SAFESPOT INTEGRATED PROJECT - IST-4-026963-IP

DELIVERABLE

SP4 – SCOVA – Cooperative Systems Applications Vehicle Based

D4.2.3 – Use case and typical accident situation

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0.1	July 2nd 2006	First draft	CRF
0.2	July 17th 2006	Filled in the whole set of Use Cases	All participants to SP4-WP2
0.3	July 24th 2006	Completed chapters 1, 2 and 4 – pre final release	CRF
1.0	July 28th 2006	Final release; overall peer review; added significant contributions from Fabio Tango (CRF), Matthias Strauß (CAS), Javier Ibañez-Guzmán (Renault).	CRF
1.1	September 5th 2006	Final release; reworked after the peer review process.	CRF
1.2	February 12th 2007	Improvements to VRU Use Cases (10a and 10b)	CRF+VOLVO
1.3	February 15th 2007	Further little improvements on UC (10a and 10b)	CRF+VOLVO

Abbreviation List

ADAS	Advanced Driver Assistance System
HMI	Human Machine Interface
IP	Integrated Project
LATC	Lateral Collision
LONC	Longitudinal Collision
OBU	On Board Unit
OV	Own Vehicle – synonym for “Host Vehicle” and “Ego Vehicle”
PTW	Powered Two Wheelers – acronym for motorcycle
RODP	Road Departure
SP	Sub Project
SP1	Sub Project 1 – SAFEPROBE of the SAFESPOT IP, technological project concerning the definition and development of the vehicle platform
SP3	Sub Project 3 – SINTECH of the SAFESPOT IP, technological project concerning the main enabling technologies, mainly for the vehicle platform and – partially - for infrastructure
SP4	Sub Project 4 – SCOVA of the SAFESPOT IP, applicative project concerning vehicle based applications
SP5	Sub Project 5 – COSSIB of SAFESPOT, applicative project concerning infrastructure based applications
SUD	System Under Design
UC	Use Case
V2I	Vehicle to Infrastructure [communication type]
V2V	Vehicle to Vehicle [communication type]
VRU	Vulnerable Road User [as a general term]
VURU	Vulnerable Road User [as cluster of the Vulnerable Road User Detection and Accident Avoidance applications of SP4]

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EXECUTIVE SUMMARY

Deliverable D4.2.3 describes the Use Cases produced inside the SP4 subproject of SAFESPOT, whose target is the development of Cooperative Systems Applications Vehicle Based.

The approach adopted to build up Use Cases of the vehicle based applications (functional behaviors into specific scenarios) is described, and the method adopted in order to provide consistent results among the three subprojects of SAFESPOT in charge of the production of Use Cases (SP1, SP4 and SP5) is presented. For the SP4 subproject, these Use Cases are related to precise sample scenarios, representing the expected way of handling potentially critical situations, from the point of view of the vehicle based applications that will be developed inside SP4.

Twenty height Use Cases have been collected, covering – in average – at least two or three specific situations for each of the ten reference applications addressed in the subproject. Four clusters of applications, also adopted as a main categories for the classification of the Use Case, are adopted inside SP4: Lateral Collision (LATC), Longitudinal Collision (LONC), Road Departure (RODP) and Vulnerable Road User (VURU).

The analysis has been carried out in a descriptive form, allowing:

- cross checks with Use Cases provided by other subprojects inside SAFESPOT. Specifically it was agreed (and carried out), inside those Tasks of SP1, SP4 and SP5 focused on the UC analysis, to perform cross evaluations between the Use Cases produced by SP4 and SP1 – SAFEPROBE, and between SP4 and SP5 - COSSIB; these evaluations and exchange of information have been the primary criterion for the selection and acceptance of the UC enclosed in the present document;
- the preliminary identification of the wanted characteristics of the SP4 applications, enabling the preparation of the application requirements.

Some conclusions are pointed out, related to the impact and the expected follow ups for the activities related to the Users Needs and Requirements of the vehicle based applications of SAFESPOT.

1. Introduction

1.1. Innovation and Contribution to the SAFESPOT objectives

A practical way for introducing the framework where the content of the present deliverable collocates, is to make a short review of the basic items adopted in the definitions of the SP4 UC, as these terms, that are context dependent, have been adopted as building blocks in the process of producing and refining the SP4 UC.

In SP4, **actors** are basically users of the system. In general, actors can be viewed as external entities (people or other systems) who interact with the system to achieve a desired goal; being SP4 focused on the development of vehicle based applications, actors are (normally) the drivers of the ego vehicles (cars, trucks, PTW). The **System Under Design** (SUD) is each one of the ten applications (see table 2.1 on chapter 2, for a short list of these application) that are developed in SP4.

Goals summarize system function in understandable verifiable terms of use that users, executives and developers can appreciate and leave little open to interpretation. In the context of SP4, goals are all related to the prevention of the specific (potentially dangerous) situations occurring in the given road scenarios, through the support of the warning system implemented – that is the SAFESPOT Safety Margin Assistant.

Use Cases (UC) are describing what happens when actors interact with the system. An actor uses the system to achieve a desired goal. The formal application of the method should allow, by recording all the ways the system is used ("cases of use" or Use Cases), to accumulate all the goals or requirements of the system. Therefore, a use case is a collection of possible sequences of interactions between the system under discussion and its Users (or Actors), relating to a particular goal. The collection of Use Cases should define all system behavior relevant to the actors to assure them that their goals will be carried out properly. Any system behavior that is irrelevant to the actors should not be included in the use cases.

There are many methods of defining how to pick or create a use case. Use Cases in this deliverable are based and strongly linked to the goal oriented Structuring Methodology presented by Alistair Cockburn of Humans and Technology; nevertheless the proposed UC have not been generated following the formal (and a little bit too rigid) approach. Even though the methodology is definitely appealing (by examining all the Actor's goals that the system satisfies yields in a straight way the functional requirements), its application would have been too complex, since it assumes the produced UC should be complete - in a formal meaning, forcing to a collection and categorization work that would be too expensive and hard to justify.

A less formal approach, based on a sampling for the production of the UC, has been preferred instead. As described in chapter 2, this informal approach has been adopted both in order to limit the complexity of the goal oriented structuring methodology, and since the actual set of UC appears sufficient for providing significant input for the definition of the application requirements and, in a following phase, the specifications for the SP4 applications.

1.2. Methodology

Use cases are goals (use cases and goals are used interchangeably) that are made up of scenarios. Scenarios consist of a sequence of steps to achieve the goal, each step in a scenario is a sub (or mini) goal of the use case. As such each sub goal represents either another use case (subordinate use case) or an autonomous action that is at the lowest level desired by our use case decomposition.

This hierarchical relationship is needed to properly model the requirements of the system being developed, consisting in the SP4 applications. A complete use case analysis requires several levels. In addition the level at which the use case is operating at it is important to understand the scope it is addressing. The level and scope are important to assure that the language and granularity of scenario steps remain consistent within the use case.

Major reason for producing the SP4 UC has been the feature of the UC, which is proper of the methodology, of representing natural “boundaries” for the definition of the system requirements for the SUD – i.e. the vehicle based applications to develop inside SP4. The process is based on an incremental approach, that starts from the collection of the basic user needs, and adopts the UC as samples of behaviors expected by the SUD. This way the system requirements are established by putting into evidence, in the collected UC, the functional characteristics and the contextual requirement enabling the deployment of the proper behaviors in each one of the SP4 applications:

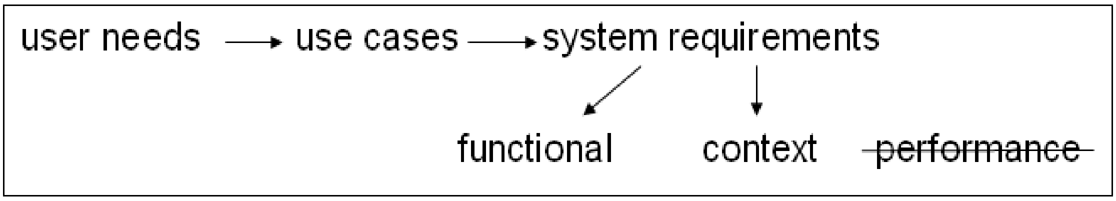


Fig. 1 – Path for producing system requirements starting from user needs and use cases.

Of course UC do not specify system requirements in terms of performance: these are under the domain of the system specifications. Other relevant tasks that are **not directly covered** through the production of the SP4 UC are:

- Specifications of the user interface design. Use cases specify the intent, not the action detail;
- Specifications of the system and implementation detail, since what is of particular importance to the actor is to be assured that the goal is properly met, not to know how it is met.

1.3. Deliverable structure

In the following chapter 2 the applied methodology for the collection of the SP4 UC is described: since the formal method is not applied, it is necessary to explicitly show the applied method and its expected benefits. Chapter 3 contain the whole set of the SP4 UC. These UC are grouped into four sections, associated to the application clusters defined inside SP4. Chapter 4 reports some conclusions for the performed activity, while chapter 5 is reporting the references relevant for the deliverable.

2. Rationale, method and benefits for the collection of the SP4 UC

Purpose of SP4 – SCOVA subproject is to specify and to develop a set of applications based on co-operative systems implementing the Safety Margin Assistance concept. These applications are grouped into four clusters, as showed below:

Application	Cluster
Road Intersection Safety	Lateral Collision - LATC
Lane Change Manoeuvre	
Safe Overtaking	
Head On Collision Warning	Longitudinal Collision - LONC
Rear End Collision	
Speed Limitation and Safety Distance	
Frontal Collision Warning	
Road Condition Status – Slippery Road	Road Departure - RODP
Curve Warning	
Vulnerable Road User Detection and Accident Avoidance	Vulnerable Road Users - VURU

Tab. 1 – Clusters and Applications to develop inside SP4 – SCOVA.

Lateral safety applications (LATC) are addressing the avoidance of the risk of lateral collision through an early warning to the driver. Specific scenarios for the three component applications are:

- road intersection safety: two types of urban intersections are analysed; in the first type it is assumed both infrastructure sensors and V2I communication are available; in the second type – longer term - the scenario is more complex, assuming all of the involved vehicles having V2V capabilities implemented (with or without the support of the infrastructure);
- lane change manoeuvre: prevention, during the road merging situations and approaching to the intersections, of the risk of lateral collisions; safe lane change manoeuvre with blind spot for trucks;

- safe overtaking: prevention of collision among vehicles in an overtake situation (integration of blind spot and early notification to the preceding driver of the intention to overtake of the vehicle behind).

Focus of the longitudinal collision cluster (LONC) is the possibility to inform the driver at an early stage about potential risk of frontal or rear-end collisions due for instance to the reduced speed of the preceding vehicles or, in case of two ways roads, due to overtaking manoeuvers that the vehicles in the opposite traffic direction have started. The cooperative vehicles communicates, directly to the other vehicles or to the SAFESPOT local infrastructure, their position and dynamics or the presence of obstacles on the road. Scenarios in for the four component applications are:

- head on collision warning: early warnings for situations where vehicles, travelling on opposite directions, may face the risk of an head on collision; specific use cases are presented where the advantages of V2V communication respect to ADAS sensing are emphasised;
- rear end collision: warnings for head to tail collisions, where host vehicle is moving (static scenarios covered by the frontal collision warning function) and it risks the rear end collision due – for instance – to a slow down due to road shape (hills, curves);
- speed limitation and safety distance: early information and warning to the driver concerning the speed and the safety margin to keep in the black spot situations in front, such as road works, static obstacles, or other factors that may limit or dynamically change speed and safety distance;
- frontal collision warning: warnings for head to tail collisions, where host vehicle is moving or static, and it risks the frontal collision due – for instance – to the presence of static or reduced speed traffic.

Road departure applications (RODP) are related to the sharing with other vehicles of the information of a slippery road status, or a bad road condition (can be due to weather condition, ice, fog...), or other factors – especially in curve - that may lead to the risk of a road departure. Scenarios for the two component applications are:

- road condition status – slippery road: a warning is broadcasted concerning the slippery road status or bad condition of the road;
- curve warning: information is gathered and delivered with a sufficient anticipation to the driver about the road curvature and the adequate speed to keep in the specific black spot. Conditions that may dynamically change the speed and the trajectory to keep in the curve (road works, static obstacles) are also tackled.

Vulnerable Road User (VURU) is focusing on the propagation of information about a vulnerable user (detected by means of infrastructure or vehicles equipped with suitable ADAS, developed outside SAFESPOT – e.g. available by previous or on going projects, like Watch-Over) to other vehicles that do not have possibility to see or detect the vulnerable road user. Two basic scenarios are addressed in the Vulnerable Road User detection and accident avoidance application:

- after the detection of a VRU the information is sent to the vehicle incoming behind (scenario related to a 2 ways road in urban situation);
- avoid accident with bicycle or motorcycle on the side of the vehicle when it decide to turn (frequent type of accident referring to the blind areas of trucks and commercial vehicles).

As introduced in chapter 1, the method adopted for the compilation of the UC is not complete (in the formal meaning of the term): just two or three UC, in average, have been produced for each of the SP4 applications, which is not sufficient for covering the whole domain of the scenarios and expected behaviours for the SP4 applications. Nevertheless the sample reported in chapter 3 has been widely discussed inside the project consortium and it has been agreed as sufficient to show how the SP4 applications are expected to react in some important scenarios.

As a further validation and double check on the matter, the following picture (taken from the web site of the US Department of Transport – see references) is worth to be shortly commented:

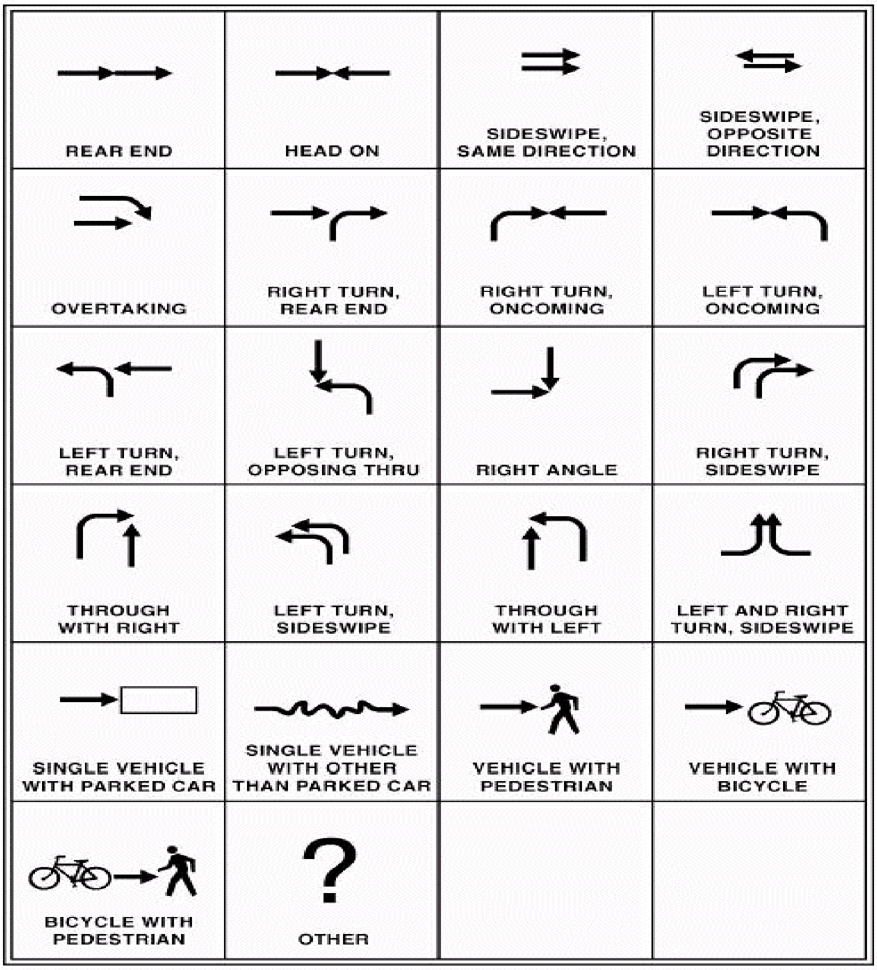


Fig. 2 – Possible taxonomy for accident type classification.

