thead>
<tr>
<th>Status Test Case</th>
<th>To Be Done</th>
<th>Link to external annexed documentation (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Case 4: Test #2: Obstacle (traffic jam &amp; slow vehicle) Brescia – Padova-WSN-ECAID</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Test Description**

**Prerequisite**
- Successful results of all the test before
- The system ECAID has the communication with the LDM
- Installation of the WSN system in Brescia-Padova (test area)
  - 10 Sensors (AMR and Pyro)
  - Base Board with a Local Detection Algorithm installed (FW_LDA)
Main PC (ECW-281B-ATOM) - SP2 applications (Data Fusion) - SP5 applications installed inside Main PC - Vanet Router dedicated gateway PC connected to main PC - 2 FIAT BRAVO (CRF) called Vehicle A and Vehicle B (with Vanet)

Description:
The components will communicate in the following sequence:
1. The vehicles are driving in a normal way
2. A slow vehicle travels in one of the lanes of the highway in the stretch of 250 m covered by the WSN
3. The communication to the Data Fusion is done and the event is written in the LDM
4. The trigger generates the notification that an obstacle has been detected
5. The SP5 application analyses the risk of the event and takes the decision to send the appropriate message to the router Vanet (SP5_MessageManager (SP5 interface with Vanet))
6. The second vehicle (B) passes the area TBD seconds later
7. The vehicle is able to see the message with the visualization tool

Notes:
The system will be tested also considering traffic jams as an obstacle.
In this case the test will be performed in the following stages:

1. Performance of WSN prototype on a 3 lane motorway (data output and writing on LDM).
2. For Brescia-Padova: integration with (TDC and ECAID) i.e. other sensor data
3. Identification of traffic patterns
4. Detection of ‘event’ (traffic jam & slow vehicle, etc)
5. Analysis of the results

Test site
- Brescia- Padova

Related test sites
- Nether-lands A16 TeleAtlas
- France - West/A86 - Navteq

Requirements:
- SP5_RQ02_36_v1.0: The system shall be able to decide if and to whom a message has to be send.
- SP5_RQ07_19_v1.0: The system shall be able to determine the period of validity of the transmitted and received messages.
- SP5_RQ16_36_v1.0: The system shall be able to query needed data from the LDM.
- SP5_RQ17_36_v1.0: The system shall be able to receive and handle the LDM data.
Use cases:
- SP5_UC13 (Accident as Obstacle)
- SP5_UC14 (Traffic jams as obstacles (slow moving vehicles))
- SP5_UC15 (Traffic jams as an obstacle results of an accident, with poor visibility)

### Expected Values / Results

The requirements are met, specifically:
- Interaction between components
- Detection of the obstacle and its position
- I-V communication
- By comparing the detection of the WSN and ECAID systems, it is expected to obtain more precision in the results with the WSN system.

### Obtained Values / Results

**Status Test Case 4**

Test Case 5: **Test #1: Obstacle-Pedestrian on the road-CRF-Test Track- Thermal imaging cameras (provided by VTT)**

**Test Description**

Prerequisite:
- Successful results of the previous tests
- Synchronization between the clock and Positioning
- Installation of the Thermal imaging cameras (provided by VTT) (test area)
- Main PC (ECW-281B-ATOM)
- SP2 applications (DataReceiver, Map Matching, Object Refinement)
- SP5 applications installed inside Main PC
- Vanet Router dedicated gateway PC connected to main PC
- 2 FIAT BRAVO (CRF) called Vehicle A (with Vanet)

Description:
The test will check the correctness of the detection of the pedestrian on the road, its positioning and the correct communication of the corresponding message with the vehicle.

The components will communicate according to the following sequence:

1. A pedestrian crosses the motorway
2. The Thermal imaging camera receives information of an obstacle
3. The camera software provided by VTT interprets the signal and recognizes the presence of an obstacle, it sends a message with the detection information (broadcast message)
4. The main PC receives the message by the SP2 applications (Data Fusion), the information is saved inside the LDM
5. The LDM throws a trigger telling to the BlackSpotMonitor that an event was found inside the table traffic event with an event = 30 (pedestrian).
6. The SP5 applications analyses this data, analyses the risk and takes the decision to create and send a message by the Vanet (beaconing) in a broadcast way telling that there is a pedestrian at the road.
7. The message is send to the router Vanet (SP5_MessageManager (SP5 interface with Vanet))
8. A vehicle with Vanet (A) passes the area TBD seconds later and receives the message
9. The vehicle is able to see the message with the visualization tool (e.g. Expositor)

Test site: Torino-Caselle

Requirements:
- SP5_RQ02_36_v1.0: The system shall be able to decide if and to whom a message has to be send.
- SP5_RQ07_19_v1.0: The system shall be able to determine the period of validity of the transmitted and received messages.
- SP5_RQ16_36_v1.0: The system shall be able to query needed data from the LDM.
- SP5_RQ17_36_v1.0: The system shall be able to receive and handle the LDM data.

Use cases:
SP5_UC17 (Pedestrian on Motorway)

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<tr>
<th>Expected Values / Results</th>
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</thead>
<tbody>
<tr>
<td>The requirements are met, specifically:</td>
</tr>
<tr>
<td>- Detection and positioning of a pedestrian on a real motorway.</td>
</tr>
<tr>
<td>- Components provide the information</td>
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<tr>
<td>- Communication between all the components</td>
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</table>

<table>
<thead>
<tr>
<th>Obtained Values / Results</th>
</tr>
</thead>
</table>

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<th>Link to external annexed documentation (if any)</th>
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### Table 11 H&IW_02 Test Site

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<td>Mizar (case 2, 3)</td>
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<td>Reference Document</td>
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</table>

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<th>Test Type</th>
<th>Test Objective</th>
<th>Test Purpose</th>
<th>Test Environment</th>
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</thead>
<tbody>
<tr>
<td>Unitary</td>
<td>Verification</td>
<td>Correctnes</td>
<td>Test Site</td>
</tr>
</tbody>
</table>

**Test Case 1: Basic functionality test for H&IW_02: Wrong Way Driving**

**Test Description**

**Prerequisite:**
The *H&IW_02 Wrong Way Driving Sub-application* relies on the detection of vehicles by roadside sensors (RFID or Camera cf.D5.3.2) or vehicles beacons.

**Description:**
This test aims to prove the basic functionalities of H&IW_02, and require a working LDM.

- A vehicle enters an area monitored by a SAFESPOT RSU, driving in the wrong direction (i.e. “a ghost driver”).
- The H&IW_02 application detects the presence of the vehicle on the LDM (the information is coming from vehicle beaconing or RSU sensors) through its BlackSpotMonitor.
- A Scenario Manager is launched (a parallel thread) and compute the safety Margin and the associated RsuHmiMessage (this uses the functions: scenarioAnalysis() - riskEval() - safetyMarginComputation - warningStrategyRealisation)

**Extended description:**

- The application retrieves additional information from the LDM about weather and traffic status to adapt the warning message, i.e. the warning destination area should be reduced or extended depending on the weather and traffic status. (this uses the function scenarioAnalysis() of object ScenarioManager)
- Then it generates the appropriate RsuHMI-MESSAGE and triggers the SendHMI-Periodic-MESSAGE from SP5_MessageManager (i.e. the SP5 interface with Vanet) and it triggers the display and possible the VMS through the SP5_ApplicationCoordinator.
- The application should operate with or without equipped vehicles. This lead at least three tests:
  - The “Ghost driver” and the approaching vehicle are equipped. Data are coming from the GD beacons, and informs both the drivers in the vehicles.
  - The “Ghost driver” is equipped and the approaching vehicle is not. Data are coming from the GD beacon, and informs the GD in the vehicle and the approaching vehicle by a VMS.
  - The “Ghost Driver” and the approaching vehicle are not equipped. Data are coming from the RSU sensor. The approaching vehicle is informed via the VMS and the ghost driver is warned with a dedicated flashing light.
Tools:
Standard H&IW log files analysis and SAFESPOT UDP messages observation.
In addition, Esposytor, can be used.

Test sites:
TBD

Requirements:
- SP5_RQ71_10_v1.0: The system shall detect a vehicle travelling in the wrong direction on a motorway with the location accurate to x metres (TBD).
- SP5_RQ72_10_v1.0: The system shall detect the speed, lane and trajectory of a vehicle travelling the wrong way on a motorway.
- Plus those of "H&IW_01 Test Site : Test Case 1: Basic performance test for H&IW_01 (Obstacle) #1: Accident/Vehicle as obstacle"

Use cases:
SP5_UC34

<table>
<thead>
<tr>
<th>Expected Values / Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>The requirements are met, specifically:</td>
</tr>
<tr>
<td>- The test sequentially starts with the first module. If it generates an output, the test continues with the next module until the total sub-application generates an output from input to output.</td>
</tr>
<tr>
<td>- During the three different tests, relevant messages are to either: vehicles, VMS and/or flashing lights.</td>
</tr>
<tr>
<td>- The VANET component sends the RsuHMImessage (extended) the vehicle display the text / icon</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Obtained Values / Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Case 1 To Be Done</td>
</tr>
</tbody>
</table>

Link to external annexed documentation (if any)

Test Case 2: Test #1: Ghost Driver in CRF using RFID sensors. Communication Test

Test Description

Prerequisite:
- The successful results of all the test before
- Synchronization of the clock and Positioning
- Installation of the RFID system in CRF test area
  - RFID readers (PCMCIA)
  - RFID antennas (both Omni directional and directed)
  - RFID tags (active tags)
- Main PC (ECW-281B-ATOM)
- SP5 applications installed inside Main PC
- SP2 applications(DataReceiver, RFID application, Map Matching, Object Refinement)
- Vanet Router dedicated gateway PC connected to main PC
- 2 FIAT BRAVO (CRF) called Vehicle A (with Vanet) and Vehicle B (ghost driver)
Description:
The test will check the correct communication between all the components using the detection system RFID. The components will communicate in the following sequence:

1. Vehicle A drives in the correct way at the area of test
2. Vehicle B drives in the wrong way at the area of test
3. The RFID system (block of antenna, reader and elaboration system) detects the presence of a ghost driver. By means of software used for ghost driver detection correct messages are produced and send to the main PC
4. The message arrive at the DataFusion Block and it is saved inside the traffic event [trafficevent.eventcause = 35 (ghost driver)]
5. The trigger detects the event inside LDM and communicates with the Black Spot Monitor
6. SP5 applications evaluates the Risk and generates a corresponding message
7. The message is received by the Vanet router
8. The Vanet router sends this message to the Vanet of Vehicle A
9. The Driver will see the message by means of the visualization tool (e.g. Esposytor) that shows the presence of a ghost driver in a x, y position.
10. Driver B avoids and accident by slowing down.

Test site:
- CRF: Centro di Ricerca FIAT test area

Related Test sites:
Italian Test

Requirements:
- SP5_RQ02_36_v1.0: The system shall be able to decide if and to whom a message has to be send.
- SP5_RQ07_19_v1.0: The system shall be able to determine the period of validity of the transmitted and received messages.
- SP5_RQ16_36_v1.0: The system shall be able to query needed data from the LDM.
- SP5_RQ17_36_v1.0: The system shall be able to receive and handle the LDM data.

Use cases:
SP5_UC34 (Ghost Driver)

Expected Values / Results
The requirements are met, specifically:
The expected results will be that two tables are verified:
- Verification Table 1 will have the Messages sent for each component described above
  Expected Send message, Real Send message, Component
- Verification Table 2 will have the Message receive for each component described above
  Expected Receive Message – Real Receive Message, Component

The test will be considered as successful if the group of Send and Receive Messages corresponds exactly to the Expected Send and Receive Messages

Obtained Values / Results

| Status Test Case2 | To Be Done | Link to external annexed documentation (if any) |
**Test Case 3: Test#2 Ghost Driver on CRF test track-Using WSN**

### Test Description

**Prerequisite:**
- The successful results of all previous tests
- Synchronization of the clock and Positioning
- Installation of the WSN system in Torino Caselle (test area)
  - 10 Sensors (AMR and Pyro)
  - Base Board with a Local Detection Algorithm installed (FW_LDA)
- Main PC (ECW-281B-ATOM)
- SP2 applications (DataReceiver, RFID application, Map Matching, Object Refinement)
- SP5 applications installed inside Main PC
- Vanet Router dedicated gateway PC connected to main PC
- 2 FIAT BRAVO (CRF) called Vehicle A and Vehicle B (with Vanet)

**Description:**
This test will focus on the verification of the correct communication between all components using the detection system of WSN. Due to the fact that Torino Caselle is a transit roadway the aim of this test is to verify the behaviour of the WSN with real traffic, and the correct communication with the vehicle. This test pretends to identify ghost drivers. Given the fact that is not possible to simulate a ghost driver in real traffic, the test will mimic that all vehicles drive in a wrong way (ghost drivers). In this test, a broadcast message will be send. The two vehicles provided with Vanet will receive a message from the Vanet router about the detected ghost drivers.

The components will communicate in this following sequence:
1. The vehicles are driving in the legal direction
2. The sensors detects that there are ghost drivers and communicate this fact to the Main RSU PC.
3. The message arrives to the DataFusion Block and it is saved inside the traffic event [trafficevent.eventcause = 35 (ghost driver)]
4. The trigger detects the event inside the LDM and communicates with the Black Spot Monitor
5. The SP5 application evaluates the Risk and generates a corresponding message. SP5_MessageManager (SP5 interface with Vanet))
6. Vehicle A enters the ghost driver area
7. The message is received by the Vanet router of Vehicle A
8. The Driver of vehicle A will sees the message by means of the visualization tool (e.g. Esposytor) that shows him that he represents a dangerous vehicle, i.e. that he is a ghost driver at position x, y. Additional, the driver will be alerted that there are other ghost drivers in the surrounding.

**Test site:**
Torino Caselle

**Requirements:**
- SP5_RQ02_36_v1.0: The system shall be able to decide if and to whom a message has to be send.
- SP5_RQ07_19_v1.0: The system shall be able to determine the period of validity of the transmitted and received messages.
- SP5_RQ16_36_v1.0: The system shall be able to query needed data from the LDM.
- SP5_RQ17_36_v1.0: The system shall be able to receive and handle the LDM data.
Use cases:
- SP5_UC34

<table>
<thead>
<tr>
<th>Expected Values / Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>The requirements are met, specifically:</td>
</tr>
<tr>
<td>- All Real Sent and Received Messages correspond to the Expected Messages as indicated in tables.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Obtained Values / Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status Test Case3 To Be Done</td>
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</table>
Table 12 H&IW_03 Test Site

<table>
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<th>TEST FORM</th>
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<tbody>
<tr>
<td>Unitary</td>
<td>Verification</td>
<td>Correctness</td>
<td></td>
</tr>
</tbody>
</table>

Test Case 1: Basic functionality test for H&IW_03: Abnormal road Condition

Test Description

Prerequisite:
The H&IW applications are designed to work in close cooperation with the SP5 Speed Alert Application. This is particularly true for "H&IW_03 Abnormal road condition" sub-application, as it may not generate Critical warnings. Only Comfort or Safety warnings. Critical warning may be generated (if necessary) by the Spa application. Therefore, a test of H&IW_03 should include a cooperation with Spa which should issue stronger warning (with higher priority) when vehicle speed is not appropriate.

Description:
- The RSU detect abnormal road condition status either form vehicle messages, or road side sensor. The first version (vehicle sensors) is not tested in SAFESPOT test sites. Therefore, only RSU sensors must be simulated. A simple writing on the LDM of weather information is sufficient for the functional test.
- The H&IW_03 application detects the presence abnormal road condition on the LDM through its BlackSpotMonitor
- A Scenario Manager is launched (a parallel thread) and compute the safety Margin and the associated RsuHmiMessage (this uses the functions: scenarioAnalysis() - riskEval() - safetyMarginComputation() - warningStrategyRealisation())
- The warningStrategyRealisation() should issue a warning for VMS if available, and start broadcasting periodic RSUHMI message on the vanet.

Extended description:
- The test should involve an equipped vehicle. It passes under the area monitored by the RSU with or without an appropriate speed. The road should be either dry, or wet. This lead to at least four tests.
- The test consist on verify that appropriate message is generated for VMS and vehicles, according to weather status and vehicle status.

Test site: TBD

Requirements:
- SP5_RQ02_36_v1.0: The system shall be able to decide if and to whom a message has to be send.
- SP5_RQ06_19_v1.0: The system shall be able to provide a priority level for each transmitted message. This is valid for V2I as well as for I2V communication.
- SP5_RQ07_19_v1.0: The system shall be able to determine the period of validity of the transmitted and received messages.
- SP5_RQ09_19_v1.0: The system must not send warnings concerning severe dangerous situations (that might cause drivers to extreme driving actions), which does in fact not happen.
- SP5_RQ19_36_v1.0: The system shall have nearly the same performance in case there are just two or 80 vehicles to manage.
- SP5_RQ20_19_v1.0: The system shall generate and transmit warning information to the drivers timely enough, so that the reaction time left to the drivers is appropriate.
- SP5_RQ24_19_v1.0: The system has to be robust enough in order to operable under different extreme weather conditions (heat, cold, snow, etc.).
- SP5_RQ29_27_v1.0: The short range communication shall be available at critical points and their vicinity (minimum 600 m).
- SP5_RQ32_19_v1.0: In the vehicle sub-system the delay between determination of position and velocity of the vehicle and transmission of this data to the roadside shall be smaller than 50 ms.
- SP5_RQ34_19_v1.0: The roadside sub-system must be able to address data directly to one vehicle distinctively (or a group of vehicles) or to broadcast to all vehicles in the vicinity of the RSU.
- SP5_RQ35_19_v1.0: In the roadside sub-system the delay between generation of warnings and transmission of this data to the vehicles shall be smaller than 50 ms.
- SP5_RQ48_36_v1.0: The system shall receive data from environmental sensors about weather (rain, snow, fog,...).
- SP5_RQ50_36_v1.0: The system shall be able to transmit the warning / recommendation to equipped vehicles.
- SP5_RQ51_19_v1.0: In vehicle assistance HMI shall present warnings to the driver in an intelligent way without distracting him. Example: Use of different actuators to smooth signalizes hazards.
- SP5_RQ61_36_v1.0: The system must be able to receive data form the vehicles as well as the infrastructure.

Use cases:
SP5_UC41

Expected Values / Results

The requirements are met, specifically:
- The purpose is to test H&IW and H&IW_03 functionalities. The test sequentially starts with the first module. If generates an output the test continuous with the next module until the total sub-application generates an output from input to output.
  - First on a dry road and vehicle with appropriate speed, no warning should be issued by the H&IW_03 application
  - Then, on a wet road, a vehicle with appropriate speed should receive only the Comfort warning
  - On a wet road, a vehicle with excessive speed should receive directly the Spa Safety or Critical Warning
  - On a wet road, VMS must display weather / road status warning.
- The VANET component sends the RsuHMImessage (extended) the vehicle display the text / icon

Obtained Values / Results

Status Test Case1 To Be Done Link to external annexed documentation (if any)
4.4 Road DEparture Prevention (RDEP)

4.4.1 Description
The objective of the Road Departure application is to reduce the number of occurrences that a vehicle departs from the road [3]. The overall application consists of two main phases.

Phase 1: Safe Drive Map creator (learning phase)
The Road Departure (RDep) application relies on the Safe Drive Map (SDM). The SDM is a Data Base filled with information from vehicles passing through the following Black Spots:
1. Deviation for Road Work
2. Dangerous curve
In this phase, the vehicle's data is queried from the LDM, processed by the RDep application and stored in the SDM.

Phase 2: Road Departure runtime application
With the information of the first phase and the live information from the vehicle passing through the Black Spots in runtime, the RDep application evaluates the risk of the vehicle to go off road. If a dangerous situation is foreseen, a warning is sent to the driver. The Black spots considered are:
1. Deviation for Road Work
2. Dangerous curve

4.4.2 Test form
In order to verify and validate the correct functionality of both phases of the Road Departure application, the following tests are planned:
- RDEP_0001 - Safe Drive Map Creation - Unitary, verification, correctness in Simulation
- RDEP_0002 - Road Departure runtime app. - Unitary, verification, correctness in Simulation
- RDEP_0003 - Safe Drive Map Creation - Integration, verification, correctness at Test Sites
- RDEP_0004 - Road Departure runtime app. - Integration, verification, correctness at Test Sites
Table 13 Rdep SDM Creator Simulation

<table>
<thead>
<tr>
<th>SP</th>
<th>WP</th>
<th>Prototype Version</th>
<th>System Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
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<td>RDep_SDM_Creator_v1.0</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>HW Release</th>
<th>SW Release</th>
<th>Compiled by / Company</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sim. PC</td>
<td>Sim. PC</td>
<td>DIBE (Andre Possani)</td>
<td>22/02/2009</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Form Progressive Numb.</th>
<th>Functional Component</th>
<th>Reference Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>1. RDep_SDM_Creator</td>
<td>D5.3.4 – Road Departure</td>
</tr>
<tr>
<td></td>
<td>2. Safe Drive Map</td>
<td>v3.4</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Test Objective</th>
<th>Test Purpose</th>
<th>Test Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unitary</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verification</td>
<td></td>
<td>Correctnes</td>
<td>Simulation</td>
</tr>
</tbody>
</table>

Test Case 1: Safe Drive Map creator (learning phase) for a Deviation of Road Work

Description:
The Road Departure application relies on the Safe Drive Map (SDM), which is a Data Base filled with information from vehicles passing through a black spot (Deviation for Road Work). Creating the SDM is the offline part of the Road Departure application. The LDM data player (MARS) is used as input (provides vehicle information) and the output is stored in the Safe Drive Map.