Accident situations reported in Fig. 2 are collected from a source which is completely external to the domain of SP4 and SAFESPOT, so it has been quite interesting to note that almost all of the collisions reported have been addressed in the UC formulated in chapter 3.

An important argument supporting the adopted approach is that it is very well focused: as a result of the SP4 UC analysis (i.e. the present deliverable) a limited set of UC has been produced. This aspect should be emphasized as a positive one: the work is specifically showing the benefit of a co-operative approach for the driving safety, with few, clear examples where the usage of “classical” ADAS sensors would have been seriously impaired or simply not useful. In a more formal (and rigid) application of the methodology the consortium would have collected a much larger set of UC, more comprehensive, but loosing the immediate perception of the benefits of the cooperative approach. Additionally, produced UC are more general, covering a larger set of accident situations.

Following steps in the project flow (namely the definition of the system requirements and – later on – of the specifications for the SP4 applications) will be facilitated significantly by the availability of the SP4 UC, even though not the requirements, nor the specifications can actually be compiled in an automatic way.

2.1. Cross checks with SP1 UC

Cross checks and common evaluations have been performed in order to ensure a coherent progress and common achievements in the building up of UC by SP4 and SP1. Anyway, it should be clearly evidenced what are the differences and why UC prepared by SP4 and SP1 are different.

First of all the SUD is different: for SP4 the “system” is a single application (from the whole set of ten reference SAFESPOT applications), while for SP1 the “system” is the on board platform.

Actors are different: basically for SP4 actors are the drivers of the equipped vehicles, while for the on board platform (the SP1 perspective) these are constituted by other SAFESPOT subsystems, like:

- in-vehicle subsystems (e.g. warning/advise generation from safety margin assistant);
- other SP1 platforms in ad hoc-network;
- SP2 platforms in ad hoc-network.

Also the goals are obviously different: these are specific goals that are meaningful for the specific subsystems for SP1 and the support content (e.g. timely warnings to the drivers for avoiding potentially dangerous situations) for SP4. Nevertheless the common objective of SP4 and SP1, that is to design and build up working SAFESPOT applications, based and working in a coherent manner on SAFESPOT vehicle platforms, reflects to UC that are interconnected.

More precisely, in comparison to the SP1 UC, the perspective of SP4 is that the produced UC should be complementary as much as possible, not reciprocally contradicting, and (eventually) with differences, – maybe significant – due to the different SUD, actors, and goals.

So, cross checks with SP1 UC have been performed, with the purpose of making explicit at least two type of problems: reciprocal incoherencies and missing of mate UC. Incoherencies arise when (for example) an UC built up inside SP4 have at least one mate UC inside SP1, but the behaviors at the application level and at the vehicle platform level are not compatible. Missing of mate UC is a type of issue due to the lack of reciprocal communication: it is for example the presence of a SP1 UC, intended as useful/supporting for a SAFESPOT vehicle based application, which is not in the set of the SP4 applications; or – similarly – the presence of a SP4 UC, assuming explicitly or not, the availability of SP1 "services", that are not described by any one of the SP1 UC.

Following picture shows (in a schematic way) the cross checks performed between SP1 and SP4 UC:

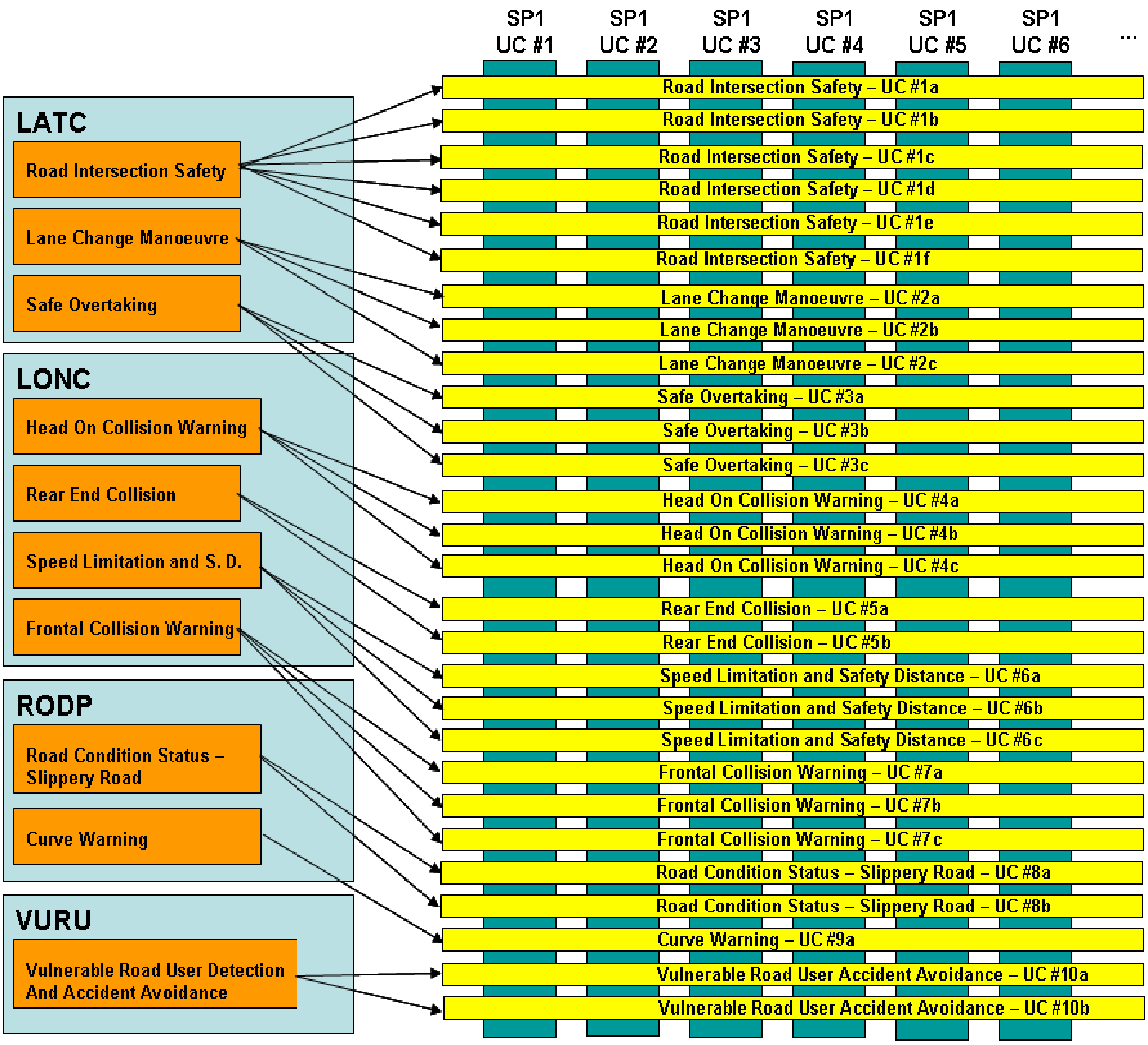


Fig. 3 – Sample of cross checks between Use Cases produced by SP4 and SP1.

In the process leading to the actual set of SP4 UC, these checks have been adopted as a relevant condition for refining, deleting or adding new ones.

2.2. Cross checks with SP5 UC

Being SP5 a project with a domain quite near to SP4 (the one of the infrastructure based applications) in the method adopted for selecting the SP4 UC the cross checks with the SP5 UC was performed in a completely different way than in 2.1.

Between SP4 and SP5, the SUD is different: for SP4 the “system” is a single vehicle based application (from the whole set of ten reference SAFESPOT applications), while for SP5 the “system” is an infrastructure based application. It should be evidenced that a rigid border has not been defined here: while SP4 focus is the one of the vehicle based applications, it is not excluded the (limited) support from the infrastructure, in case it is functional to the implementation of a given vehicle based application. The same is even more true for SP5: here the active presence of the vehicles in the context of the infrastructure based applications is simply unavoidable, as showed in the following paragraphs.

SP4 UC 8a or 9a could be given as example of this concept: into these UC the infrastructure is present, but its role is not central (in the given examples it is the one of relay stations, in order to allow V2V communication to overcome physical barriers). UC of this type are legitimately inside the domain of the vehicle based applications; clearly from the point of view of SP4 the acceptance of UC including the limited support from the infrastructure has been carried out taking into account priorities in the relevance of the UC and availability of resources for its implementations.

So, the cross checks performed from SP4 versus the SP5 UC, had the primary objective of avoiding to produce duplicated UC inside SP4 and SP5.

From a more specific analysis, it turns out that actors are the same for SP4 and SP5: basically the vehicle drivers are the actors both for SP4 and for SP5 UC.

Also the goals are common: these are the provision of a timely and effective support content (in terms of warnings to the drivers for avoiding potentially dangerous situations).

So, the common objective of SP4 and SP5, that is to design and build up working SAFESPOT applications (vehicle based or infrastructure based), reflects to UC that are in some manner “parallel”. Here the risk is that someone of the SP4 UC where infrastructure support is explicitly necessary, is overlapping/redundant respect to some UC belonging to SP5, and reciprocally, that someone of the SP5 UC shows a vehicle support content which is overlapping/redundant respect to some UC belonging to SP4.

Performed analysis showed that for all of the SP4 UC needing some support from the infrastructure, the trigger for the UC is always vehicle based, and the support from the infrastructure is limited. In all of these UC it seems proper to keep them inside the domain of the vehicle based applications (SP4).

A similar analysis has been performed on the SP5 UC, ensuring that the major focus of the produced UC is on the infrastructure based applications. Even when the trigger for the UC is vehicle based, there the infrastructure support is the main function performed, ensuring no overlaps/duplications respect to the SP4 UC.

3. Use Cases for the SP4 Applications

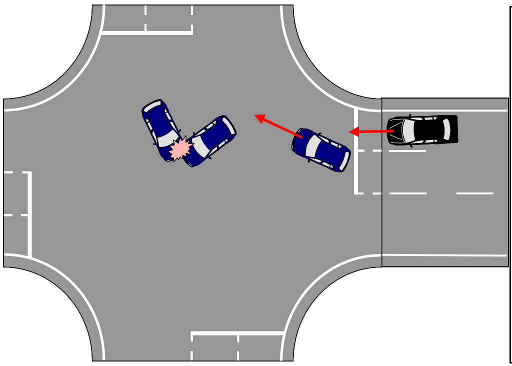
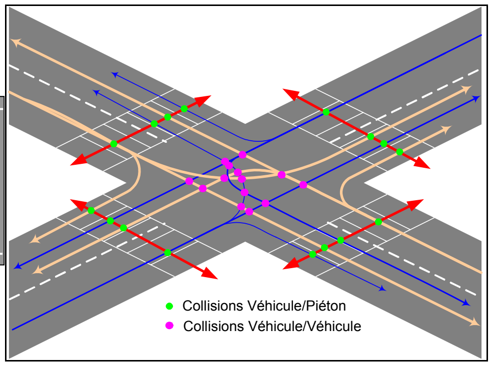
Use Case for the SP4 Applications are grouped based on the cluster of the related vehicle based applications

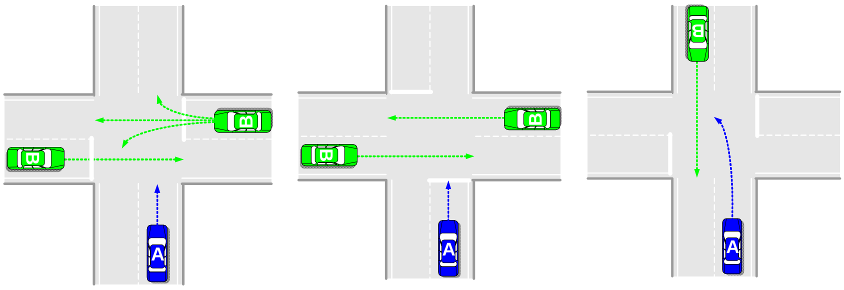
3.1. Use Cases for the LATC cluster

Six Use Cases are proposed for the Road Intersection Safety application:

- Accident at intersections;
- Obstructed view at intersection;
- Permission denial to go-ahead;
- Defect traffic signs;
- Other vehicle brakes hard due to red light;
- Approaching emergency vehicle warning.

3.1.1. Accident at intersections - 1a

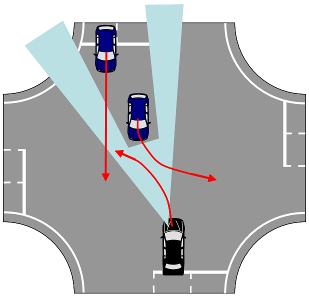
Case Name	Accident at intersections
Case ID	SP4_UC_Accident at intersection – 1a
Status	Final - V1.2
Short description	A crash happens at an intersection resulting in a dangerous situation; the drivers approaching an intersection are warned about such event.  
Purpose	Avoid critical situations resulting from an accident
Rationale	Intersections are probably the most complex part of road infrastructures and paces where collisions result in serious injury or death. An accident at an intersection can result in other accidents as an unforeseen situation would exist. On intersections traffic-flow is very complex, then the driving behavior of other drivers could change immediately, due to such unforeseen situations.
Authors	CAS – Strauss Matthias – V1.0 Renault – Javier Ibañez-Guzmán – V1.1
Level	Level of priority: 1

Driving environment	Accidentology data from Germany and France has shown that there are three types likely scenarios where 65% of accidents causing serious injury occur and where 70% of deaths are likely to occur. These scenarios are represented as follows.  Occlusion effects need to be incorporated as well as bad visibility conditions	
Vehicle probe type	Truck, motorcycle, vehicle	
Risk's source	One or more of the vehicles involved does not send the required information. The driver can't survey the situation due to too many vehicles. Latency in the information transmitted. Signal spoofing from malicious vehicles. The OBU's aren't able to send their information after the crash.	
Successful end condition	The vehicle driver is informed on time about the presence of an accident and is able to take the correct action.	
Failed end condition	The vehicle driver is not informed in time about the presence of an accident. The information could not be displayed on the HMI or the driver is not capable of understanding it on time.	
Trigger	There are three phases: Associate accident position to the intersection represented in the map database. Broadcast information to the vehicles associated to the intersection. Receiving vehicles determine whether the information is pertinent to their trajectory. Positioning data of accident and intersection details by the transmitting vehicle.	
Frequency of occurrence	On intersections with an accident on it at the moment -> seldom	
Primary Actor	Truck, motorcycle, vehicle	
Secondary Actor(s)	Drivers of all other vehicles	
Scenario Description	**Step**	**Action**
	1	Detection and identification of an oncoming intersection by map-sensors
	2	An accident occurs
	3	Broadcasting of the accident details by the cars involved
	4	Display accident location in all vehicles in the immediate environment next to the intersection
	5	The Safety Margin in the SAFESPOT system is modified accordingly. It determines whether or not there is a risk associated with the accident and the vehicle and warns the driver accordingly.