![Diagram](Diagram.png)

The following procedure are done at least 20 times:
1. In a two lane straight road, the vehicle drives in the left lane with a speed of 15m/s ± 5m/s.
2. As soon as the driver can see that a Road Work deviation is present ahead obstructing the left lane, it should lower its speed and do the correct maneuver while changing to the right lane. The RDep_SDM_Creator program should monitor and record the vehicle’s trajectory.
After having all the sample trajectories, the RDep_SDM_Creator will analyze the obtained trajectories and will calculate the values for the Safe Drive Map.

Tools:
- LDM data player (MARS)

Requirements:
- SP5_RQ16_36_v1.0 – The system shall be able to query needed data from the LDM

**Expected Values / Results**

The requirements are met, specifically:
1. The RDep_SDM_Creator is able to query the LDM for all the static and dynamic information of the vehicles present in the coverage area.
2. The RDep_SDM_Creator is able to store the trajectories of the vehicles and analyze them.
3. The values for the Safe Drive Map is calculated by the RDep_SDM_Creator.

**Obtained Values / Results**

**Test Case 2: Safe Drive Map creator (learning phase) for a Dangerous Curve**

**Test Description**

Description: The Road Departure application relies on the Safe Drive Map (SDM), which is a Data Base filled with information from vehicles passing through a black spot (Dangerous Curve). Creating the SDM is the offline part of the Road Departure application. The LDM data player (MARS) is used as input (provides vehicle information) and the output is stored in the Safe Drive Map.

The following procedure should be done at least 20 times:
1. While approaching to the dangerous bend, the vehicle enters the dangerous curve keeping the average speed of 15m/s ± 5m/s;
2. The vehicle should drive through the curve in a comfortable situation and should never leave its lane. The RDep_SDM_Creator program should monitor and record the vehicle’s trajectory.

After having all the sample trajectories, the RDep_SDM_Creator will analyze the obtained trajectories and will calculate the values for the Safe Drive Map.
## Tools:
- LDM data player (MARS)

## Requirements:
- SP5_RQ16_36_v1.0 – The system shall be able to query needed data from the LDM

### Expected Values / Results

<table>
<thead>
<tr>
<th>Status Test Case2</th>
<th>To Be Done</th>
<th>Link to external annexed documentation (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The requirements are met, specifically:
1. The RDep_SDM.Creator is able to query the LDM for all the static and dynamic information of the vehicles present in the coverage area.
2. The RDep_SDM.Creator is able to store the trajectories of the vehicles and analyze them.
3. The values for the Safe Drive Map is calculated by the RDep_SDM.Creator.

### Obtained Values / Results
Table 14 Rdep Runtime Simulation

<table>
<thead>
<tr>
<th>SP</th>
<th>5</th>
<th>WP</th>
<th>5</th>
<th>Prototype Version</th>
<th>System Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW Release</td>
<td>Sim. PC</td>
<td>SW Release</td>
<td>Sim. PC</td>
<td>Compiled by / Company: DIBE (Andre Possani)</td>
<td>Date: 25/02/2009</td>
</tr>
<tr>
<td>Form Progressive Numb.</td>
<td>14</td>
<td>Functional Component</td>
<td>Road Departure runtime app.</td>
<td>Reference Document: D5.3.4 – Road Departure v3.4</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Test Objective</th>
<th>Test Purpose</th>
<th>Test Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unitary</td>
<td>Verification</td>
<td>Correctness</td>
<td>Simulation</td>
</tr>
</tbody>
</table>

Test Case 1: Road Departure Runtime application for a Deviation of Road Work

Test Description:
Whenever a vehicle travel along the Road Work deviation, the RSU monitors the vehicle’s trajectory and Road Departure Runtime application predicts the near future trajectory and compares it with the SDM information. Depending on the risk analysis of the application, a Comfort, Safety or Critical warning is issued and sent to the HMI through the Message Manager.

The condition of “No Warning” is summarized by the following steps:
1. In a two lane straight road, the vehicle drives in the left lane with a speed of 15m/s ± 5m/s.
2a. As soon as the driver can see that a Road Work deviation is present ahead obstructing the left lane, it lowers its speed and does the correct manoeuvre while changing to the right lane. No warning is issued.
2b. The vehicle travels through the monitored area without lowering its speed making it difficult to do the correct change lane manoeuvre;
2c. The vehicle travels too near the Road Work deviation area;

Input:
LDM data player

Output:
Simulated HMI

Road Departure Safe Drive Map
Tools:
- LDM data player (MARS)
- Simulated HMI (simple green-yellow-red icon display, included in the RDep application)

Requirements:
- SP5_RQ02_36_v1.0 – The system shall be able to decide if and to whom a warning message has to be send
- SP5_RQ04_36_v1.0 – The system shall be able to predict the vehicle’s trajectory
- SP5_RQ16_36_v1.0 – The system shall be able to query needed data from the LDM

Expected Values / Results

The requirements are met, specifically:
1. The Road Departure Runtime application is able to query the LDM for all the static and dynamic information of the vehicles present in the coverage area.
2. The Road Departure Runtime application is able to predict the trajectory of the vehicle and compare it with the values of the SDM.
4. The Road Departure Runtime application is able to decide if and to whom a warning message has to be send.

Obtained Values / Results

Test Case 2: Road Departure Runtime application for a Dangerous Curve

Test Description
Whenever a vehicle travel along the Dangerous Curve, the RSU monitors the vehicle’s trajectory and Road Departure Runtime application predicts the near future trajectory and compares it with the SDM information. Depending on the risk analysis of the application, a Comfort, Safety or Critical warning is issued and sent to the HMI through the Message Manager.

The condition of "No Warning" is summarized by the following steps:
1. While approaching to the dangerous bend, the vehicle enters the curve keeping the average speed of 15m/s ± 5m/s.
2a The vehicle should drive through the curve in a comfortable situation and should never leave its lane. No warning should be issued.
In the condition of "Warning", the step 2 above is changed as follows:

2b The vehicle travels through the monitored area without respecting the speed limits, making it difficult to drive smoothly;
2c The vehicle travels too near the lane lines or even leaves its lane;

Tools:
- LDM data player (MARS)
- Simulated HMI (simple green-yellow-red icon display, included in the RDep application)

Requirements:
- SP5_RQ02_36_v1.0 – The system shall be able to decide if and to whom a warning message has to be send
- SP5_RQ04_36_v1.0 – The system shall be able to predict the vehicle’s trajectory
- SP5_RQ16_36_v1.0 – The system shall be able to query needed data from the LDM

Expected Values / Results
The requirements are met, specifically:
1. The Road Departure Runtime application is able to query the LDM for all the static and dynamic information of the vehicles present in the coverage area.
2. The Road Departure Runtime application is able to predict the trajectory of the vehicle and compare it with the values of the SDM.
3. The Road Departure Runtime application is able to decide if and to whom a warning message has to be send.

Obtained Values / Results

<table>
<thead>
<tr>
<th>Status Test Case</th>
<th>To Be Done</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Case 2</td>
<td>To Be Done</td>
</tr>
</tbody>
</table>

Link to external annexed documentation (if any)
### Table 15 Rdep SDM creator Test site

<table>
<thead>
<tr>
<th>Test Case 1: Safe Drive Map creator (learning phase) for a Deviation of Road Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Description:</td>
</tr>
<tr>
<td>The Road Departure application relies on the Safe Drive Map (SDM), which is a Data Base filled with information from vehicles passing through a black spot (Deviation for Road Work). Creating the SDM is the offline part of the Road Departure application.</td>
</tr>
<tr>
<td>The following procedure is performed at least 20 times:</td>
</tr>
<tr>
<td>1. In a two lane straight road, the vehicle should drive in the left lane with a speed of 15m/s ± 5m/s.</td>
</tr>
<tr>
<td>2. As soon as the driver can see that a Road Work deviation is present ahead obstructing the left lane, it should lower its speed and do the correct manoeuvre while changing to the right lane. The RDep_SDM_Creator program should monitor and record the vehicle’s trajectory.</td>
</tr>
<tr>
<td>After having all the sample trajectories, the RDep_SDM_Creator will analyze the obtained trajectories and will calculate the values for the Safe Drive Map.</td>
</tr>
</tbody>
</table>

Test sites:
Most probably, the CRF Test Track in Orbassano (Italy) will be used for the Test Case 1.
### Requirements:
- SP5_RQ16_36_v1.0 – The system shall be able to query needed data from the LDM
- SP5_RQ49_19_v1.0 – The RSU subsystem shall be able to receive at minimum the current vehicle position and speed
- SP5_RQ52_36_v1.0 – The system shall receive static vehicle data like width, length, type of vehicle, mass.
- SP5_RQ61_36_v1.0 – The system must be able to receive data from the vehicles as well as the infrastructure

### Expected Values / Results
1. The RDep_SDM_Creator should be able to query the LDM for all the static and dynamic information of the vehicles present in the coverage area.
2. The RSU subsystem should be able to provide at minimum the current vehicle position and speed
3. The system should receive static vehicle data like width, length, type of vehicle, mass
4. The system should be able to receive data from the vehicles as well as the infrastructure
5. The RDep_SDM_Creator should be able to store the trajectories of the vehicles and analyze them.
6. The values for the Safe Drive Map should be calculated by the RDep_SDM_Creator.

### Obtained Values / Results

<table>
<thead>
<tr>
<th>Status</th>
<th>Test Case</th>
<th>Link to external annexed documentation (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Test Case 1 To Be Done</td>
<td></td>
</tr>
</tbody>
</table>

**Test Case 2: Safe Drive Map creator (learning phase) for a Dangerous Curve**

**Test Description**

Description:
The Road Departure application relies on the Safe Drive Map (SDM), which is a Data Base filled with information from vehicles passing through a black spot (Dangerous Curve). Creating the SDM is the offline part of the Road Departure application.

The following procedure should be done at least 20 times:
1. While approaching to the dangerous bend, the vehicle enters the dangerous curve keeping the average speed of 15m/s ± 5m/s;
2. The vehicle should drive through the curve in a comfortable situation and should never leave its lane. The RDep_SDM_Creator program should monitor and record the vehicle’s trajectory.

After having all the sample trajectories, the RDep_SDM_Creator will analyze the obtained trajectories and will calculate the values for the Safe Drive Map.

Test sites:
Most probably, the LIVIC Test Track in Satory (France) will be used for the Test Case 2.
Requirements:
- SP5_RQ16_36_v1.0 – The system shall be able to query needed data from the LDM
- SP5_RQ49_19_v1.0 – The RSU subsystem shall be able to receive at minimum the current vehicle position and speed
- SP5_RQ52_36_v1.0 – The system shall receive static vehicle data like width, length, type of vehicle, mass.
- SP5_RQ61_36_v1.0 – The system must be able to receive data from the vehicles as well as the infrastructure

Expected Values / Results

The requirements are met, specifically:
1. The RDep_SDM_Creator is able to query the LDM for all the static and dynamic information of the vehicles present in the coverage area.
2. The RSU subsystem is able to provide at minimum the current vehicle position and speed
3. The system receives static vehicle data like width, length, type of vehicle, mass
4. The system is able to receive data from the vehicles as well as the infrastructure
5. The RDep_SDM_Creator is able to store the trajectories of the vehicles and analyze them.
6. The values for the Safe Drive Map is calculated by the RDep_SDM_Creator.

Obtained Values / Results

Status Test Case2 | To Be Done | Link to external annexed documentation (if any)
Table 16 Rdep Runtime Test site

| Test Case 1: Road Departure Runtime application for a Deviation of Road Work |
| Description |

Whenever a vehicle travels along the Road Work deviation, the RSU monitors the vehicle’s trajectory and Road Departure Runtime application predicts the near future trajectory and compares it with the SDM information. Depending on the risk analysis of the application, a Comfort, Safety or Critical warning is issued and sent to the HMI of the vehicle through the VANET.

The condition of "No Warning" is summarized by the following steps:
1. In a two lane straight road, the vehicle should drive in the left lane with a speed of $15\text{m/s} \pm 5\text{m/s}$.
2a. As soon as the driver can see that a Road Work deviation is present ahead obstructing the left lane, it should lower its speed and do the correct manoeuvre while changing to the right lane. No warning should be issued.

In the condition of "Warning", the step 2 above is changed as follows:
2b. The vehicle travels through the monitored area without lowering its speed making it difficult to do the correct change lane manoeuvre;
2c. The vehicle travels too near the Road Work deviation area;

Test sites:
Most probably, the CRF Test Track in Orbassano (Italy) will be used for the Test Case 1.
<table>
<thead>
<tr>
<th>Requirements:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- SP5_RQ02_36_v1.0 – The system shall be able to decide if and to whom a warning message has to be</td>
</tr>
<tr>
<td>send</td>
</tr>
<tr>
<td>- SP5_RQ04_36_v1.0 – The system shall be able to predict the vehicle’s trajectory</td>
</tr>
<tr>
<td>- SP5_RQ16_36_v1.0 – The system shall be able to query needed data from the LDM</td>
</tr>
<tr>
<td>- SP5_RQ49_19_v1.0 – The RSU subsystem shall be able to receive at minimum the current vehicle</td>
</tr>
<tr>
<td>position and speed</td>
</tr>
<tr>
<td>- SP5_RQ50_36_v1.0 – The system shall be able to transmit the warning to equipped vehicles</td>
</tr>
<tr>
<td>- SP5_RQ52_36_v1.0 – The system shall receive static vehicle data like width, length, type of</td>
</tr>
<tr>
<td>vehicle, mass</td>
</tr>
<tr>
<td>- SP5_RQ61_36_v1.0 – The system must be able to receive data from the vehicles as well as the</td>
</tr>
<tr>
<td>infrastructure</td>
</tr>
</tbody>
</table>

### Expected Values / Results

The requirements are met, specifically:
1. The Road Departure Runtime application is able to query the LDM for all the static and dynamic information of the vehicles present in the coverage area.
2. The Road Departure Runtime application is able to predict the trajectory of the vehicle and compare it with the values of the SDM.
3. The Road Departure Runtime application is able to decide if and to whom a warning message has to be sent.
4. The RSU subsystem is able to provide at minimum the current vehicle position and speed
5. The system is able to transmit the warning messages to the equipped vehicles
6. The system receives static vehicle data like width, length, type of vehicle, mass
7. The system is able to receive data from the vehicles as well as the infrastructure

### Obtained Values / Results

<table>
<thead>
<tr>
<th>Status Test Case</th>
<th>To Be Done</th>
<th>Link to external annexed documentation (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Case 2: Road Departure Runtime application for a Dangerous Curve</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Test Description

Description:
Whenever a vehicle travel along the Dangerous Curve, the RSU monitors the vehicle’s trajectory and Road Departure Runtime application predicts the near future trajectory and compares it with the SDM information. Depending on the risk analysis of the application, a Comfort, Safety or Critical warning is issued and sent to the HMI of the vehicle through the VANET.

The condition of “No Warning” is summarized by the following steps:
1 – While approaching to the dangerous bend, the vehicle enters the curve keeping the average speed of 15m/s ± 5m/s.
2a – The vehicle should drive through the curve in a comfortable situation and should never leave its lane. No warning should be issued.

In the condition of “Warning”, the step 2 above is changed as follows:
2b - The vehicle travels through the monitored area without respecting the speed limits, making it difficult to drive smoothly;
2c - The vehicle travels too near the lane lines or even leaves its lane;

Test sites:
Most probably, the LIVIC Test Track in Satory (France) will be used for the Test Case 2.
Requirements:
- SP5_RQ02_36_v1.0 – The system shall be able to decide if and to whom a warning message has to be send
- SP5_RQ04_36_v1.0 – The system shall be able to predict the vehicle’s trajectory
- SP5_RQ16_36_v1.0 – The system shall be able to query needed data from the LDM
- SP5_RQ49_19_v1.0 – The RSU subsystem shall be able to receive at minimum the current vehicle position and speed
- SP5_RQ50_36_v1.0 – The system shall be able to transmit the warning to equipped vehicles
- SP5_RQ52_36_v1.0 – The system shall receive static vehicle data like width, length, type of vehicle, mass.
- SP5_RQ61_36_v1.0 – The system must be able to receive data from the vehicles as well as the infrastructure

Expected Values / Results

The requirements are met, specifically:
1. The Road Departure Runtime application is able to query the LDM for all the static and dynamic information of the vehicles present in the coverage area.
2. The Road Departure Runtime application is able to predict the trajectory of the vehicle and compare it with the values of the SDM.
3. The Road Departure Runtime application is able to decide if and to whom a warning message has to be send.
4. The RSU subsystem is able to provide at minimum the current vehicle position and speed
5. The system is able to transmit the warning messages to the equipped vehicles
6. The system receives static vehicle data like width, length, type of vehicle, mass

Obtained Values / Results

<table>
<thead>
<tr>
<th>Status Test Case</th>
<th>To Be Done</th>
<th>Link to external annexed documentation (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.5 Safety Margins for Assistance and Emergency Vehicles (SMAEV)

4.5.1 Description

The Safety margin for Assistance and Emergency Vehicles (SMAEV) application has two main objectives:

1. to enhance safety and efficiency of Assistance and Emergency Vehicles;
2. to optimize their management through the use of SAFESPOT-CoSSIB applications itself.

Assistance and Emergency Vehicles (AEV) are integrated in the SAFESPOT system by the SMAEV application. These vehicles can be equipped with road signs/VMS on their rear/top. They have the capability to transmit SAFESPOT warning messages like CoSSIB Road Side Units do. However, key is the presence of an HMI for the road operator to manually select the most suited road signalling.

Three main functionalities characterise SMAEV application

1. Assistance Vehicle signalling enhancement. An example is the case of signalled CoSSIB assistance vehicles driving behind slow moving vehicles.
2. Supply CoSSIB service in uncovered areas. In this way, the Assistance vehicle acts as a Mobile Roadside Unit either amplifying the signalling of a nearby fixed Roadside Unit, or providing its own signalling.
3. Emergency vehicles protection at crossings. This application allows emergency vehicles to have the highest priority at intersections that are governed by IRIS/SMAEV applications, and it allows other road users to give way in order to ensure a “green route”

This application contains two sub-applications, dedicated to Assistance Vehicles and Emergency Vehicles respectively:

1. SMAEV_01: Safety margin for assistance vehicle signalling a critical event (by using a mobile RSU).
2. SMAEV_02: Safety margin for emergency vehicles crossing an intersection

For more information the reader is referred to [19].

4.5.2 Modules

The SMAEV application modules are:

- The SMAEV app module is the centre of the application as it contains its main logical structure.
- The HMI module (server-client) allows the user to browse through the functionalities (Use Cases), editing messages and visualising the details of the incoming events (e.g. a new message from a nearby RSU).
- The LDM manager module retrieves data from the LDM database via the Bosch Q-API. The relevant data concern the vehicle dynamics (provided by the gateway, external to SP5) and position (provided by the positioning module, external to SP5).

- The VMS panel module allows to manage the VMS device and to send via RS232 the information that should be displayed on it, i.e. the Variable Message itself.

- The VANET message module composes the UDP Message that is sent to the router device. The latter will provide for the delivery of the message to the VANET. This module is in practice the Message Manager for SMAEV application.

Figure 6 shows the logical architecture of SMAEV application.

4.5.3 Test form

4.5.3.1 Module and application testing
The application works correctly if it performs all its functionalities (1) without fault and (2) complying with the specifications reported in D5.3.5 [19], with the minor variations reported in D5.4.1 and D5.4.2 (Possani et al., planned submission in 2009). Table 17 SMAEV module test checklist list the details.
Table 17 SMAEV module test check list

<table>
<thead>
<tr>
<th>Description</th>
<th>Checked items:</th>
</tr>
</thead>
<tbody>
<tr>
<td>by navigating through the HMI client browser, all functionalities are</td>
<td>- Use Case selection (tab panel switching)</td>
</tr>
<tr>
<td>correctly performed by the HMI server</td>
<td>- Manual entering of data: all selectable options are actually valid, no</td>
</tr>
<tr>
<td></td>
<td>fault, no conflict</td>
</tr>
<tr>
<td></td>
<td>- Start/stop of Use Case (UC11, 12, 51)</td>
</tr>
<tr>
<td></td>
<td>- Switch from (UC12 to UC51)</td>
</tr>
<tr>
<td></td>
<td>- Start/stop sync (UC61)</td>
</tr>
<tr>
<td></td>
<td>- Data correctly displayed to the User (RSU message, current message)</td>
</tr>
<tr>
<td>- data retrieval from LDM is correctly performed</td>
<td>- Vehicle position</td>
</tr>
<tr>
<td></td>
<td>- Vehicle speed</td>
</tr>
<tr>
<td></td>
<td>- HMI messages from VANET</td>
</tr>
<tr>
<td>- data transmission to VMS panel is correctly performed</td>
<td>- A subset of the data inserted via HMI is correctly transmitted via serial</td>
</tr>
<tr>
<td></td>
<td>port and displayed on the VMS panel</td>
</tr>
<tr>
<td>- data transmission to VANET is correctly performed</td>
<td>- A subset of the data inserted via HMI is utilized to compose an UDP message</td>
</tr>
<tr>
<td></td>
<td>that is correctly sent to the VANET router</td>
</tr>
</tbody>
</table>

4.5.3.2 System testing

Figure 7 shows the physical architecture of SMAEV application, taken from D5.4.2 (Possani et al., planned submission in 2009).