Exceptions	**Step**	**Action**
	1	One or more vehicles don't send information
	2	No accident is detected on the intersection
	4	The SAFESPOT system may propose recommendations to the driver, depending on the situations
Super ordinates	<Insert the name of any use case(s) that includes the current use case>	
Subordinates	<Insert name of any use case(s) used by the current use case>	
Open issues	How could the OBU's send their information after a crash? (*) Determination with certainty that the intersection associated to the accident is the correct one, failure to do so could generate cause accidents, disrupt traffic, etc.	
Comments	There should be a similar case from the infrastructure point of view. That is upon the occurrence of an accident, this information is uploaded to an Infrastructure component associated to the intersection. A sensor at the intersection could also inform of an accident or a reliable third party could communicate such information to a traffic control centre which should transmit to the Infrastructure component. Whatever way the information is collected, this can be broadcasted to approaching vehicle via the infrastructure module associated to the intersection. It could be thus feasible to set perhaps the same use case, the variant being the methods in which vehicle and infrastructure communicate the information to other vehicles.	

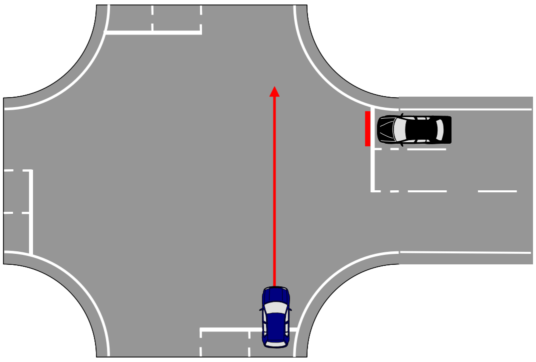
(*) Work on the IP project GST, or other e-call projects, should assist with this issue.

3.1.2. Obstructed view at intersections – 1b

Case Name	Obstructed view at intersections
Case ID	SP4_UC_Obstructed view at intersections – 1b
Status	Final - V1.1
Short description	Assumes all vehicles at the Intersection are SAFESPOT type vehicles. In this scenario the vehicle driver is informed about the presence of other vehicles at an intersection. The system warns in particular drivers of the presence of vehicles that could be masked by other vehicles. The purposes is to enhance the driver knowledge of the immediate environment. 
Purpose	To avoid collisions between vehicles, which are not able to "see" each other.
Rationale	One of the main reasons accidents occur are unforeseen situations. At intersections several objects might obstruct the view of a driver. These could be: Buildings, Vegetation, Pedestrians, Cyclists, Cars, Trucks… The presence of other vehicles can be masked. If each vehicle broadcasts its presence and this can be projected onto a representation of the intersection, it is possible to overcome all occlusion problems.
Authors	CAS – Strauss Matthias – V1.0 Renault – Javier Ibañez-Guzmán – V1.1
Level	Level of priority: 1
Driving environment	The target intersections are those included in the use case SP4_UC_Accident at intersection – 1a. Bad visibility conditions need to be included.
Vehicle probe type	Truck, motorcycle, vehicle
Risk's source	One ore more of the involved vehicles do not send the required information either because it is not a SAFESPOT vehicle or that there is a system malfunction. The driver can't survey the situation due to too many vehicles. The accuracy and latency on the relative position of the vehicles with regard to the intersection.
Successful end condition	The vehicle driver is informed in time about the presence of all other vehicles and/or the risk of a collision with regard to the intersection attributes and the direction of travel by the subject vehicle. The driver is able to make the appropriate manoeuvres.
Failed end condition	The vehicle driver is not informed in time about the presence of all other vehicles. The situation is not displayed in a comprehensive manner on the vehicle HMI.

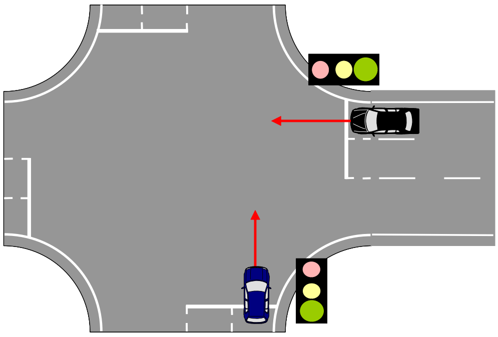
Trigger	Detection and identification of an oncoming intersection by the positioning sensors and digital map database.	
Frequency of occurrence	At every intersection -> very often	
Primary Actor	Truck, motorcycle, vehicle	
Secondary Actor(s)	Drivers of all other vehicles	
Scenario Description	**Step**	**Action**
	1	Detection of an oncoming intersection
	2	Display all vehicles near or at the intersection
	3	Analyze the risk of the situation
	4	The SAFESPOT system warns the driver if a risk is identified.
Extensions	**Step**	**Action**
	1	One or more vehicle do not send information.
	2	No vehicle is in the range of the vehicle (range to be defined).
	4	The SAFESPOT system may propose recommendations to the driver, depending on the situations
Super ordinates	<Insert the name of any use case(s) that includes the current use case>	
Subordinates	<Insert name of any use case(s) used by the current use case>	
Open issues	Latencies are very important; information should arrive on time for vehicles to manoeuvre accordingly. The presence of non-SAFESPOT vehicles needs to be known else the information is incomplete. Can information on the intersection be reconstructed using data collected by the exteroceptive SAFESPOT vehicle onboard sensors?	
Comments	In principle information from all the SAFESPOT vehicles would be shared and a dynamic map of the immediate environment of the vehicle built including a representation of the intersection. Notions such as the time to Intersection, the tagging of vehicle speeds and their direction of motion to the representation of the vehicles in the driver IHM could be explored. This application should also have its counterpart in the SP5-Cossib subproject, most likely that for intersections equipped by infrastructure equipment, that is sensors could detect other vehicles, pedestrians, etc and fuse information from the SAFESPOT vehicles, providing a bird-eye view of the intersection.	

3.1.3. Permission denial to go-ahead – 1c

Case Name	Permission denial to go-ahead
Case ID	SP4_UC_Permission denial to go-ahead – 1c
Status	Final - V1.2
Short description	Due to a detected dangerous situation the driver is not allowed to go ahead: the driver waiting at an intersection is not allowed to cross if a dangerous situation is detected, even if he has the right of way. 
Purpose	Avoid accidents by holding the vehicle, so it can not drive away (haptic warning)
Rationale	The most critical crashes are side crashes occurring at high speeds. Due to the small space inside vehicle doors, there are not many passive safety components installed. For motorcyclists, side crashes could be fatal or result in serious injury. By constraining the motion of the subject vehicle as it is to cross an intersection, if a dangerous situation results from a drive away, start, it is possible to stop the own vehicle and avoid an accident if there are restrictions on its speed. When the own vehicle is very slow or standing, a drive away could be avoided independent of the right of way.
Authors	CAS – Strauss Matthias – V1.0 Renault – Javier Ibañez-Guzmán – V1.1
Level	Level of priority: 2
Driving environment	The target intersections are those included in the use case SP4_UC_Accident at intersection – 1a. Bad visibility conditions need to be included as well as intersections in rural and urban environments.
Vehicle probe type	Trucks, especially motorcycles, vehicles
Risk's source	Latencies on the received information and the time interval for the driver to effect a maneuver. The triggering of the event by information sent by other vehicles, is there sufficient time? One or more of the involved vehicles does not send the required information. The driver can't survey the situation due to too many vehicles. The own vehicle is too fast to stop it in time.
Successful end condition	The vehicle driver is informed in time about the danger of the situation and the vehicle can not drive away (cross the intersection).
Failed end condition	The vehicle driver is not informed about the situation and the car could not be stopped. The situation could not be displayed on the HMI due to the complexity and the high dynamic.

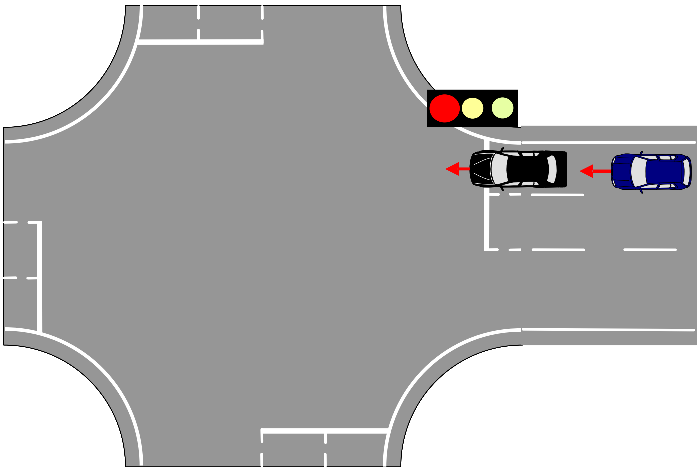
Trigger	Detection of an oncoming intersection by map-sensors and very low speed or standstill from the own vehicle.	
Frequency of occurrence	On intersections when right of way is not given -> sometimes	
Primary Actor	Truck, motorcycle, vehicle	
Secondary Actor(s)	Drivers of all other vehicles	
Scenario Description	**Step**	**Action**
	1	Detection of an oncoming intersection by map-sensors and very low speed or standstill of own vehicle
	2	It is detected that a drive away will lead to an accidents independent of the right of way rules.
	3	Avoid Drive away from own vehicle
	4	Display the situation to the own driver
Exceptions	**Step**	**Action**
	1a	Own speed is very high
	1b	Own driver has right of way
	1c	Do not stop the own vehicle because, it has right of way
	1b.1	If own driver has no right of way, stop the own vehicle independent of the own speed.
Super ordinates	<Insert the name of any use case(s) that includes the current use case>	
Subordinates	<Insert name of any use case(s) used by the current use case>	
Open issues	Unknown	
Comments	<Insert any comments on the contents of the use case>	

3.1.4. Defect traffic signs – 1d

Case Name	Defect traffic signs
Case ID	SP4_UC_Defect traffic lights – 1d
Status	Final - V1.2
Short description	Validation of defect or false traffic lights: both drivers think that they have right of way, due to defect or misinterpreted traffic lights. 
Purpose	Avoid accidents by verifying the actual traffic lights.
Rationale	False or defect traffic lights lead to an undefined situation. If both drivers think they have right of way an accident is probable. To avoid such an accident, the traffic-sign situation could be verified by the vehicles and shown to the drivers.
Authors	CAS – Strauss Matthias – V1.0
Level	Level of priority: 3
Driving environment	All kinds of intersections. All kinds of weather.
Vehicle probe type	Trucks, motorcycles, vehicles
Risk's source	One ore more of the involved vehicles doesn't send the required information. The driver doesn't understand that his car warns him for a red light, when the traffic light is green.
Successful end condition	The vehicle driver is informed in time about the danger of the situation and stops the own vehicle.
Failed end condition	The vehicle driver is not informed in time about the false traffic lights.
Trigger	Detection of an oncoming intersection by map-sensors and detection of false or defective traffic lights.
Frequency of occurrence	On intersections with defect traffic lights – seldom
Primary Actor	Truck, motorcycle, vehicle
Secondary Actor(s)	Drivers of all other vehicles

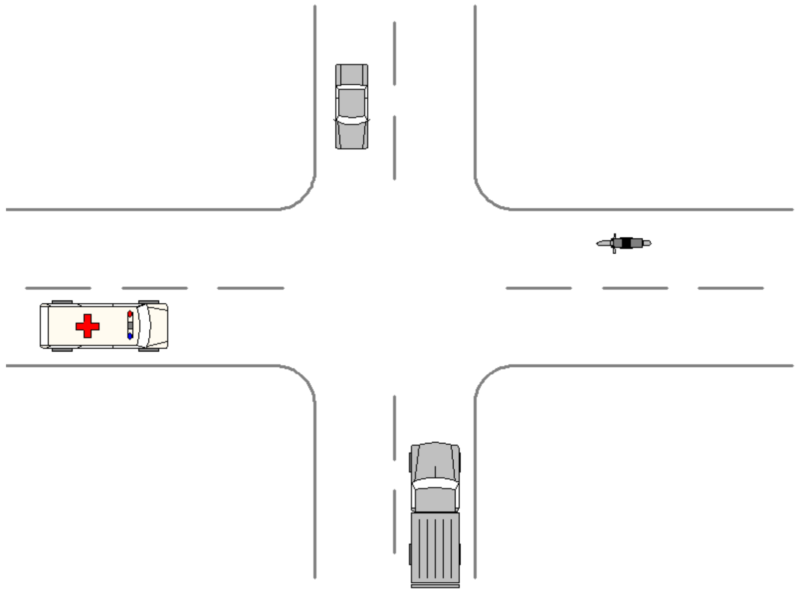
Scenario Description	**Step**	**Action**
	1	Detection of an oncoming intersection by map-sensors
	2	Detection of false traffic lights
	3	Warn drivers
	4	Driver stops vehicle
Exceptions	**Step**	**Action**
Super ordinates	<Insert the name of any use case(s) that includes the current use case>	
Subordinates	<Insert name of any use case(s) used by the current use case>	
Open issues	Unknown	
Comments	<Insert any comments on the contents of the use case>	

3.1.5. Other vehicle brakes hard due to red light – 1e

Case Name	Other vehicle brakes hard due to red light
Case ID	SP4_UC_Other vehicle brakes hard due to red light – 1e
Status	Final - V1.1
Short description	The vehicle in front of the own brakes hard, because the traffic sign switches from green to red. 
Purpose	Avoid accidents coming from an unforeseen emergency braking vehicle
Rationale	If a traffic light is in the yellow phase some drivers try to drive over the intersection and some drivers stop. This leads to a problem if the first driver makes an emergency brake due to the red traffic light and the second driver reacts too late. An other problem could be, that the road adherence is very low and the second driver doesn't react in the right matter.
Authors	CAS – Strauss Matthias – V1.0
Level	Level of priority: 2
Driving environment	All kinds of intersections. All kinds of weather, especially slippery road conditions.
Vehicle probe type	Trucks, motorcycles, vehicles
Risk's source	One ore more of the involved vehicles doesn't send the required information. The time is to short for the second driver to react in time.
Successful end condition	The vehicle driver is informed in time about the braking vehicle in front and eventually the adherence of the road.
Failed end condition	The vehicle driver is not informed in time about the braking vehicle.
Trigger	Detection of an oncoming intersection by map-sensors and the detection of a changing traffic light.