The system is functioning correctly if all its components behave without fault. Although detailed tests on the physical components are outside the scope of SP5, it is necessary to test the integrated prototype. The plan is to utilise a checklist analogous to the list used for testing the application, though with some differences. Table 18 shows the testing.
<table>
<thead>
<tr>
<th>Description</th>
<th>Checked items</th>
</tr>
</thead>
<tbody>
<tr>
<td>all components are properly connected</td>
<td></td>
</tr>
<tr>
<td>vehicle gateway is configured to work on Fiat Croma and provides correct output data</td>
<td></td>
</tr>
<tr>
<td>data from gateway are correctly acquired and stored into the LDM</td>
<td>- Vehicle position</td>
</tr>
<tr>
<td></td>
<td>- Vehicle speed</td>
</tr>
<tr>
<td>upon reception of an UDP message the router sends it to the VANET and another vehicle receives it</td>
<td>- Event messages</td>
</tr>
<tr>
<td></td>
<td>- Periodic Messages</td>
</tr>
</tbody>
</table>

This testing will be performed every time that there is a new software release related to one component. Additional testing might be performed upon the indications of the partners supplying the modules.

For SMAEV_01 and SMAEV_02 the following tests are planned.
### Table 19 SMAEV_01 Test site

<table>
<thead>
<tr>
<th>SP</th>
<th>WP</th>
<th>Prototype Version</th>
<th>System Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW Release</td>
<td>SW Release</td>
<td>Compiled by / Company</td>
<td>CRF (Filippo Visintainer)</td>
</tr>
<tr>
<td>Form Progressive Numb.</td>
<td></td>
<td>Date</td>
<td>23/01/2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Functional Component</td>
<td>SMAEV 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reference Document</td>
<td>D5.3.5 §5.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Test Objective</th>
<th>Test Purpose</th>
<th>Test Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integration</td>
<td>Verification</td>
<td>Correctnes</td>
<td>Test Site</td>
</tr>
</tbody>
</table>

**Test Case 1: Slow Assistance Vehicle moving on the road**

**Test Description**

AV = Assistance Vehicle - i.e. CRF COSSIB demonstrator vehicle, integrating SP5-SMAEV01 sub-application

SAFESPOT vehicle = CRF SAFEPROBE or SCOA demonstrator vehicle, integrating SP5 client

Description:

1. The AV moves at slow speed on lane 1. UC11 (Safety margin for maintenance vehicle on snow removal or salting operation) functionality is switched on.
2. The operator inside the AV starts UC11 from the AV HMI module and gives corresponding warning of slow vehicle (due, for example, to road maintenance operation)
3. A SAFESPOT vehicle comes on lane 2 from behind, heading the same direction of the AV at higher speed

![UC11 functionality is switched off](attachment:UC11_off.png)

UC11 functionality is switched off

![Slow speed (20, 30 km/h)](attachment:slow_speed.png)

Slow speed (20, 30 km/h)

![UC11 functionality is switched on](attachment:UC11_on.png)

UC11 functionality is switched on

![SAFESPOT Vehicle overtaking](attachment:SAFESPOT.png)

SAFESPOT Vehicle overtaking

![AV](attachment:AV.png)

AV
Trials
Repeated trials with the following characteristics will be performed:
A. Varying the speed values of AV (e.g. 30, 20 km/h, stopped); SF vehicle at 70 km/h
B. SAFESPOT vehicle overtaking at 3 different speed values (50, 70, 90 km/h); AV at 30 km/h
C. SAFESPOT vehicle arriving at 3 different speed values and slowing down as soon as the VMS signal is seen and interpreted by the driver (50, 70, 90 km/h); AV at 30 km/h
D. SAFESPOT vehicle arriving at different speed and slowing down as soon as the VANET message is received and interpreted by the driver (50, 70, 90 km/h); AV at 30 km/h

Test Sites:
- Torino-Caselle

Requirements:
- SP5_RQ02_36_v1.0
- SP5_RQ06_19_v1.0
- SP5_RQ07_19_v1.0
- SP5_RQ12_33_v1.0
- SP5_RQ14_33_v1.0
- SP5_RQ16_36_v1.0
- SP5_RQ17_36_v1.0

Use cases:
SP5_UC51 - P5_UC11

Expected Values / Results

The requirements are met, specifically:
Results for every trial
- A warning of the following kind: “Operation type Lane Speed AdditionalWarning” is displayed on the display of an incoming SAFESPOT vehicle.
- A subset of this message is displayed on the VMS panel placed on top of the AV demonstrator, so that also non-SAFESPOT vehicles can see the warning.

Results specific for trial A
- By varying the AV speed, the attribute “Speed” in the warning should change accordingly. This is verified by comparing the message in step 3 and step 5.
- When the vehicle stops (step 7) the message should autonomously change into: “Operation type Lane STOPPED VEHICLE AdditionalWarning”;

Results specific for trial B
- VANET message is received independently of the relative speed between SAFESPOT vehicle and AV.

Results specific for trials C and D: VANET versus VMS-only
- Assuming a straight road, upon reception of signal the SAFESPOT vehicle should be able to slow down and queue behind the AV (i.e. the two vehicles should proceed at the same speed).
- The distance between AV and SF vehicles when they are able to queue will be considered: the higher the distance, the better the results.
- The comparison between trial C and D will give an indication of the added value of VANET with respect of VMS only. The trials will be made on two different lanes for safety reasons.
### Test Case 2: Assistance Vehicle signalling an event during its trip

#### Test Description

**Description:**
1. A SAFESPOT vehicle is running on lane 1
2. The AV, with UC12 (Assistance vehicle patrolling or signalling a traffic event on a road) active comes from far away, heading the same direction at higher speed, and overtakes the SAFESPOT vehicle (virtually the AV is moving to a site where an event has happened)

![Test Diagram](image)

**Trials**

Trials will be performed varying the relative speed between AV and SF vehicle (from 10 km/h to 90 km/h of relative speed).

**Test Sites:**
- Torino-Caselle

**Requirements:**
- SP5_RQ02_36_v1.0
- SP5_RQ06_19_v1.0
- SP5_RQ07_19_v1.0
- SP5_RQ12_33_v1.0
- SP5_RQ14_33_v1.0
Use cases:
- SP5_UC51 - P5_UC12

Expected Values / Results

The requirements are met, specifically:

- Results for every trial

A warning of the following kind:
- "ATTENTION Event type, Event relative position, Event direction lanes"; is displayed on the display the SAFESPOT vehicle.
- A subset of this message should be correctly displayed on the VMS panel placed on top of the AV demonstrator, so that also non-SAFESPOT vehicle can see the warning.

Results comparing the trials
- The VANET warning should be received when the vehicle is still behind the SAFESPOT vehicle, independently from the speed.

This should prove the improved effectiveness of the use of VANET with respect to VMS only. Indeed
- with VMS only there is a difference in perception between the conditions "AV coming from behind" and "AV running in front", as in the former the signal is read through the rear-view mirror and the latter is direct in the scene in front. This difference in perception is more critical the higher the relative speed.
- with the addition of VANET, the signalling is the same on both situations, and it is displayed on the vehicle HMI

Obtained Values / Results

Status Test Case 2: To Be Done

Link to external annexed documentation (if any)

Test Case 3: Event warning – vehicle stopped

Test Description

Description:
1. The AV is stopped, 50 m before a parked car, which simulates the accident (i.e. 50 m away in the direction of motion).
2. A SAFESPOT vehicle passes by. Upon reception of a signal the SAFESPOT vehicle slows down and stops.
Trials

A. With VMS and VANET, varying the absolute speed of SF vehicle (from 50 km/h to 90 km/h of relative speed).
B. With VMS only, varying the absolute speed of SF vehicle (from 50 km/h to 90 km/h of relative speed).

Test Sites:
- Torino-Caselle

Requirements:
- SP5_RQ02_36_v1.0
- SP5_RQ06_19_v1.0
- SP5_RQ07_19_v1.0
- SP5_RQ11_33_v1.0
- SP5_RQ12_33_v1.0
- SP5_RQ13_33_v1.0
- SP5_RQ14_33_v1.0
- SP5_RQ16_36_v1.0
- SP5_RQ17_36_v1.0

Use cases:
SP5_UC51

Expected Values / Results

The requirements are met, specifically:
Results for every trial
- A warning of the following kind: “ATTENTION Event type, Event relative position Event direction lanes”; is displayed on the display of an incoming SAFESPOT vehicle.
- A subset of this message should be correctly displayed on the VMS panel placed on top of the AV demonstrator, so that also non-SAFESPOT vehicle can see the warning.

**Capability to stop**
- Upon reception of a signal the SAFESPOT vehicle should slow down and stop.
- The distance between the accident (or a reference point) and the SF vehicle when it is stopped: the higher the distance, the better the result.
- The comparison between trial sets A and B will give an indication of the added value of VANET with respect of VMS only, assuming a straight road. The trials will be made on two different lanes for safety reasons.

**Obtained Values / Results**

<table>
<thead>
<tr>
<th>Status Test Case</th>
<th>To Be Done</th>
<th>Link to external annexed documentation (if any)</th>
</tr>
</thead>
</table>

**Test Case 4: Entering UC51 from UC12: continuity of service**

**Test Description**

1. The SAFESPOT vehicle moves on lane 1, at about 50 km/h. It is heading towards an accident, without knowing it.
2. The AV vehicle approaches and overtakes the SAFESPOT vehicle, sending an UC12 message. Both vehicles proceed together on two different lanes (for safety reasons, in this testing phase) keeping at a distance of about 100-150 m from one another.
3. The AV stops 50m before the accident position and, in a single step operation on the HMI (like pressing a button) it switches to UC51.
4. The SAFESPOT vehicle is still coming behind at 50 km/h. As soon as the SAFESPOT vehicle receives the warning of UC51 it stops.

**Trials**

Trials shall be performed with and without the shortcut UC12 => UC51.

**Test Sites:**
- Torino-Caselle
Requirements:
- SP5_RQ12_33_v1.0
- SP5_RQ14_33_v1.0
- SP5_RQ16_36_v1.0
- SP5_RQ17_36_v1.0

Use cases:
- SP5_UC51, SP5_UC12

Expected Values / Results

The requirements are met, specifically:

Operator HMI
- The operator should be able to switch from UC12 to UC51 in sequence without interruption.

Capability to stop
- Having received the UC12 message, the vehicle should queue behind the safety car (at a distance D determined in the trial).
- Upon reception of a new signal (switching from UC12 to UC51 signal), the SAFESPOT vehicle should slow down and stop.
- The distance between the accident (or a reference point) and the SF vehicle when it is stopped.
- The continuity of service is met if the vehicle is able to stop before the accident.
- This will be tested with and without the HMI shortcut, in order to quantitatively measure the effectiveness of this shortcut.

Obtained Values / Results

Status Test Case4 To Be Done Link to external annexed documentation (if any)

Test Case 5: Assistance Vehicle - RSU cooperation

Test Description

Description:
1. The AV approaches a fixed RSU (100-200 m). The RSU is sending an 'RSU HMI-Message' from the application Hazard and Incident Warning.
2. As soon as the AV operator sees, through the HMI, what message of type 'RsuHMIMessage' the RSU is sending, the operator decides to stop the AV. Distance is expected to be 100-200 m before the RSU. Signalling amplification is still disabled.
3. A SAFESPOT vehicle passes by.
4. The operator decides to switch on amplification (UC61) and give the same warning as the RSU.
5. The same SAFESPOT vehicle passes by again.
Trials
Trials shall be performed varying the speed at which the AV approaches the RSU.

Test Sites:
- Torino-Caselle

Requirements:
- SP5_RQ02_36_v1.0
- SP5_RQ12_33_v1.0
- SP5_RQ16_36_v1.0
- SP5_RQ17_36_v1.0

Use cases:
SP5_UC61

Expected Values / Results

The requirements are met, specifically:  
**Amplification effectiveness**
- Let the RSU range be $D_{\text{max}}$, assuming that the physical communication devices have an equal range on RSU and AV, the AV should ideally be capable to extend the range up to a distance $D_{\text{amp}} = 2D_{\text{max}}$.

Realistically this distance is expected to be less. One of the main causes is that the AV has to see the message, decide to amplify it and stop. Therefore it will not stop exactly at the border of the range, and most of the times it will not move backwards to reach the border. It makes sense to think that $D_{\text{amp}}$ will be higher the lower the initial speed of the AV.

- These trials aim in fact at giving an estimation of $D_{\text{amp}}$ close not too far from the real conditions.
### Table 20  SMAEV 02 Test site

<table>
<thead>
<tr>
<th>SP</th>
<th>WP</th>
<th>Prototype Version</th>
<th>System Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW Release</td>
<td>SW Release</td>
<td>SMAEV 2.1</td>
<td>Compiled by / Company: SODIT (Nicolas Etienne)</td>
</tr>
<tr>
<td>Form Progressive Numb.</td>
<td>Functional Component</td>
<td>SMAEV 2</td>
<td>Reference Document: D5.3.5 §5.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Test Objective</th>
<th>Test Purpose</th>
<th>Test Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integration</td>
<td>Verification</td>
<td>Correctness</td>
<td>Test Site</td>
</tr>
</tbody>
</table>

#### Test Case 1: Emergency vehicle crosses intersection

**Test Description**

The aim of this test is to validate the behaviour of the system when an emergency vehicle wants to cross an intersection in urban area. Nominal case.

- the EV (Emergency Vehicle) Driver switches its status by using the SMAEV_02 HMI.
- the RSU (Road side unit) is able to detect the EV and to handle its request.

Test sites:
- SATORY

![Diagram of emergency vehicle crossing intersection]

**Test sites:**
- SATORY
### Requirements:
- SP5_RQ30

### Use cases:
SP5_UC52 case

### Expected Values / Results

The requirements are met, specifically:
- The EV receives information telling him its request is being processed ("YOUR REQUEST IS BEING TREATED") and after receive a confirmation message: "YOU ARE HAVING PRIORITY".
- The EV Status changes to "Emergency status".
- The SF vehicles are informed of the emergency situation and can take care of the EV (they receive warningHMIMessage).
- The PRM (Priority Request Manager) manages the behaviour or the TLC (Traffic Light Controller).
- The TLC is set in such a way that vehicles and pedestrians lights are red. Green for the EV arrival lane.

When the EV has left the crossing area, the TLC must return to normal behaviour.

### Obtained Values / Results

**Status Test Case1** To Be Done | Link to external annexed documentation (if any)
--- | ---

### Test Case 2: Failure mode status

**Test Description**

The aim of this test is to validate the behaviour in warning failure mode.

The EV asks for the emergency status.

One of the following failures occur:
- Bad data into LDM
- Cannot localize the EV
- TLC in security mode
- VANET does not work.

Test sites:
- SATORY

### Requirements:
- SP5_RQ30

### Use cases:
- SP5_UC52 case
### Expected Values / Results

The requirements are met, specifically:
- No change in the EV Status
- Other SF vehicle does not receive any information about the EV arriving.
- PRM is not able to take any decision concerning the EV request.

<table>
<thead>
<tr>
<th>Status Test Case</th>
<th>To Be Done</th>
<th>Link to external annexed documentation (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Case2</td>
<td>To Be Done</td>
<td></td>
</tr>
</tbody>
</table>
### 4.6 Applications at related Test sites

Table 21 summarises at which test sites the SP5 applications are tested.

<table>
<thead>
<tr>
<th>Application</th>
<th>Country</th>
<th>Location</th>
<th>TS-leader</th>
<th>IRIS</th>
<th>SpA</th>
<th>H&amp;IW</th>
<th>RDep</th>
<th>SMAEV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>France</td>
<td>West/A86</td>
<td>LIVIC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>* H&amp;IW_01, Test case 1</td>
<td>* H&amp;IW_01, Test case 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>France</td>
<td>CG22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>* H&amp;IW_01, Test case 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>France</td>
<td>Satory</td>
<td>LIVIC</td>
<td>TBD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>* Rdep SDM creator, Test case 2</td>
<td>* Rdep Runtime, Test case 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>France</td>
<td>Highway</td>
<td>CG22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>France</td>
<td>TBD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Germany</td>
<td>Dortmund</td>
<td>TV</td>
<td>* IRIS, Test case 1</td>
<td>* IRIS, Test case 2</td>
<td>* IRIS, Test case 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Italy</td>
<td>Brescia- Padova</td>
<td></td>
<td>* H&amp;IW_01, Test case 1</td>
<td>* H&amp;IW_01, Test case 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Italy</td>
<td>Orbassano</td>
<td>CRF</td>
<td>* H&amp;IW_02, Test case 2</td>
<td>* Rdep SDM creator, Test case 1</td>
<td>* Rdep Runtime, Test case 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Italy</td>
<td>Torino</td>
<td>Caselle</td>
<td>* H&amp;IW_01, Test case 3</td>
<td>* H&amp;IW_01, Test case 5</td>
<td>* H&amp;IW_02, Test case 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5 Discussion and conclusion

The deliverable provides the Test plan & validation plans for the five infrastructure-based applications. For each, module, application and systems, the scenarios, the tools or test sites and the assessment criteria are defined. These assessment criteria address the requirements that have been defined in the previous phases of the SAFESPOT project.

Not all the defined requirements are covered in the test plans due to several reasons. For example, functionalities are not planned to be demonstrated or evaluated, the requirements became obsolete, and the considered functionalities are not part of SP5. In the overview is reported of all SP5 requirements and whether they are addressed in the Test and validation plan or not. As described in chapter 1.2, full testing with all possible combinations and all possible conditions for all requirements is practically impossible. The adopted methodological approach allowed to overcome this limitation by ensuring to carry out at least one complete system test for all addressed applications, covering all of the related functionalities and requirements.

The test plans are defined in such a way that the overlap between tests of different applications is minimized. Furthermore, for each application, at least one complete system test is defined. If required, additional tests will be defined during the test phase. Due to this approach, the test phase continues after the due date of this deliverable. The project website reflects the current state of testing and reporting.
6 References

[1] ISO 9001- Section 7.3.1 Design and Development Planning, Section 7.3.5 Design and Development Verification, Section 7.3.6 Design and Development, Section 4.2.4 Control of Records. (2009).