Frequency of occurrence	On intersections while traffic lights are changing - often	
Primary Actor	Truck, motorcycle, vehicle	
Secondary Actor(s)	Drivers of all other vehicles	
Scenario Description	**Step**	**Action**
	1	Detection of an oncoming intersection by map-sensors
	2	Detection of changing traffic lights
	3	First vehicle is braking and broadcast this information and the road adherence.
	4	Second vehicle receives data and driver is warned
Exceptions	**Step**	**Action**
Super ordinates	SP4_UC_FrontalCollisionWarning – 7a – 7b – 7c	
Subordinates	<Insert name of any use case(s) used by the current use case>	
Open issues	Unknown	
Comments	<Insert any comments on the contents of the use case>	

3.1.6. Approaching emergency vehicle warning – 1f

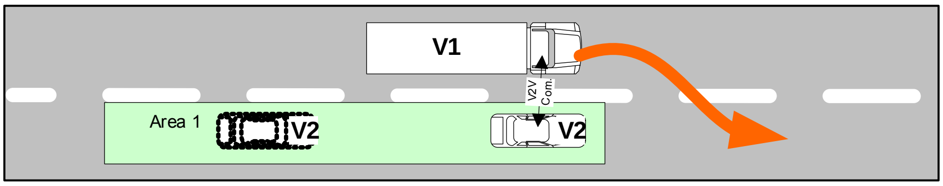
Case Name	Approaching Emergency Vehicle Warning
Case ID	SP4_UC_Approaching Emergency Vehicle Warning – 1f
Status	Final - V1.0
Short description	Assumes all vehicles within the immediate environment of the Intersection are SAFESPOT type. In this scenario an emergency vehicle broadcasts its presence as it nears an intersection indicating its position and expected trajectory. The system warns drivers of the arrival of the emergency vehicle or informs them to stop so this can traverse the intersection. 
Purpose	To facilitate the transit of emergency vehicles and to reduce the risk of collisions by broadcasting their passage as they approach an identified intersection.
Rationale	The safe and rapid passage of emergency vehicles in congested environments is difficult and potentially hazardous in densely populated environments. The presence of an emergency vehicle as it approaches an intersection can be informed to other immediate vehicles, this in turn ensures that there is awareness by drivers of the presence of an emergency vehicle, thus the possibility of an unforeseen situation is avoided. In case of major incidents, messages from the emergency vehicles can be broadcasted forming a pseudo-tunnel, that becomes like a safe passage for emergency vehicles.
Authors	Renault – Javier Ibañez-Guzmán – V1.0
Level	Level of priority: 2
Driving environment	The target intersections are those included in the use case SP4_UC_Accident at intersection – 1a. Bad visibility conditions need to be included.
Vehicle probe type	Truck, motorcycle, vehicle
Risk's source	The possibility of other vehicles not receiving in time the information, or the wrong identification of the next oncoming intersection by the emergency vehicle system. The accuracy and latency on the relative position of the emergency vehicle with regard to the intersection.

Successful end condition	All vehicles approaching the intersection are informed of an oncoming emergency vehicle. The emergency crosses the intersection without a drastic reduction of its cruising speed and moves towards the next intersection. Only drivers involved in the trajectory of the vehicle are give way to the approaching emergency vehicle	
Failed end condition	Drivers are not informed on time of the arrival of the emergency vehicle and block unwillingly its way. They do not have sufficient time to position their vehicles out of the way.	
Trigger	Detection and identification of an oncoming intersection by the positioning sensors and digital map database in the emergency vehicle, and broadcast of the information to the vehicles within its immediate environment.	
Frequency of occurrence	At every intersection →very often	
Primary Actor	Truck, motorcycle, vehicle	
Secondary Actor(s)	Drivers of all other vehicles	
Scenario Description	**Step**	**Action**
	1	Detection and identification of an oncoming intersection
	2	Broadcast the position and direction of motions together with the Intersection ID to the neighboring vehicles
	3	Analysis within the receiving vehicles to determine whether or the information is relevant to their trajectory. This is proportional to the time to intersection estimation.
	4	The SAFESPOT system warns the driver of the relevant vehicles.
Exceptions	**Step**	**Action**
	1	One or more vehicles do not receive the information on time.
	2	The SAFESPOT system may propose recommendations to the driver, depending on the situations
Super ordinates	<Insert the name of any use case(s) that includes the current use case>	
Subordinates	<Insert name of any use case(s) used by the current use case>	
Open issues	Can the emergency vehicle have already a pre-planned path so it broadcasts additional information as it travels? The certainty that it is to cross a given intersection, failure to do this can cause traffic congestions, etc.	
Comments	The application is complementary to any security application addressing Intersections and Infrastructure. That is the broadcast is made from the infrastructure component to all vehicles approaching the intersection.	

Three Use Cases are proposed for the Lane Change Manoeuvre application:

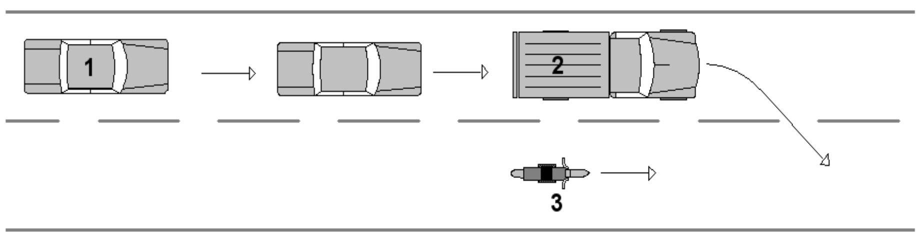
- Lane change manoeuvre for trucks with blind spots;
- Lane change manoeuvre for car/trucks;
- Lane change manoeuvre for ramp in motorways:

3.1.7. Lane change manoeuvre for trucks with blind spots – 2a

Case Name	Lane Change manoeuvre for Trucks with blind spot
Case ID	SP4_UC_LaneChangeManoeuvre – 2a
Status	Final - V4.1
Short description	This scenario aims to inform and/or warn truck driver (V1) about the presence of other vehicle (V2) around him during maneuver, especially during lane change maneuver. 
Purpose	Avoid accident due to blind spot with trucks during lane change manoeuvres
Rationale	Even if specific rear mirror help driver to have a good vision around its vehicle, some blind spot already exist in some situations. Due to the dimension of the truck, it is relevant in some situations to improve the driver information about the presence of other vehicles around him. The relative speed information with other vehicles can be taken into account to appreciate the safety of some manoeuvers. Some lateral collision or/and rear end collision can be avoided with other vehicles.
Authors	Volvo – Laurent Jacques
Level	Level of priority: 2
Driving environment	Road with different lanes in the same direction like motorway, some urban or extra-urban road.
Vehicle probe type	Truck, motorcycle, vehicle
Risk's source	
Successful end condition	The driver is informed in time about the presence of a vehicle around him and of a possible risk of collision. He is able in time to adapt his manoeuvre and avoid a collision.
Failed end condition	- The driver receives the information too late about a vehicle presence around him. - Failed communication link
Trigger	Detection of a lane change initiation from the truck

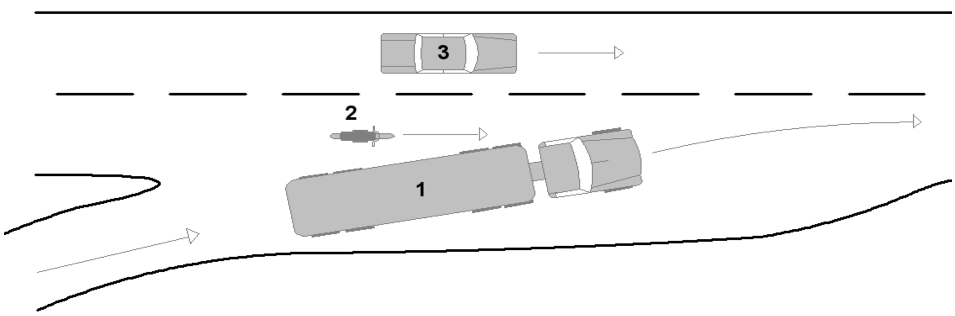
Frequency of occurrence	High – Especially on motorway environment	
Primary Actor	Truck Driver	
Secondary Actor(s)	Vehicle drivers around the truck	
Scenario Description	**Step**	**Action**
	1	V1 detects the lane change manoeuvre
	2	V1 receives information from V2 about its position and speed
	3	V1 identifies vehicle (1 or more) than represent a risk of collision for the truck. These vehicles are in the area 1. This area can be defined considering relative speed and distance of the vehicle around the truck.
	4	The truck driver is warned about the situation
Exceptions	**Step**	**Action**
	1	The lane change manoeuvre is not detected by the on board system.
	2	There is no vehicle around the trucks that have to be considered for a collision risk.
	3	The vehicle is behind the truck and its speed is lower than the truck speed.
	4	The SAFESPOT system may propose in some case some recommendation to the driver
	4	Other vehicle concerned by the collision or just behind (to be defined) can be informed or/and warned
Super ordinates		
Subordinates		
Open issues	- Area 1 has to be defined (specific for each car/truck manufacturer) - Time respond is very critical and short in this case.	
Comments	The detection of the lane change is not part of SAFESPOT. Some existing systems have been developed in previous project and can be used to detect lane change manoeuvre. In SAFESPOT, information from map about road type and number of lanes can be used to consider this scenario in some specific situations. For instance, this scenario is applicable for some road with two lanes or more.	

3.1.8. Lane change manoeuvre for car/trucks – 2b

Case Name	Lane Change manoeuvre for Car/Trucks
Case ID	SP4_UC_LaneChangeManoeuvre – 2b
Status	Final - V1.1
Short description	A car/truck (2) is changing lane while a PTW (3) is approaching. A following vehicle (1) detects PTW and informs vehicle (2) 
Purpose	Avoid accident due to blind spot with PTW during lane change manoeuvres
Rationale	Even if specific rear mirror are helping driver to have a good vision around its vehicle, some blind spot already exist in some situations. Due to the differential of speed between surrounding traffic and PTW in filtering manoeuvres (especially in case of car queues) it is relevant in some situations to improve the driver information about the presence of other vehicles around him. Some lateral collision or/and rear end collision can be avoided with other vehicles.
Authors	Piaggio – Pieve M., Ducci I., Cravini P. – V1.0
Level	Level of priority: 2
Driving environment	Road with different lanes in the same direction like motorway, some urban or peri-urban road and roads approaching regulated intersections
Vehicle probe type	Truck, vehicle
Risk's source	
Successful end condition	The driver is informed in time about the presence of a PTW around him and of a possible risk of collision. He is able in time to adapt his manoeuvre and avoid a collision.
Failed end condition	Vehicle 1 does not communicate timely. Vehicle 2 does not receive information timely.
Trigger	Detection of a safe lane change from the car
Frequency of occurrence	High
Primary Actor	Car Driver

Secondary Actor(s)	Drivers of following vehicles	
Scenario Description	**Step**	**Action**
	1	Host vehicle (1) detects PTW (3) passing through
	2	Host vehicle detects the lane change manoeuvre of vehicle (2)
	3	Vehicle (1) warns vehicle (2) driver about PTW motion
Exceptions	**Step**	**Action**
Super ordinates	<Insert the name of any use case(s) that includes the current use case>	
Subordinates	<Insert name of any use case(s) used by the current use case>	
Open issues	- Areas of manoeuvre surrounding vehicles 1 and 2 should be defined, and are most probably specific for each car/truck manufacturer - Time respond is very critical and short in this case.	
Comments	<Insert any comments on the contents of the use case>	

3.1.9. Lane change manoeuvre on ramp in motorways – 2c

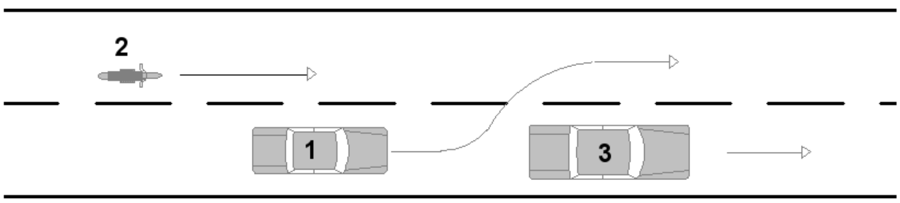
Case Name	Lane Change manoeuvre on ramp in motorways
Case ID	SP4_UC_LaneChangeManoeuvre – 2c
Status	Final - V1.2
Short description	The truck (1) is entering into motorway lane without seeing an incoming PTW (2). The PTW is not able to avoid truck (1) due to the presence of vehicle (3). Truck is informed about PTW presence. This UC is not specific for PTW, being very likely to happen also with normal vehicles of other type(s) 
Purpose	Avoid accident due to blind spot with PTW during lane change manoeuvres
Rationale	Even if specific rear mirror are helping driver to have a good vision around its vehicle, some blind spot already exist in some situations. For PTW path change is more difficult than cars.
Authors	Piaggio – Pieve M., Ducci I., Cravini P. – V1.0
Level	Level of priority: 1
Driving environment	Motorways, near extended on ramps
Vehicle probe type	Truck, vehicle
Risk's source	
Successful end condition	The driver is informed in time about the presence of a PTW around him and of a possible risk of collision. He is able in time to adapt his manoeuvre and avoid a collision (e.g. moving out to the right and stopping)
Failed end condition	Vehicle 1 does not receive information timely.
Trigger	Detection of a safe lane change from the truck
Frequency of occurrence	High
Primary Actor	Truck Driver
Secondary Actor(s)	PTW rider

Scenario Description	**Step**	**Action**
	1	Truck (1) detects that PTW (2) is incoming
	2	Truck informs the truck driver about PTW motion
	3	
Exceptions	**Step**	**Action**
Super ordinates	<Insert the name of any use case(s) that includes the current use case>	
Subordinates	<Insert name of any use case(s) used by the current use case>	
Open issues	- Areas of manoeuvre surrounding vehicles 1 and 2 should be defined, and are most probably specific for each car/truck manufacturer - Time respond is very critical and short in this case	
Comments	<Insert any comments on the contents of the use case>	

Three Use Cases are proposed for the Safe Overtaking application:

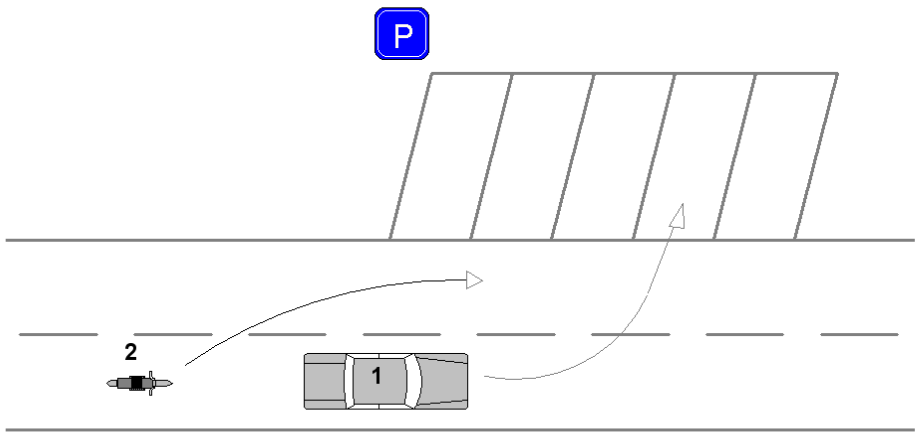
- Safe overtaking in urban and semiurban roads with PTW already in overtaking;
- PTW overtaking OV while OV is turning left to park area;
- PTW overtaking OV while OV is turning left to park area.