### Table 22 Overview of Requirements

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Requirement Definition</th>
<th>Application</th>
<th>Verified by test:</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ01</td>
<td>Trajectories of Vehicles</td>
<td>The system shall be able to calculate the trajectories of all vehicles approaching and passing critical points e.g. urban intersections.</td>
<td>All</td>
<td>IRIS simulation, Test Case 1</td>
</tr>
<tr>
<td>RQ02</td>
<td>Message Management</td>
<td>The system shall be able to decide if and to whom a message has to be send.</td>
<td>All</td>
<td>H&amp;IW_01 and H&amp;IW_01 simulation, Test Case 1, H&amp;IW_01 and H&amp;IW_01 simulation, Test Case 2, H&amp;IW_01 simulation, Test Case 1, H&amp;IW_01 simulation, Test Case 2, H&amp;IW_03 simulation, Test Case 1, H&amp;IW_01 test site, Test Case 1, 2, H&amp;IW_01 test site, Test Case 3, 4, 5, H&amp;IW_02 test site, Test Case 1, 2, 3, Rdep Runtime simulation, Test Case 1, 2, Rdep Runtime test site, Test Case 1, 2, SMAEV_01 test site, Test Case 1, 2, 3, 5</td>
</tr>
<tr>
<td>RQ03</td>
<td>Trajectories of Cyclists</td>
<td>The system shall be able to calculate the trajectories of all cyclists approaching and passing the intersection.</td>
<td>IRIS</td>
<td></td>
</tr>
<tr>
<td>RQ04</td>
<td>Prediction of Trajectories</td>
<td>The system shall be able to predict the vehicle’s trajectories.</td>
<td>All</td>
<td>IRIS simulation, Test Case 1, IRIS test site, Test Case 2, Rdep Runtime simulation, Test Case 1, 2, Rdep Runtime test site, Test Case 1, 2</td>
</tr>
<tr>
<td>RQ05</td>
<td>Identify Safety Critical Situations</td>
<td>The system shall be able to identify safety critical situations at the surrounding of a critical point e.g. an urban intersection.</td>
<td>All</td>
<td>IRIS simulation, Test Case 2, IRIS test site, Test Case 3, H&amp;IW_01 simulation, Test Case 1, H&amp;IW_01 simulation, Test Case 2, H&amp;IW_01 test site, Test Case 1, 2, H&amp;IW_02 test site, Test Case 1, 2, H&amp;IW_03 test site, Test Case 1, H&amp;IW_03 test site, Test Case 1, SMAEV_01 test site, Test Case 1, 2, 3</td>
</tr>
<tr>
<td>RQ06</td>
<td>Priority Level of Message</td>
<td>The system shall be able to provide a priority level for each transmitted message. This is valid for V2I as well as for I2V communication.</td>
<td>All</td>
<td>IRIS test site, Test Case 1, SpA_02 simulation, Test Case 1, H&amp;IW_03 simulation, Test Case 1, H&amp;IW_01 test site, Test Case 1, 2, H&amp;IW_02 test site, Test Case 1, H&amp;IW_03 test site, Test Case 1, SMAEV_01 test site, Test Case 1, 2, 3</td>
</tr>
<tr>
<td>RQ07</td>
<td>Validity of Messages</td>
<td>The system shall be able to determine the period of validity of the transmitted and received messages.</td>
<td>All</td>
<td>IRIS test site, Test Case 1, H&amp;IW_01 and H&amp;IW_01 simulation, Test Case 1, H&amp;IW_01 and H&amp;IW_01 simulation, Test Case 2, H&amp;IW_01 simulation, Test Case 1, H&amp;IW_01 test site, Test Case 1, 2, H&amp;IW_02 test site, Test Case 1, 2, 3, SMAEV_01 test site, Test Case 1, 2, 3</td>
</tr>
<tr>
<td>RQ08</td>
<td>Traffic Light Status</td>
<td>The system shall take into account the actual and short-term forecast of the traffic light control status.</td>
<td>IRIS, SMAEV</td>
<td>IRIS simulation, Test Case 1, 2, IRIS test site, Test Case 2</td>
</tr>
<tr>
<td>RQ09</td>
<td>Message Management 2</td>
<td>The system must not send warnings concerning severe dangerous situations (that might cause drivers to extreme driving actions), which does in fact not happen.</td>
<td>IRIS, SMAEV, H&amp;IW</td>
<td>H&amp;IW_01 simulation, Test Case 1, H&amp;IW_01 simulation, Test Case 2, H&amp;IW_01 simulation, Test Case 1, H&amp;IW_01 test site, Test Case 1, 2, H&amp;IW_02 test site, Test Case 1, H&amp;IW_03 test site, Test Case 1</td>
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Appendix A. Overview of Requirements
<table>
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<tr>
<th>Requirement</th>
<th>Description</th>
<th>System Capabilities</th>
<th>Test Sites</th>
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<tr>
<td><strong>RQ10</strong></td>
<td>Data exchange with traffic lights controller</td>
<td>The system must be able to communicate bi-directionally with Traffic Lights Controller.</td>
<td>IRIS, SMAEV</td>
</tr>
<tr>
<td><strong>RQ11</strong></td>
<td>Positioning</td>
<td>The system shall be able to calculate the exact position of all assistance vehicles.</td>
<td>SMAEV SMAEV_01 test site, Test Case 3</td>
</tr>
<tr>
<td><strong>RQ12</strong></td>
<td>Data exchange</td>
<td>The system shall be able to transmit information towards several supporters (e.g. VMS, radio, PND).</td>
<td>SMAEV H&amp;IW_01 simulation, Test Case 1 H&amp;IW_01 simulation, Test Case 2 H&amp;IW_01 test site, Test Case 1, 2 H&amp;IW_02 test site, Test Case 1 SMAEV_01 test site, Test Case 1, 2, 3, 4, 5</td>
</tr>
<tr>
<td><strong>RQ13</strong></td>
<td>Sensor 6</td>
<td>The system shall be able to calculate the distance between vehicles.</td>
<td>SMAEV SMAEV_01 test site, Test Case 3</td>
</tr>
<tr>
<td><strong>RQ14</strong></td>
<td>Vehicle 4</td>
<td>The assistance vehicles shall be able to transmit their position, speed and nature of operation.</td>
<td>SMAEV SMAEV_01 test site, Test Case 1, 2, 3, 4</td>
</tr>
<tr>
<td><strong>RQ15</strong></td>
<td>Sensor 7</td>
<td>The system shall be able to detect drivers approaching to the assistance vehicle and to see if there is a dangerous situation.</td>
<td>SMAEV</td>
</tr>
<tr>
<td><strong>RQ16</strong></td>
<td>Query from the LDM</td>
<td>The system shall be able to query needed data from the LDM.</td>
<td>All H&amp;IW_01 and H&amp;IW_01 simulation, Test Case 1 H&amp;IW_01 and H&amp;IW_01 simulation, Test Case 2 H&amp;IW_01 simulation, Test Case 1 H&amp;IW_01 simulation, Test Case 2 H&amp;IW_01 test site, Test Case 1, 2 H&amp;IW_01 test site, Test Case 3, 4, 5 H&amp;IW_02 test site, Test Case 1, 2, 3 Rdep SDM Creator simulation, Test Case 1, 2 Rdep SDM Creator test site, Test Case 1, 2 Rdep Runtime simulation, Test Case 1, 2 Rdep Runtime test site, Test Case 1, 2 SMAEV_01 test site, Test Case 1, 2, 3, 4, 5</td>
</tr>
<tr>
<td><strong>RQ17</strong></td>
<td>Receive data from the LDM</td>
<td>The system shall be able to receive and handle the LDM data.</td>
<td>All H&amp;IW_01 and H&amp;IW_01 simulation, Test Case 1 H&amp;IW_01 and H&amp;IW_01 simulation, Test Case 2 H&amp;IW_01 simulation, Test Case 1 H&amp;IW_01 simulation, Test Case 2 H&amp;IW_01 test site, Test Case 1, 2 H&amp;IW_01 test site, Test Case 3, 4, 5 H&amp;IW_02 test site, Test Case 1, 2, 3 SMAEV_01 test site, Test Case 1, 2, 3, 4, 5</td>
</tr>
<tr>
<td><strong>RQ18</strong></td>
<td>Simultaneity</td>
<td>The system shall be able to manage all vehicles in the vicinity of a critical point (e.g. the intersection) simultaneously.</td>
<td>IRIS IRIS simulation, Test Case 1, 2 H&amp;IW_01 simulation, Test Case 1 H&amp;IW_01 simulation, Test Case 2 H&amp;IW_01 test site, Test Case 1, 2 H&amp;IW_02 test site, Test Case 1</td>
</tr>
<tr>
<td><strong>RQ19</strong></td>
<td>Scalability</td>
<td>The system shall have nearly the same performance in case there are just two or 80 vehicles to manage.</td>
<td>IRIS IRIS simulation, Test Case 1, 2 H&amp;IW_03 simulation, Test Case 1 H&amp;IW_03 test site, Test Case 1</td>
</tr>
<tr>
<td><strong>RQ20</strong></td>
<td>Time of Warning Generation</td>
<td>The system shall generate and transmit warning information to the drivers timely enough, so that the reaction time left to the drivers is appropriate.</td>
<td>IRIS SpA_02 simulation, Test Case 1 H&amp;IW_01 simulation, Test Case 1 H&amp;IW_01 simulation, Test Case 2 H&amp;IW_03 simulation, Test Case 1 H&amp;IW_01 test site, Test Case 1, 2 H&amp;IW_02 test site, Test Case 1 H&amp;IW_03 test site, Test Case 1</td>
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<tr>
<td>RQ</td>
<td>Version</td>
<td>Description</td>
<td>Testing Approach</td>
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<tr>
<td>RQ21</td>
<td>36.0</td>
<td>Operating with different Vendors</td>
<td>All</td>
</tr>
<tr>
<td>RQ22</td>
<td>10.0</td>
<td>R/S Warning</td>
<td>H&amp;W</td>
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<tr>
<td>RQ23</td>
<td>10.0</td>
<td>Warning</td>
<td>All</td>
</tr>
<tr>
<td>RQ24</td>
<td>19.0</td>
<td>Robustness of System</td>
<td>All</td>
</tr>
<tr>
<td>RQ25</td>
<td>19.0</td>
<td>Anonymity</td>
<td>All</td>
</tr>
<tr>
<td>RQ26</td>
<td>36.0</td>
<td>Position of Pedestrian 1</td>
<td>IRIS</td>
</tr>
<tr>
<td>RQ27</td>
<td>27.0</td>
<td>Position of Pedestrian 2</td>
<td>H&amp;W</td>
</tr>
<tr>
<td>RQ28</td>
<td>19.0</td>
<td>Range of Communication</td>
<td>IRIS</td>
</tr>
<tr>
<td>RQ29</td>
<td>27.0</td>
<td>Range of Communication</td>
<td>H&amp;W</td>
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<tr>
<td>RQ30</td>
<td>19.0</td>
<td>Simultaneous Communication</td>
<td>IRIS</td>
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<tr>
<td>RQ31</td>
<td>27.0</td>
<td>Simultaneous Communication</td>
<td>H&amp;W</td>
</tr>
<tr>
<td>RQ</td>
<td>Description</td>
<td>Time of Data Delay</td>
<td>Time of Connection</td>
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<tr>
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<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>RQ32</td>
<td>In the vehicle sub-system the delay between determination of position and velocity of the vehicle and transmission of this data to the roadside shall be smaller than 50 ms.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ33</td>
<td>All data transmitted from the vehicle to the infrastructure shall have a timestamp referring to the creation time of the data (and not to the transmission time point).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ34</td>
<td>The roadside sub-system must be able to address data directly to one vehicle distinctively (or a group of vehicles) or to broadcast to all vehicles in the vicinity of the RSU.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ35</td>
<td>In the roadside sub-system the delay between generation of warnings and transmission of this data to the vehicles shall be smaller than 50 ms.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ36</td>
<td>The time needed to set-up a connection between an incoming vehicle and the roadside communication system should be smaller than 0.8 seconds.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ37</td>
<td>The vehicle subsystem should be able to filter the relevant information to the driver.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ38</td>
<td>The information exchange between RSU and Vehicle has to be secured against misuse.</td>
<td></td>
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</tr>
<tr>
<td>RQ39</td>
<td>Loss of communication in the vehicle subsystem must be signalized to the driver.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ40</td>
<td>Messages that are exchanged between vehicles and RSU have to be unified to insure system interoperability.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ41_19_v1.0</td>
<td>Static Map contents</td>
<td>The LDM shall describe the static geometry of critical points (e.g., intersections) in a detailed, accurate and systematic way. The geometry shall comprise at least approaches, exits, lanes (also bicycle lanes), stop lines and pedestrian crossings as well as the topology of the lanes (left-turn, right-turn, straight ahead).</td>
<td>IRIS, H&amp;W</td>
</tr>
<tr>
<td>RQ42_19_v1.0</td>
<td>Unique scheme for dynamic traffic data</td>
<td>The LDM shall provide a unique scheme for dynamic traffic information to refer to.</td>
<td>IRIS</td>
</tr>
<tr>
<td>RQ43_36_v1.0</td>
<td>Rules of Right of way</td>
<td>The LDM shall provide information about the rules of right of way at the intersection.</td>
<td>IRIS</td>
</tr>
<tr>
<td>RQ44_19_v1.0</td>
<td>Position of Vehicles 1</td>
<td>The system shall receive the position of the vehicles with an accuracy enabling to distinguish between two vehicles.</td>
<td>IRIS, SMAEV, H&amp;W</td>
</tr>
<tr>
<td>RQ45_27_v1.0</td>
<td>Position of Vehicles 2</td>
<td>In critical points the position of the vehicles shall be determined with a minimal accuracy of +/- 1m.</td>
<td>All</td>
</tr>
<tr>
<td>RQ46_19_v1.0</td>
<td>Position of Vehicles 3</td>
<td>The positioning of vehicles have to fulfil the accuracy up to a lane detection extend.</td>
<td>IRIS</td>
</tr>
<tr>
<td>RQ47_19_v1.0</td>
<td>Push Buttons</td>
<td>In case of pedestrians and cyclists the system shall take into account demand signals (push buttons) or data from according road-side sensors.</td>
<td>IRIS</td>
</tr>
<tr>
<td>RQ48_36_v1.0</td>
<td>Environmental Data</td>
<td>The system shall receive data from environmental sensors about weather (rain, snow, fog…).</td>
<td>IRIS</td>
</tr>
<tr>
<td>RQ49_19_v1.0</td>
<td>Position and speed of vehicles</td>
<td>The RSU subsystem shall be able to receive at minimum the current vehicle position and speed.</td>
<td>All</td>
</tr>
<tr>
<td>RQ50_36_v1.0</td>
<td>Transmission of warnings</td>
<td>The system shall be able to transmit the warning / recommendation to equipped vehicles.</td>
<td>All</td>
</tr>
<tr>
<td>RQ</td>
<td>V.</td>
<td>Description</td>
<td>Data Sources</td>
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<tr>
<td>RQ51</td>
<td>19</td>
<td>HMI In vehicle assistance HMI shall present warnings to the driver in an intelligent way without distracting him. Example: Use of different actuators to smooth signalizes hazards.</td>
<td>All H&amp;IW_03 simulation, Test Case 1 H&amp;IW_01 test site, Test Case 1, 2 H&amp;IW_02 test site, Test Case 1 H&amp;IW_03 test site, Test Case 1</td>
</tr>
<tr>
<td>RQ52</td>
<td>36</td>
<td>Static Vehicle Data The system shall receive static vehicle data like width, length, type of vehicle, mass.</td>
<td>All H&amp;IW_01 test site, Test Case 1, 2 H&amp;IW_02 test site, Test Case 1 Rdep SDM Creator test site, Test Case 1, 2 Rdep Runtime test site, Test Case 1, 2</td>
</tr>
<tr>
<td>RQ53</td>
<td>19</td>
<td>Dynamic Vehicle Data The system shall receive in the vicinity of the urban intersection the position, speed and acceleration and driving direction with a frequency of 2/sec or shorter.</td>
<td>IRIS IRIS test site, Test Case 1, 2</td>
</tr>
<tr>
<td>RQ54</td>
<td>36</td>
<td>Extended Dynamic Vehicle Data The system shall receive in the vicinity of the urban intersection extended dynamic vehicle data like position of brake and acceleration pedal, angle of steering wheel.</td>
<td>IRIS IRIS test site, Test Case 1, 2</td>
</tr>
<tr>
<td>RQ55</td>
<td>27</td>
<td>Data from Vehicles The system shall receive in the vicinity of a critical point in a motorway the position, speed and possibly acceleration with a frequency of 5/sec or shorter.</td>
<td>H&amp;IW</td>
</tr>
<tr>
<td>RQ56</td>
<td>19</td>
<td>Status of Vehicle's Indicator The system shall receive in the vicinity of the urban intersection the indicator state of the vehicles or alternatively / additionally – in case of an activated navigation system - their turning relations with respect to this intersection.</td>
<td>IRIS IRIS test site, Test Case 1, 2</td>
</tr>
<tr>
<td>RQ57</td>
<td>19</td>
<td>Position of Vehicles 4 The system shall receive the position of the vehicles in the near vicinity of the urban intersection (&lt;30m from stop line) with an accuracy enabling to assign the vehicle clearly to a lane.</td>
<td>IRIS IRIS test site, Test Case 2</td>
</tr>
<tr>
<td>RQ58</td>
<td>10</td>
<td>Diagnostic The system shall be able to have information about the status of every sensor system.</td>
<td>All</td>
</tr>
<tr>
<td>RQ59</td>
<td>36</td>
<td>End of Tailback The system shall be able to receive the position of the end of a tailback at an intersection.</td>
<td>IRIS</td>
</tr>
<tr>
<td>RQ</td>
<td>Description</td>
<td>System Requirements</td>
<td>Test Sites</td>
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</tr>
</tbody>
</table>
| RQ60 | Lack of Friction | The system shall receive information about the lack of friction of a road segment. | All | H&IW_01 test site, Test Case 1, 2  
| | | | | H&IW_02 test site, Test Case 1 |
| RQ61 | Data Reception | The system must be able to receive data form the vehicles as well as the infrastructure. | All | IRIS test site, Test Case 1  
| | | | | H&IW_03 simulation, Test Case 1  
| | | | | H&IW_01 test site, Test Case 1, 2  
| | | | | H&IW_02 test site, Test Case 1  
| | | | | H&IW_03 test site, Test Case 1  
| | | | | Rdep SDM Creator test site, Test Case 1, 2  
| | | | | Rdep Runtime test site, Test Case 1, 2 |
| RQ62 | Event recognition - accident | The system shall acquire data on the occurrence of accidents on a motorway (or freeway) conditions and provide longitudinal localisation accurate to 25 metres (TBC). | H&IW |
| RQ63 | Event recognition - obstacle | The system shall acquire data on obstacles present on a motorway (or freeway) and provide longitudinal localisation accurate to 25 metres (TBC). | H&IW |
| RQ64 | Event recognition - obstacle | The system shall acquire data on obstacles (objects on road, stationary queue, slow moving vehicles, etc) at ‘black spots’ and provide a longitudinal localisation accurate to 25 metres (TBC). | H&IW |
| RQ65 | Obstacle description | The system shall provide other details of the obstacle where possible : type of object (accident, queue, rocks, dropped load, etc), lanes affected, speed (for moving object), precise location, etc. | H&IW |
| RQ66 | Network attributes | The system shall acquire data on the status of the network for two kilometres (TBC) upstream of the ‘obstacle’ in terms of traffic flow conditions. | H&IW |
| RQ67 | Network attributes | The system shall acquire data on the infrastructure attributes from the location of the obstacle for two kilometres upstream (bends, tunnels, bridges, etc). | H&IW |
| RQ68 | Road status | The system shall acquire data on the weather conditions in the ‘critical area’ (extent TBD) of the obstacle or accident, i.e. wet/dry road surface, rain, fog, ice, which may affect | H&IW, IRIS | H&IW_01 test site, Test Case 1, 2  
| | | | | H&IW_02 test site, Test Case 1 |
| RQ69  
| V Warning | The system shall send appropriate warnings to equipped vehicles within the critical (e and a) zones to permit them to reduce speed and/or change lane and avoid a (secondary) collision. | H&W | SpA_02 simulation, Test Case 1, H&W_01 test site, Test Case 1, 2, H&W_02 test site, Test Case 1 |
| RQ70  
| Warning | The communications media for the message broadcast will take into account the local conditions, canyons, tunnels, etc. | H&W |
| RQ71  
| Event recognition - ghost driver | The system shall detect a vehicle travelling in the wrong direction on a motorway with the location accurate to x metres (TBD). | H&W | H&W_02 simulation, Test Case 1, H&W_02 test site, Test Case 1 |
| RQ72  
| Event recognition - ghost driver | The system shall detect the speed, lane and trajectory of a vehicle travelling the wrong way on a motorway. | H&W | H&W_02 simulation, Test Case 1, H&W_02 test site, Test Case 1 |
| RQ73  
| Event recognition - dangerous overtaking | The system shall acquire data on situations on a rural roads where a vehicle is overtaking (i.e. is on wrong side of road) and other vehicles are arriving on the same side inside the 'critical' distance (unable to avoid a collision without braking). | H&W |
| RQ74  
| Warning | The system shall be able to send a warning message to a SF equipped overtaking vehicle which risks a collision. | H&W |
| RQ75  
| Warning | The system shall be able to send a warning message to vehicles approaching an overtaking vehicle travelling in the same lane. | H&W |
| RQ76  
| Event Recognition - pedestrian | The system shall be able to detect a pedestrian walking on a motorway with location accurate to x metres (TBD). | H&W |
| RQ77  
<p>| Warning | The system shall be able to send warning message to equipped vehicles to inform of pedestrian on motorway. | H&amp;W |</p>
<table>
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<tr>
<th>RQ87</th>
<th>Sensor 5</th>
<th>Location and speed (continuous); accuracy and timeliness needs to be analysed in detail.</th>
<th>IRIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ88</td>
<td>Vehicle 1</td>
<td>The intended route on the intersection shall be known. Either in some direct manner, or indirectly through the status of vehicles indicator.</td>
<td>IRIS IRIS simulation, Test Case 1 IRIS test site, Test Case 1, 2</td>
</tr>
<tr>
<td>RQ89</td>
<td>Vehicle 2</td>
<td>Information about emergency vehicles that need to ignore a red light shall be available.</td>
<td>IRIS IRIS test site, Test Case 1</td>
</tr>
<tr>
<td>RQ90</td>
<td>Sensor 1</td>
<td>Sensors (or aggregates) shall be able to cover complete crossing trajectories.</td>
<td>IRIS</td>
</tr>
<tr>
<td>RQ91</td>
<td>Sensor 2</td>
<td>Sensors (or aggregates) shall be able to detect stationary road-users, including pedestrians, bicycles and motorcycles.</td>
<td>IRIS</td>
</tr>
<tr>
<td>RQ92</td>
<td>Sensor 3</td>
<td>Sensors (or aggregates) shall be able to determine speed vectors of detected road-users.</td>
<td>IRIS</td>
</tr>
<tr>
<td>RQ93</td>
<td>Mapping 1</td>
<td>Localisation should be accurate to the level of a lane and with a 1 meter accuracy, this (in combination with the vehicles indicator makes it possible to determine whether a vehicle is about to turn</td>
<td>IRIS IRIS test site, Test Case 2</td>
</tr>
<tr>
<td>RQ94</td>
<td>Sensor 4</td>
<td>When processing is needed for sensing, the processing time should be in the order of at most 0.1 second.</td>
<td>IRIS IRIS simulation, Test Case 2</td>
</tr>
<tr>
<td>RQ95</td>
<td>Vehicle 3</td>
<td>It shall be possible to give warnings to drivers. Preferably with a graphical identification of the type and location of potential conflicts.</td>
<td>IRIS IRIS test site, Test Case 1</td>
</tr>
</tbody>
</table>