3.1.10. Safe overtaking in urban and semiurban roads with PTW already in overtaking – 3a

Case Name	Safe overtaking in urban and semiurban roads with PTW already in overtaking
Case ID	SP4_UC_SafeOvertaking – 3a
Status	Final - V1.1
Short description	Host vehicle (1) starts to overtake vehicle (3) while a Powered Two Wheelers (2) is already in overtaking manoeuvre PTW (2) informs the host vehicle (1) about its manoeuvre. 
Purpose	Avoid collision between PTW and car by giving warning to vehicle (1).
Rationale	This situation is critical for PTW users due to blinds spots and differential of speed between PTW and car that does not allow the driver to be aware about the presence of motorcyclist.
Authors	Piaggio – M. Pieve, I. Ducci, P. Cravini – V1.0
Level	Level of priority: 1
Driving environment	Urban and semiurban roads
Host-vehicle type	PTW, vehicle
Risk's source	Communication V2V could fail
Successful end condition	Driver is informed timely of the presence and the action of PTW Vehicle waits for an overtaking manoeuvre

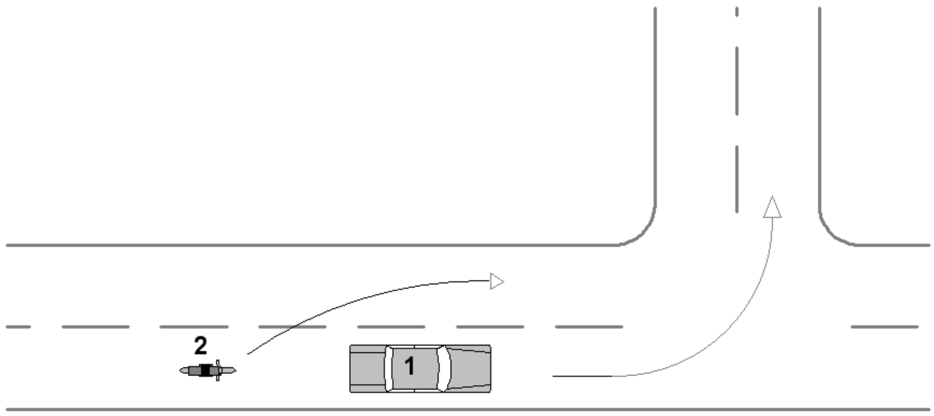
Failed end condition	Driver is not informed timely Vehicle performs anyway the overtaking manoeuvre	
Trigger	Vehicle is incoming an overtaking manoeuvre. Detection of presence of PTW	
Frequency of occurrence	Unknown	
Primary Actor	Vehicle driver	
Secondary Actor(s)	PTW rider	
Scenario Description	**Step**	**Action**
	1	Probe-vehicle detects its overtaking manoeuvre
	2	Vehicle detects the PTW manoeuvre
	3	Vehicle warns driver about the presence of PTW
Exceptions	**Step**	**Action**
Super ordinates	<Insert the name of any use case(s) that includes the current use case>	
Subordinates	<Insert name of any use case(s) used by the current use case>	
Open issues	Unknown	
Comments	<Insert any comments on the contents of the use case>	

3.1.11. PTW overtaking OV while OV is turning left to park area – 3b

Case Name	PTW overtaking OV while OV is turning left to park area
Case ID	SP4_UC_SafeOvertaking – 3b
Status	Final - V1.1
Short description	Host vehicle (1) is going to turn left to the park area while a PTW is approaching or is already in overtaking manoeuvre. PTW (2) informs the host vehicle to interrupt the turning operation. 
Purpose	Avoid collision between PTW and car by giving warning to vehicle (1).
Rationale	This situation is quite frequent and critical for PTW users due to lack of perception by the car driver and the difficulty from PTW side to perform successfully any collision avoidance manoeuvre.
Authors	Piaggio – M. Pieve, I. Ducci, P. Cravini – V1.0
Level	Level of priority: 2
Driving environment	Urban and semiurban roads
Host-vehicle type	PTW, vehicle
Risk's source	Communication V2V could fail
Successful end condition	Driver is informed timely of the presence and the action of PTW Vehicle waits for an overtaking manoeuvre
Failed end condition	Driver is not informed timely Vehicle performs anyway the turning manoeuvre
Trigger	Vehicle is incoming an overtaking manoeuvre. Detection of presence of PTW

Frequency of occurrence	Unknown	
Primary Actor	Vehicle driver	
Secondary Actor(s)	PTW rider	
Scenario Description	**Step**	**Action**
	1	Probe-vehicle detects its turning manoeuvre
	2	Vehicle detects the PTW manoeuvre
	3	Vehicle warns driver about the presence of PTW
Exceptions	**Step**	**Action**
Super ordinates	<Insert the name of any use case(s) that includes the current use case>	
Subordinates	<Insert name of any use case(s) used by the current use case>	
Open issues	Unknown	
Comments	<Insert any comments on the contents of the use case>	

3.1.12. PTW overtaking OV while OV is turning left into another road – 3c

Case Name	PTW overtaking OV while OV is turning left into another road
Case ID	SP4_UC_SafeOvertaking – 3c
Status	Final - V1.1
Short description	This scenario is quite similar to SP4_UC_SafeOvertaking – 3b. Host vehicle (1) is going to turn left while a PTW is approaching or is already in overtaking manoeuvre. PTW (2) informs the host vehicle to interrupt the turning operation. 
Purpose	Avoid collision between PTW and car by giving warning to vehicle (1).
Rationale	This situation is quite frequent and critical for PTW users due to lack of perception by the car driver and the difficulty from PTW side to perfom successfully any collision avoidance manoeuvre.
Authors	Piaggio – M. Pieve, I. Ducci, P. Cravini – V1.0
Level	Level of priority: 1
Driving environment	Urban and semiurban roads
Host-vehicle type	PTW, vehicle
Risk's source	Communication V2V could fail
Successful end condition	Driver is informed timely of the presence and the action of PTW Vehicle waits for an overtaking manoeuvre
Failed end condition	Driver is not informed timely Vehicle performs anyway the turning manoeuvre
Trigger	Vehicle is incoming an overtaking manoeuvre. Detection of presence of PTW
Frequency of occurrence	Unknown

Primary Actor	Vehicle driver	
Secondary Actor(s)	PTW rider	
Scenario Description	**Step**	**Action**
	1	Probe-vehicle detects its turning manoeuvre
	2	Vehicle detects the PTW manoeuvre
	3	Vehicle warns driver about the presence of PTW
Exceptions	**Step**	**Action**
Super ordinates	<Insert the name of any use case(s) that includes the current use case>	
Subordinates	<Insert name of any use case(s) used by the current use case>	
Open issues	Unknown	
Comments	<Insert any comments on the contents of the use case>	

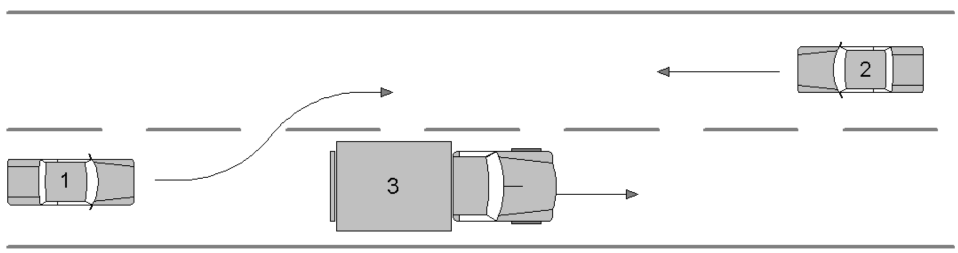
3.2. Use Cases for the LONC cluster

Three Use Cases are presented for the Head On Collision Warning function:

- Head On Collision Warning due to hazardous overtaking attempt by host vehicle;
- Head On Collision Warning due to hazardous overtaking attempt by a second vehicle;
- Head On Collision Warning due to the presence of an auto bus vehicle climbing down through an hairpin curve.

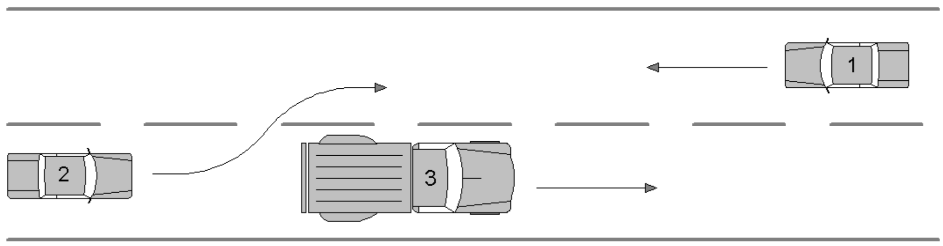
The first UC is related to a situation where host vehicle attempts an overtaking manoeuvre and is facing the risk of an head on collision due to the approaching of a second vehicle from the opposite lane. The second UC is describing the same situation, but the perspective (host vehicle) is the one of the vehicle which is driving normally and it is facing the head on collision risk due to an hazardous overtaking attempt started by a second vehicle. Third UC is referring to a completely different situation, where the risk of an head on collision is due to the presence of an auto bus vehicle climbing down through an hairpin curve.

3.2.1. Head on collision warning due to hazardous overtaking attempt by host vehicle – 4a

Case Name	Head On Collision Warning due to hazardous overtaking attempt by host vehicle
Case ID	SP4_UC_HeadOnCollisionWarning – 4a
Status	Final - V1.1
Short description	As in the pictogram below, host vehicle (1) attempts an overtaking maneuver to vehicle (3) which obstructs the driver's (1) field of view, while vehicle (2) is approaching from the opposite lane. 
Purpose	To warn the driver of vehicle 1 that another oncoming vehicle is in the adjacent lane and thus it is needed to delay or abort the overtaking manoeuvre
Rationale	To avoid or reduce the accidents linked to head-on collision situations
Authors	CRF – E. Bianco, F. Tango, F. Vernacchia, G. Vivo – V1.0
Level	Level of priority: 1

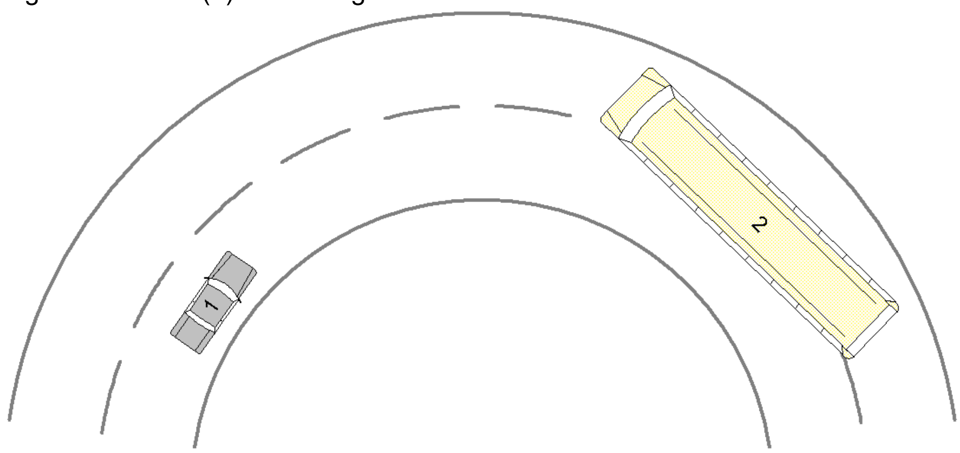
Driving environment	Motorways, extra-urban and rural roads	
Host-vehicle type	Truck, motorcycle, vehicle	
Risk's source	Vehicle 2 does not send information Vehicle 1 does not receive timely the information	
Successful end condition	Vehicle 1 receives the information and avoids the overtaking manoeuvre	
Failed end condition	Vehicle 1 does not receive the information and the overtaking manoeuvre starts anyway	
Trigger	Vehicle 2 is approaching while the driver of vehicle want to start an overtaking manoeuvre	
Frequency of occurrence	Unknown	
Primary Actor	Vehicle	
Secondary Actor(s)	Others vehicles	
Scenario Description	**Step**	**Action**
	1	Vehicle (1) wants to overtake vehicle (3)
	2	Vehicle (2) sends information
	3	Vehicle (1) receives it
	4	Driver (1) receives warning for head-on collision danger
Exceptions	**Step**	**Action**
	2	Vehicle (2) does not send information
	3	Vehicle (1) does not receive it
Super ordinates	<Insert the name of any use case(s) that includes the current use case>	
Subordinates	<Insert name of any use case(s) used by the current use case>	
Open issues	Unknown	
Comments	<Insert any comments on the contents of the use case>	

3.2.2. Head on collision warning due to hazardous overtaking attempt by a second vehicle - 4b

Case Name	Head On Collision Warning due to hazardous overtaking attempt by a second vehicle
Case ID	SP4_UC_HeadOnCollisionWarning – 4b
Status	Final - V1.1
Short description	Mirror UC respect to SP4_UC_HeadOnCollisionWarning – 4a. Here host vehicle (1) drives straight on its lane, while a second vehicle (2) attempts an overtaking manoeuvre to vehicle (3) 
Purpose	To warn the driver of vehicle 1 that another vehicle, oncoming in the adjacent lane, is attempting or it has initiated an overtaking manoeuvre and thus it is needed to take counter measures (slow down, or brake, or move laterally to facilitate the manoeuvre)
Rationale	To avoid or reduce the accidents linked to head-on collision situations
Authors	CRF – E. Bianco, F. Tango, F. Vernacchia, G. Vivo – V1.0
Level	Level of priority: 1
Driving environment	Motorways, extra-urban and rural roads
Host-vehicle type	Truck, motorcycle, vehicle
Risk's source	Vehicle 2 does not transmit information Vehicle 1 does not receive timely the information
Successful end condition	Vehicle 1 receives the information and slow down or brake or move laterally
Failed end condition	Vehicle 1 does not receive the information
Trigger	Driver of vehicle 2 switch to left arrow on, or moves laterally in order to begin an overtaking manoeuvre
Frequency of occurrence	Unknown
Primary Actor	Vehicle
Secondary Actor(s)	Others vehicles

Scenario Description	**Step**	**Action**
	1	Vehicle (2) wants to overtake vehicle (3)
	2	Vehicle (2) sends information (direction idication, lateral position, etc.)
	3	Vehicle (1) receives it
	4	Driver (1) receives warning for head-on collision danger
Exceptions	**Step**	**Action**
	2	Vehicle (2) does not send information
	3	Vehicle (1) does not receive it
Super ordinates	<Insert the name of any use case(s) that includes the current use case>	
Subordinates	<Insert name of any use case(s) used by the current use case>	
Open issues	Unknown	
Comments	<Insert any comments on the contents of the use case>	

3.2.3. Head on collision warning due to the presence of an auto bus vehicle climbing down through an hairpin curve – 4c

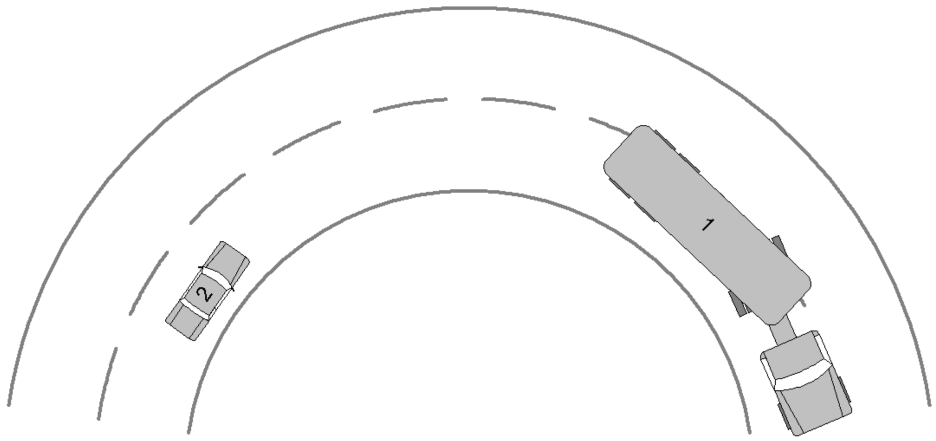
Case Name	Head On Collision Warning due to the presence of an auto bus vehicle climbing down through an hairpin curve
Case ID	SP4_UC_HeadOnCollisionWarning – 4c
Status	Final - V1.1
Short description	Host vehicle (1) drives climbing up a sharp hairpin curve, while a heavy vehicle – e.g. an auto bus (2) is climbing down 
Purpose	To warn the driver of vehicle 1 about the head/on collision risk, due to the presence of an oncoming vehicle in a specific black/spot (hairpin curve)
Rationale	Due to the limitations of the on-board sensorial system and to the road morphology, V2V and V2I communication can help in avoiding head-on collision situation.
Authors	CRF – E. Bianco, F. Tango, F. Vernacchia, G. Vivo – V1.0
Level	Level of priority: 3
Driving environment	Extra-urban and rural roads
Host-vehicle type	Truck, motorcycle, vehicle
Risk's source	Wrong , missing or delayed communication from V2V or V2I Obstructing obstacles
Successful end condition	Driver 1 receives communication and avoid the head-on collision.
Failed end condition	Driver 1 does not receive the communication timely.
Trigger	Vehicle 1 is approaching a sharp curve when another vehicle (vehicle 2) is climbing down with the risk of frontal impact
Frequency of occurrence	Not very frequent, but quite dangerous

Primary Actor	Vehicle	
Secondary Actor(s)	Others vehicles	
Scenario Description	**Step**	**Action**
	1	Vehicle 1 is approaching a sharp curve on a one carriage-way rural road
	2	Vehicle 2 is climbing down
	3	Vehicle 2 communicates the information about its status
	4	Vehicle 1 receives such a information
		Driver 1 is informed of a possible head-on collision and takes the appropriate corrective actions
Exceptions	**Step**	**Action**
		Vehicle 1 does not receive information
	Ì	Vehicle 2 does not transmit the information
Super ordinates	<Insert the name of any use case(s) that includes the current use case>	
Subordinates	<Insert name of any use case(s) used by the current use case>	
Open issues	Unknown	
Comments	<Insert any comments on the contents of the use case>	

Two Use Cases are presented for the Rear End Collision application:

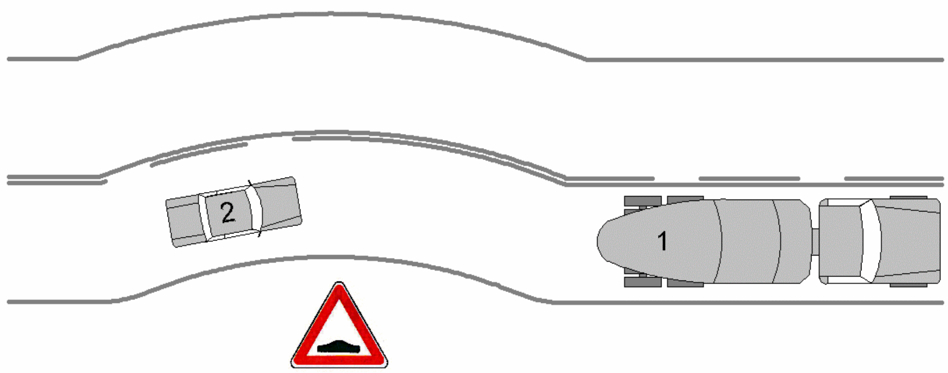
- Rear End Collision due to the presence of an heavy vehicle climbing up through an hairpin curve at a low speed;
- Rear End Collision due to the presence of an slower vehicle at the end of a hilly road segment.

3.2.4. Rear end collision due to the presence of an heavy vehicle climbing up through an hairpin curve at a low speed – 5a

Case Name	Rear End Collision due to the presence of an heavy vehicle climbing up through an hairpin curve at a low speed
Case ID	SP4_UC_RearEndCollision – 5a
Status	Final - V1.1
Short description	A vehicle (2) is climbing up a sharp hairpin curve, while a heavy vehicle (1), short ahead, is driving at a low speed due to the ramping road. 
Purpose	To warn the driver (1) of a possible danger of rear-end collision
Rationale	To inform the driver of the host vehicle in a situation where the direct sensing capabilities of the involved vehicles cannot detect the potential risk
Authors	CRF – E. Bianco, F. Tango, F. Vernacchia, G. Vivo – V1.0
Level	Level of priority: 3
Driving environment	Highways, rural and extra-urban roads
Host-vehicle type	Truck, motorcycle, vehicle
Risk's source	Communication V2V (between 1 and 2) fails
Successful end condition	Driver (1) becomes aware of the potential risk and can take some recovery actions or counter-measures (speeding up, pushing the horn, etc.) in order to avoid the collision
Failed end condition	Vehicle (1) does not receive information and a possible risk of rear-end collision occurs

Trigger	Vehicle (1) receives information about the oncoming of another vehicle, approaching at a higher speed beyond the curve.	
Frequency of occurrence	Unknown, in numerical terms, but quite dangerous	
Primary Actor	Ego-vehicle	
Secondary Actor(s)	Other vehicles	
Scenario Description	**Step**	**Action**
	1	Vehicle (2) sends information about its status
	2	Vehicle (1) receives the information about the presence of the vehicle approaching at a higher speed behind the curve
	3	Driver (1) is warned about the possible risky situation
Exceptions	**Step**	**Action**
	1	Vehicle (2) does not send information about its status
	2	Vehicle (1) does not receive such an information
Super ordinates	<Insert the name of any use case(s) that includes the current use case>	
Subordinates	<Insert name of any use case(s) used by the current use case>	
Open issues	Unknown	
Comments	<Insert any comments on the contents of the use case>	

3.2.5. Rear end collision due to the presence of an slower vehicle at the end of a hilly road segment – 5b

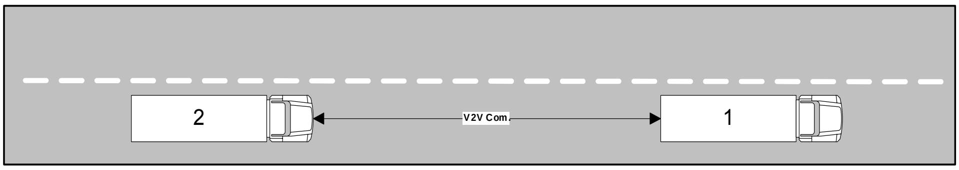
Case Name	Rear End Collision due to the presence of an slower vehicle at the end of a hilly road segment
Case ID	SP4_UC_RearEndCollision – 5b
Status	Final - V1.1
Short description	A vehicle (2) is driving at a sustained speed before the top of an hill, while a slower vehicle (1) – e.g. a concrete-mixer – is short ahead, but still not visible, due to the specific shape of the road. 
Purpose	To avoid rear-end collision between vehicle 1 and 2
Rationale	Due to the particular morphology of the road, sensorial system of vehicle 2 is not able to detect in time the vehicle 1
Authors	CRF – E. Bianco, F. Tango, F. Vernacchia, G. Vivo – V1.0
Level	Level of priority: 2
Driving environment	Extra-urban, and rural roads
Host-vehicle type	Truck, motorcycle, vehicle
Risk's source	Specific obstruction for communication V2V or V2I
Successful end condition	Driver of host vehicle is informed of the presence of another vehicle (2) which is approaching from behind the hill at a higher speed
Failed end condition	Driver is not informed about the presence of vehicle 2 and he / she can detect it too late
Trigger	The approaching of a vehicle driving at a relatively high speed
Frequency of occurrence	Unknown
Primary Actor	Vehicle
Secondary Actor(s)	Others vehicles

Scenario Description	**Step**	**Action**
	1	Vehicle 2 is approaching a hill
	2	Host vehicle (1) is driving at a slower speed down the hill
	3	Vehicle 2 transmit information about its status
	4	Vehicle 1 receives such an information
	5	Driver 1 is warned about in advance and can take possible counter-measures (speeding up, pushing the horn, etc.)
Exceptions	**Step**	**Action**
		Vehicle 2 does not transmit the information
		Vehicle 1 does not receive the information
Super ordinates	<Insert the name of any use case(s) that includes the current use case>	
Subordinates	<Insert name of any use case(s) used by the current use case>	
Open issues	Unknown	
Comments	<Insert any comments on the contents of the use case>	

Three Use Cases are presented for the Speed Limitation and Safety Distance application:

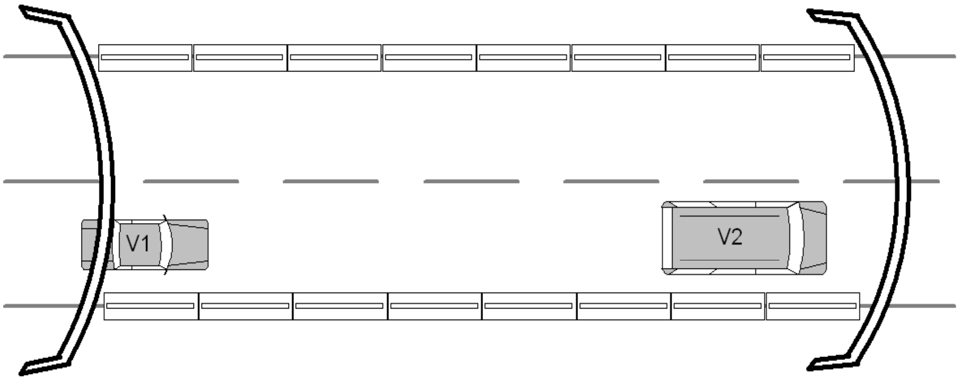
- Speed limitation and Safety Distance and trucks driver recommendations;
- Safety Margin Assistant on black spots – tunnels;
- Safety Margin Assistant on black spots – reduction of lanes.

3.2.6. Speed limitation and safety distance and trucks driver recommendations – 6a

Case Name	Speed limitation and Safety Distance and trucks driver recommendations
Case ID	SP4_UC_SpeedAndDistance – 6a
Status	Final - V2.1
Short description	This scenario aims to provide to the vehicle driver (2) some recommendations in term of speed and safety distance regarding the behavior or status of the vehicle in front. Special focus can be done on trucks carrying dangerous goods. 
Purpose	Regarding the situation in front of the vehicle, it is possible to provide some recommendations to the driver (2) in order to take into account the status or the behavior of the vehicle (1). For instance, if the vehicle (1) is carrying dangerous goods, the recommendation to the driver could be to increase the safety distance.
Rationale	Some existing recommendations on speed limitation and safety distance have been considered in some previous projects. Some new considerations can be added to improve the recommendation to the driver regarding additional information coming from other vehicles.
Authors	Volvo – Laurent Jacques – V1.0
Level	Level of priority: 3
Driving environment	Any road
Vehicle probe type	Truck, vehicle
Risk's source	Specific obstruction for communication V2V or V2I
Successful end condition	This UC is relevant as long as the position, status or behavior of the vehicle (1) has an impact on the vehicle (2).
Failed end condition	No detection of the dangerous goods Failed communication link

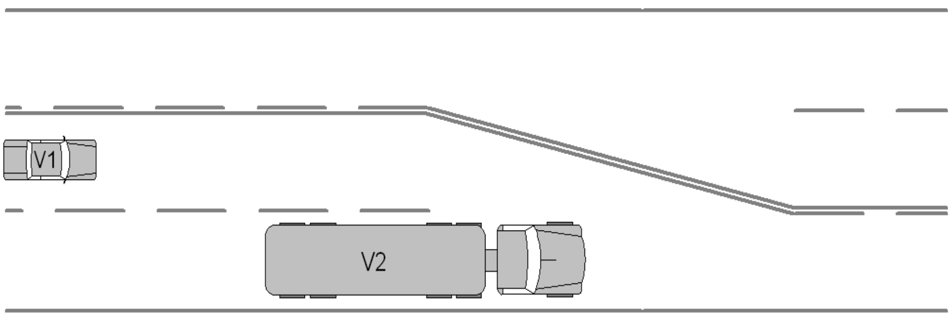
Trigger	The status of the vehicle (1) can be: - dangerous goods - Vehicle status (diagnosis information) Vehicle abnormal behaviour: difficult to detect (drowsiness…)	
Frequency of occurrence	Very frequent, in all traffic scenarios	
Primary Actor	V2	
Secondary Actor(s)	Others vehicles	
Scenario Description	**Step**	**Action**
	1	Abnormal behaviour or specific status of the Vehicle (1) is detected
	2	Vehicle (1) send information to vehicle behind
	3	Vehicle (2) receives information
	4	From vehicle (2), the vehicle driver is informed about the vehicle status in front and a safety recommendation is provided to him
Exceptions	**Step**	**Action**
		Vehicle 1 does not transmit the information
		Vehicle 2 does not receive the information
Super ordinates		
Subordinates	SP1_UC1xx_4 Ego vehicle approaching truck carrying dangerous goods. SP1_UC2xx_4 Ego vehicle carrying dangerous goods approaches other vehicle	
Open issues	To be classified witch type of events can be detected and sent by the infrastructure and by the vehicle. For instance speed reduction is sent by the vehicle.	
Comments	Some links with SP4_UC_RearEndCollision – 5a	

3.2.7. Safety margin assistant on black spots – tunnels – 6b

Case Name	Safety Margin Assistant on black spots - tunnels
Case ID	SP4_UC_SpeedAndDistance – 6b
Status	Final - V1.1
Short description	Driver of vehicle V1 gets speed recommendations before approaching and inside a tunnel from two possible specific sources: the infrastructure, with specific sensing and communication capabilities in order to recommend the proper distance to keep from the vehicle in front, or directly through V2V communication, from vehicle in front (V2). 
Purpose	To help driver of vehicle V1 keeping the proper speed and distance from the vehicle preceding.
Rationale	Even though the scenarios related to tunnels have been widely faced in other projects, the safety margin assistance on black spots – like tunnels - is of specific relevance as a reference of the SAFESPOT concept.
Authors	MMSE – Luciano Picerno – V1.0
Level	Level of priority: 3
Driving environment	Black spots on any type of road
Vehicle probe type	Vehicle, ptw, truck
Risk's source	- Small safety distance / not obeying of the speed recommendations – especially in black spots like tunnels – may be retained as major sources of risk for front-to-back collisions - No GPS reception inside a tunnel. The accuracy of the positioning can be reduced.
Successful end condition	Driver of vehicle V1 gets timely information on the speed and distance to keep in the given scenario
Failed end condition	Failed or not timely information is delivered to driver of vehicle V1

Trigger	1. The infrastructure, by means of specific sensing and communication equipment, delivers timely information about the speed and the distance to keep from the vehicle preceding 2. Vehicle V2, by means of V2V communication, deliver its position and speed to vehicle V1, where the safety margin assistant evaluates and present to the driver information about the proper speed and distance to keep from the vehicle in front	
Frequency of occurrence	Always, in the specific black spot (tunnel scenario)	
Primary Actor	Driver of V1, who is the primary receiver and handler of the speed recommendation	
Secondary Actor(s)	Driver of other vehicles, following V1	
Scenario Description	**Step**	**Action**
	1	Infrastructure detects speeds and relative distance between V1 and V2
	2	Infrastructure sends this information to vehicle V1
	3	Vehicle V1 receives information
	4	Driver of vehicle V1 is informed about the status of vehicle in front; speed and distance recommendations are given.
Exceptions	**Step**	**Action**
	1a	Variant: UC is implemented by V2V communication and no information is provided by the infrastructure
	2a	Variant: vehicle V2 sends its position and speed to vehicle V1
Super ordinates		
Subordinates		
Open issues	To be checked if the UC can be implemented in the foreseen test sites; other types of black spots can demonstrate the same concept instead.	
Comments		

3.2.8. Safety margin assistant on black spots – reduction of lanes – 6c

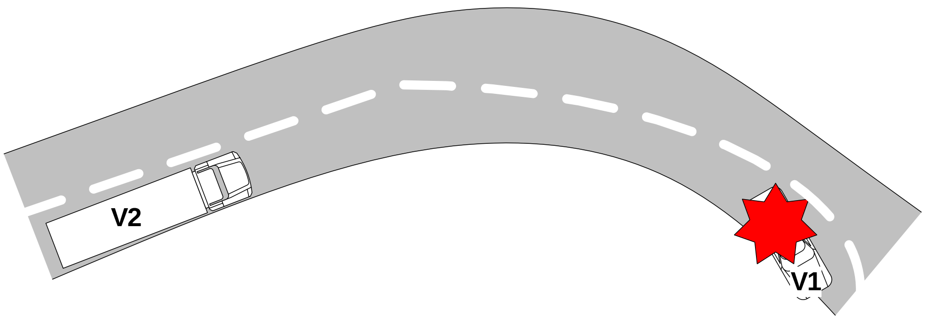
Case Name	Safety Margin Assistant on black spots – reduction of lanes
Case ID	SP4_UC_SpeedAndDistance – 6c
Status	Final - V1.1
Short description	Driver of vehicle V1 gets speed recommendations in a black spot where (for road works or due to the road morphology) the number of lanes gets reduced. In this type of condition, where the risk of accident is very high, it may be assumed the infrastructure is equipped with specific devices enabling the direct communication to vehicle V1 of the very dangerous situation. As alternative, a similar functionality may be obtained through V2V communication, from vehicle in front (V2), assuming lane geometry information is recovered through navigation or lane position sensing. 
Purpose	To help driver of vehicle V1 being timely informed of reducing its speed in order to keep the safety distance from the vehicle preceding.
Rationale	In order to cover scenarios which are potentially very dangerous, in black spots generated by road works (lane reduction) or road morphology.
Authors	MMSE – Luciano Picerno – V1.0
Level	Level of priority: 1
Driving environment	Black spots generated by lane reduction on any type of road, especially on highways
Vehicle probe type	Vehicle, ptw, truck
Risk's source	The reduction of lanes may lead to change quickly the actual driving maneuvers (an overtaking in the pictogram) and behavior. Into these circumstances the risk of longitudinal and lateral impacts are relevant.
Successful end condition	Driver of vehicle V1 gets timely information on the speed and distance to keep in the given scenario. In the pictogram, the overtaking manoeuver, just started, is aborted.
Failed end condition	Failed or not timely information is delivered to driver of vehicle V1

Trigger	1. The infrastructure, by means of specific communication equipment, delivers timely information about the reduction of number of road lanes to vehicle V1 2. As alternative, vehicle V2, by means of V2V communication, deliver its position and speed to vehicle V1, where the safety margin assistant evaluates and present to the driver information about the proper speed and distance to keep from the vehicle in front; in case V2 is equipped with lane position sensors, information regarding the reduction of number of lanes is also delivered to V1	
Frequency of occurrence	Very frequent, in the specified situations (e.g. road works in highways)	
Primary Actor	Driver of V1, who is the primary receiver and handler of the speed recommendation	
Secondary Actor(s)	Driver of other vehicles, approaching the same black spot	
Scenario Description	**Step**	**Action**
	1	Infrastructure is equipped with specific communication devices for supporting vehicles approaching to the black spot
	2	Infrastructure sends information related to the presence of vehicle V2 and to the reduction of number of lanes to vehicle V1
	3	Vehicle V1 receives information
	4	Driver of vehicle V1 is informed about the status of vehicle in front; speed and distance recommendations are given. In the scenario showed in the pictogram, the overtaking manoeuvre is aborted.
Exceptions	**Step**	**Action**
	1a	Variant: UC is implemented by V2V communication and no information is provided by the infrastructure
	2a	Variant: vehicle V2 sends its position and speed to vehicle V1
	2b	Variant: in case vehicle V2 is equipped of lane position sensors, also information about the reduced number of lanes is delivered to vehicle V1 through direct V2V communication
Super ordinates		
Subordinates		
Open issues	To be checked if the UC can be implemented in the foreseen test sites; other types of black spots can demonstrate the same concept instead.	
Comments		

Three Use Cases are proposed for the Frontal Collision Warning application:

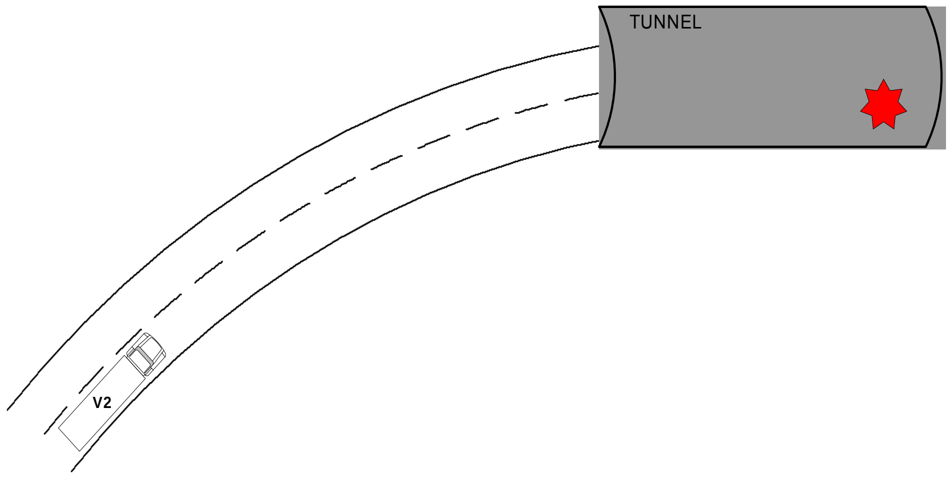
- Frontal collision warning due to static obstacle in front;
- Frontal collision warning due to static obstacle in a tunnel;
- Frontal collision warning due to abnormal vehicle behaviour in front.

3.2.9. Frontal collision warning due to static obstacle in front – 7a

Case Name	Frontal collision warning due to static obstacle in front
Case ID	SP4_UC_FrontalCollisionWarning – 7a
Status	Final - V2.1
Short description	This scenario aims to inform and/or warn truck driver about the presence of a static obstacle in front. 
Purpose	Inform or/and warn the driver in order to anticipate the vehicle deceleration cause by static obstacle on the road in front. It can be for instance due to accident or a vehicle breakdown…
Rationale	Radar or Lidar sensor performances are limited (distance around 200 meters), and in some cases, the driver can not be informed enough in advance about a risk in front. For instance, sensor performances can be limited if an accident occurs after a curve or due to bad weather conditions. Better anticipation for trucks is important to safely stop the vehicle.
Authors	Volvo – Laurent Jacques
Level	Level of priority: 2
Driving environment	Any road. Perhaps not efficient in urban area
Vehicle probe type	Truck, motorcycle, vehicle
Risk's source	Wrong , missing or delayed communication from V2V or V2I
Successful end condition	The driver is informed in time about the presence of a static obstacle in front. He is able in time to adapt his behaviour to the new situation.
Failed end condition	- The vehicle V1 is on a degraded condition (crashed for instance), and the SAFESPOT system is not able to send any information - The driver receives the information too late about an obstacle in front

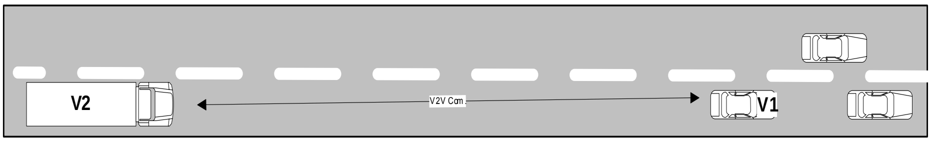
Trigger	Obstacle detection	
Frequency of occurrence	Not very frequent in numerical terms, but very dangerous	
Primary Actor	V2	
Secondary Actor(s)	V1 Others vehicles Infrastructure (?)	
Scenario Description	**Step**	**Action**
	1	A static obstacle is detected on the road and represents a risk for other vehicles
	2	The SAFESPOT system sends the information relative to the obstacle to approaching vehicles.
	3	From V2, the SAFESPOT system analyses the information and is able to identify if there is a risk for the driver.
	4	The truck driver is warned about the situation
Exceptions	**Step**	**Action**
	2	The vehicle is not able to send the information to other vehicle
	4	Other vehicle concerned by the collision or just behind (to be defined) can be informed or/and warned
Super ordinates		
Subordinates		
Open issues	- Vehicles can receive the information coming from infrastructure and/or vehicle. - Does the SAFESPOT system is able to send any information if engine is stopped?	
Comments	The source of information can be both: - The vehicle which is stopped on the road has the possibility to send the information to others vehicle. (Does the SAFESPOT system able to send information if the engine is stopped?) - The infrastructure is informed by the accident position and description. In this case, the infrastructure sends the information to vehicles. (cameras in motorways and tunnels, accident detection, stopped vehicle detection…) The location and description of the obstacle is important and can influence on the driver behavior. Position, lane obstructed, fixed or moving, vehicle in fire…	

3.2.10. Frontal collision warning due to static obstacle in a tunnel – 7b

Case Name	Frontal collision warning due to static obstacle in a tunnel
Case ID	SP4_UC_FrontalCollisionWarning – 7b
Status	Final - V1.1
Short description	This scenario aims to inform and/or warn truck driver about an abnormal obstacle in a tunnel 
Purpose	Inform or/and warn driver about static obstacle in a tunnel. This obstacle can be due to stopped traffic or obstacle on the road. The driver is able to anticipate the deceleration in order to avoid a risk of collision.
Rationale	Accidents in tunnel are not frequent but the severity is high. Some tunnel specificities can be mentioned: - The visibility in a tunnel is reduced at the entrance due to the strong difference of brightness. - The visibility is reduced in the curve due to the wall on the side. - The presence of object on the road is critical in this environment
Authors	Volvo – Laurent Jacques
Level	Level of priority: 2
Driving environment	Tunnel
Vehicle probe type	Truck, motorcycle, vehicle
Risk's source	No GPS reception inside a tunnel. The accuracy of the positioning can be reduced. Objects are detected by the infrastructure and the information of its position has to be good. (witch lane, position from the entrance)
Successful end condition	The driver is informed in time about the presence and the position of a static obstacle in front. He is able in time to adapt his behaviour to the new situation.

Failed end condition	Lack of accuracy in obstacle positioning can ensure a non efficient safety recommendation to the driver Lack of accuracy in vehicle positioning can ensure a non efficient safety recommendation to the driver Failed communication link	
Trigger	A vehicle can itself detect as stopped in a tunnel as an abnormal situation. Tunnel infrastructures are well equipped with sensors like cameras to detect some incident in their area.	
Frequency of occurrence	Quite rare in numerical terms, but extremely dangerous	
Primary Actor	V2	
Secondary Actor(s)	Other vehicles Infrastructure	
Scenario Description	**Step**	**Action**
	1	A static obstacle is detected in the tunnel and represents a risk for other vehicles
	2	The SAFESPOT system sends the information relative to the obstacle to vehicles approaching
	3	From V2, the SAFESPOT system receives, analyses the information and is able to identify if there is a risk for the driver.
	4	The truck driver is warned about the situation
Exceptions	**Step**	**Action**
	2	If the obstacle is an object, the infrastructure sends the information to vehicles. If the obstacle is a vehicle, it's the vehicle who send the information to other vehicles
	2	The vehicle is not able to send the information to other vehicle
Super ordinates		
Subordinates		
Open issues	To be classified with type of events can be detected and sent by the infrastructure and by the vehicle.	
Comments	Link with SP4_UC_FrontalCollisionWarning – 7a	

3.2.11. Frontal collision warning due to abnormal vehicle behaviour in front – 7c

Case Name	Frontal Collision Warning due to abnormal vehicle behaviour in front
Case ID	SP4_UC_FrontalCollisionWarning – 7c
Status	Final - V1.1
Short description	This scenario aims to inform and/or warn truck driver about a strong deceleration or more generally abnormal behavior in front. 
Purpose	The goal is to inform or/and warn driver that there is a vehicle potentially dangerous in front
Rationale	Not only speed limitation will determine your speed or behavior on a road. You will have also to make attention to the behavior of other vehicle in front of you. Braking operation, zigzag driving, non constant speed… will have to be taken into account to adapt and define your behavior (speed reduction, lane change…)
Authors	Volvo – Laurent Jacques
Level	Level of priority: 2
Driving environment	Any road.
Vehicle probe type	Truck, motorcycle, vehicle
Risk's source	
Successful end condition	The driver is informed in time about the potentially dangerous obstacle in front. He is able in time to adapt his behaviour to the new situation.
Failed end condition	Failed communication link
Trigger	Events detection that can highlight abnormal behavior can come from vehicle sensor or infrastructure sensor.
Frequency of occurrence	Very frequent, especially in relation with highway congestions
Primary Actor	Vehicle 2
Secondary Actor(s)	Vehicle 1 Other vehicles behind V2

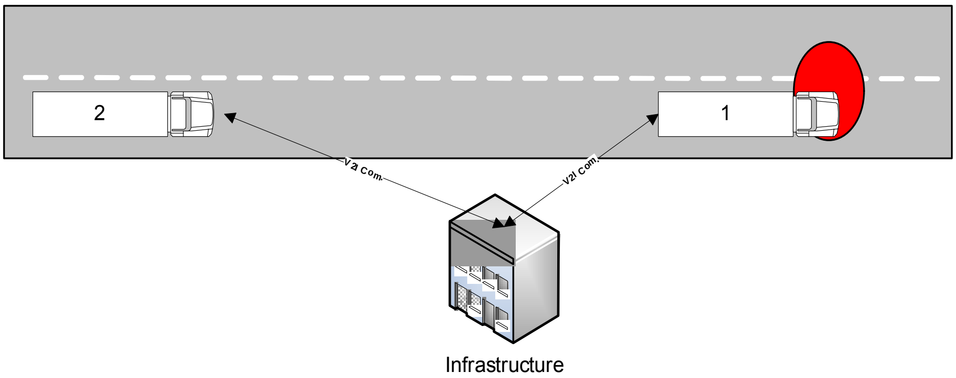
Scenario Description	**Step**	**Action**
	1	An abnormal behaviour is detected in V1
	2	V1 sent the information to other vehicles
	3	From V2, the SAFESPOT system analyses the information and is able to identify if there is a risk for the driver.
	4	From V2, the truck driver is warned about the situation
Exceptions	**Step**	**Action**
	2	The information can be sent by the infrastructure if it detects this event (in some case)
Super ordinates		
Subordinates		
Open issues	To be classified with type of events can be detected and sent by the infrastructure and by the vehicle. For instance speed reduction is sent by the vehicle.	
Comments	Some existing systems have been developed in previous projects and allow to identify some abnormal behavior (lane tracking, speed monitoring, drowsiness…)	

3.3. Use Cases for the RODP cluster

Two Use Cases are presented regarding the Road Condition Status – Slippery Road application:

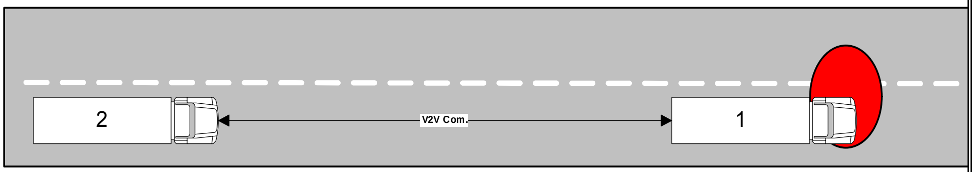
- Road Condition Status – V2I Based;
- Road Condition Status V2V Based.

3.3.1. Road condition status – V2I based - 8a

Case Name	Road Condition Status – V2I Based
Case ID	SP4_UC_RoadConditionStatusV2I – 8a
Status	Final - V2.1
Short description	This scenario aims to inform and/or the driver in V2 about the road condition status detected by V1. The data is transferred via a road control center. 
Purpose	The driver in V2 shall be informed about the road condition status measured by V1 so that the driver of V2 can be informed about the current road condition. The infrastructure (road monitoring centre) is collecting and analysing the information.
Rationale	The infrastructure (road monitoring centre) can enhance the information on the road condition by taking into account information from several vehicles as well as incorporating other data such as weather data. The infrastructure is also monitoring the road condition by listening to the V2V communication between the vehicles.
Authors	Volvo – Andreas Ekfjorden
Level	Level of priority: 2
Driving environment	Any type of road
Vehicle probe type	Truck, motorcycle, vehicle
Risk's source	Roads with low friction (low μ-estimate) may result in accidents (the road is slippery) if the speed and driving style is not adopted correctly.
Successful end condition	Information on road condition is transferred to the infrastructure and is transmitted back to V2 Information is presented to the driver in V2.

Failed end condition	The data is not correctly measured. The information is not transferred to the infrastructure. The data is not sent to V2.	
Trigger	Low friction is detected by V1	
Frequency of occurrence	Unknown	
Primary Actor	Vehicle V1 SAFESPOT system	
Secondary Actor(s)	Driver of V2. Infrastructure road control center.	
Scenario Description	**Step**	**Action**
	1	The road condition is measured by V1 sensors
	2	The friction estimate is sent to the infrastructure
	3	The infrastructure evaluates the information (the data shall not be too old, shall be verified etc)
	4	The infrastructure broadcasts the information
Exceptions	**Step**	**Action**
	4b	The information from the infrastructure is received by V2
	5b	SAFESPOT system in V2 evaluates how the driver shall be informed about the road condition.
Super ordinates		
Subordinates		
Open issues	The classification on the road condition status (type of estimate)	
Comments		

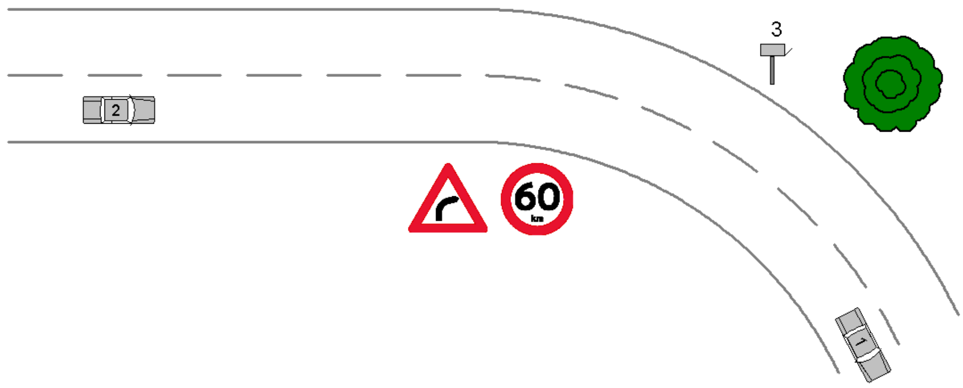
3.3.2. Road Condition Status – V2V Based – 8b

Case Name	Road Condition Status V2V Based
Case ID	SP4_UC_RoadConditionStatusV2V – 8b
Status	Final - V2.1
Short description	This scenario aims to inform and/or the driver in V2 about the road condition status detected by V1. The road condition is here described as a μ-value. 
Purpose	The driver in V2 shall be informed about the road condition status measured by V1 so that the driver of V2 can be informed.
Rationale	Scaring among road users information on the road status by means of V2V communication
Authors	Volvo – Andreas Ekfjorden
Level	Level of priority: 2
Driving environment	Any type of road
Vehicle probe type	Truck, motorcycle, vehicle
Risk's source	Roads with low friction estimate may result in accidents (the road is slippery) if the speed and driving style is not adopted correctly.
Successful end condition	Information on road condition is presented to the driver of V2.
Failed end condition	The data is not correctly measured. The information is not sent to V2.
Trigger	Low friction is detected by V1
Frequency of occurrence	Unknown
Primary Actor	Vehicle V1 SAFESPOT system
Secondary Actor(s)	Driver of V2.

Scenario Description	**Step**	**Action**
	1	The road condition is measured by V1 sensors
	2	The friction estimate is sent to V2
	3	SAFESPOT system in V2 evaluates how the driver shall be informed about the road condition.
Exceptions	**Step**	**Action**
Super ordinates		
Subordinates		
Open issues	Unknown	
Comments	Link with SP4_UC_Road condition status V2I based – 8a	

One Use Case is proposed for the Curve Warning application: Curve Warning in rural black spots, based on a transponder in the infrastructure keeping memory of the speeds adopted by passing vehicles.

3.3.3. Curve warning in rural black spots – 9a

Case Name	Curve Warning in rural black spots, based on a transponder in the infrastructure keeping memory of the speeds adopted by passing vehicles.
Case ID	SP4_UC_CurveWarning – 9a
Status	Final - V1.1
Short description	Host vehicle (1) transmits to an infrastructure transponder (3) its speed and (possibly) other vehicle dynamics information. In a second time a vehicle approaching to the rural black spot (2) receives this information, adapting its speed depending on multiple parameters, including map and navigational information, if available, and the behavior of other vehicles. 
Purpose	By the broadcasting of information from the host-vehicle, also a vehicle approaching a sharp curve without any digital maps or other navigation systems installed on-board, can travel inside the curve safely (with the suggestion of reference speed to keep) On the other hand, if the vehicle is already equipped with digital maps, the information of how other vehicle behold in the same situations can help to reduce the number of false and missing alarms.
Rationale	To avoid (or reduce) the accidents due to too high speed in approaching a sharp curve
Authors	CRF – E. Bianco, F. Tango, F. Vernacchia, G. Vivo – V1.0
Level	Level of priority: 3
Driving environment	Motorways and rural roads
Host-vehicle type	Truck, motorcycle, vehicle
Risk's source	Wrong , missing or delayed communication from V2V or V2I
Successful end condition	Driver is informed timely of the sharp curve Vehicle is entering the curve with the right speed

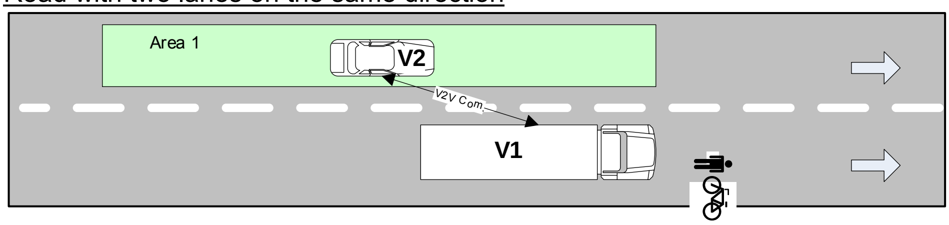
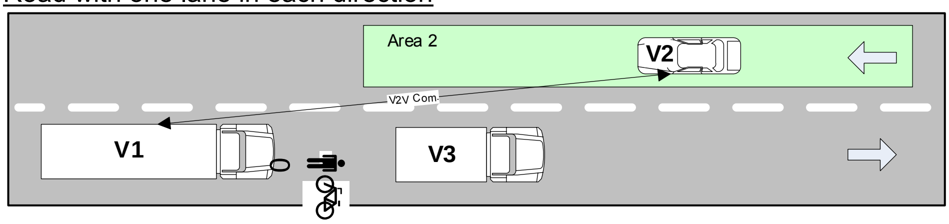
Failed end condition	Driver is not informed timely of the sharp curve Vehicle is not entering the curve with the right speed	
Trigger	Detection of sharp curve (from another vehicle passing or form infrastructure) Availability of communication (with the related information) Host-vehicle approaches the curve (too fast)	
Frequency of occurrence	Unknown	
Primary Actor	Ego-vehicle	
Secondary Actor(s)	Others vehicles and infrastructure	
Scenario Description	**Step**	**Action**
	1	Probe-vehicle is passing through the curve and transmits safe-speed information to the infrastructure
	2	Infrastructure receives, stores and transmits the information
	3	Host-vehicle is approaching the sharp curve too fast
	4	Host-vehicle receives the information
	5	Host-vehicle adapts the speed to the external condition
Exceptions	**Step**	**Action**
	3a	Vehicle uses information only if appropriate (probe vehicle is a motorbike, ego-vehicle is a truck)
Super ordinates	<Insert the name of any use case(s) that includes the current use case>	
Subordinates	<Insert name of any use case(s) used by the current use case>	
Open issues	Unknown	
Comments	<Insert any comments on the contents of the use case>	

3.4. Use Cases for the VURU cluster

The Vulnerable Road User Detection and Accident Avoidance function is the single function belonging to the VURU cluster of applications. For this application three Use Cases are proposed (first two belonging to the same situation related to the VRU crossing a road):

- Vulnerable road users crossing a road, based on on-board detection system;
- Vulnerable road users crossing a road, based on environment analyses;
- Vulnerable road users in blind spots of a truck.

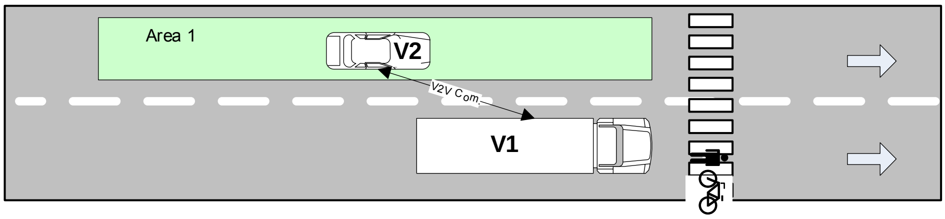
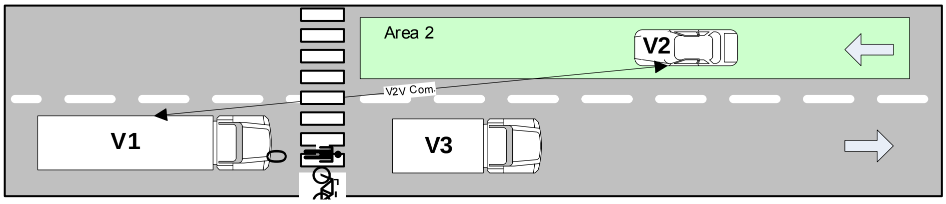
3.4.1. Vulnerable road users crossing a road, based on on-board detection system – 10a-1

Case Name	Vulnerable road users crossing a road, based on on-board detection system
Case ID	SP4_UC_VRUAccidentAvoidance – 10a-1
Status	Final - V1.2 (The final version of UC10a has been divided on two new different UC)
Short description	This scenario aims to inform/warn/recommend vehicle driver about the presence of a vulnerable road user who is crossing a road. The vehicle V1 is equipped with an on-board VRU detection system. A VRU is not detected by the driver V2 because due to the bad visibility: hidden by a vehicle (V1 or V3) or due to bad weather condition <u>Road with two lanes on the same direction</u>  <u>Road with one lane in each direction</u> 
Purpose	Avoid collision between vehicle and vulnerable road user (VRU), for instance pedestrian or bicycle
Rationale	Especially in urban and extra-urban roads with two or more lanes, the presence of vulnerable road user can be not detected by other vehicle drivers (V2) which are approaching. Several reasons for this: - VRU are hidden by a vehicle (especially bus and trucks) - There is bad visibility like sun reflection, bad weather, or just during the night.

Authors	Volvo – Laurent Jacques Renault SA – Javier Ibanez-Guzmàn	
Level	Level of priority: 2	
Driving environment	Urban and Inter-urban area Road with several lanes on the same direction, one lane in each direction. Are excluded from this use case, VRU in motorway This scenario can take place near a pedestrian crossing area or not This scenario can take place near a bicycle crossing area or not This scenario can take place near an intersection or not	
Vehicle probe type	V1: Truck, Bus, Car, PTW V2: Truck, Bus, Car, PTW	
Risk's source	The main risk is the reliability of the VRU detection system and the area covered.	
Successful end condition	The vehicle V2 driver is informed in time about the presence of a VRU in front that represent a possible risk of collision. He is able in time to adapt his behaviour.	
Failed end condition	- The vehicle V1 does not detect the VRU - The driver receives the information too late about a VRU presence in front	
Trigger	The detection of pedestrian is done by a VRU detection system embedded on V1. In this case, it can be VRU on or off the pedestrian crossing. It can be on or off an intersection. Constraints are due to the performance of the system: area covered maximum vehicle speed, detection of static or in motion obstacle…	
Frequency of occurrence	Most of pedestrian accidents are in urban and inter-urban areas. The location of the collision is not always on the zebra crossing.	
Primary Actor	Vehicle V1	
Secondary Actor(s)	Vehicle V2 VRU	
Scenario Description	**Step**	**Action**
	1	Using on board detection system, Vehicle V1 detect the presence of VRU on the road. The driver of V1 is informed about the situation (this is not part of SAFESPOT)
	2	The V1 SAFESPOT system broadcast information about; Its position and the position of the VRU
	3	The V2 SAFESPOT system receives the information and analyses the safety margin regarding some parameters: - V2 position and distance from the V1 and VRU, V2 speed
	4	The SAFESPOT system informs/warns/recommends the driver if a risk is identified.

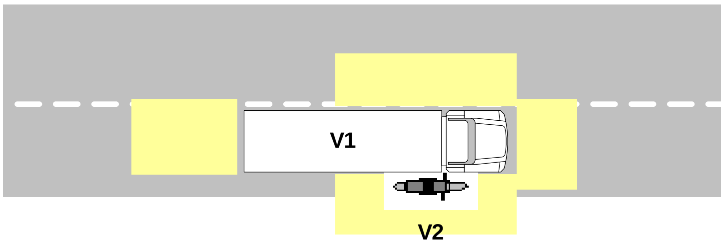
Exceptions	**Step**	**Action**
	1	The infrastructure is able to have some sensors in sensitive area like intersections and bus stop. It can broadcast information on the position of VRU to vehicle approaching the area. In this case, the infrastructure has to provide information that is relative to a risk. For instance, the pedestrian is crossing the road. There is no interest to know that there is a pedestrian on the sidewalk. (This alternative solution is more part of SP5 and can be an interesting alternative demonstration on the test site).
	2	The detection can be performed by the vehicle V3. Some system equips the back of vehicle to detect some obstacle.
Super ordinates		
Subordinates		
Open issues	Performance of the on board detection system to be defined (area covered, detection of static and in motion objects…). Alternative solution: Performance of the infrastructure detection system to be defined.	
Comments	The detection of the vulnerable road user by the vehicle and information to the truck driver is not part of SAFESPOT. Some existing on board detection systems have been developed in previous projects and can be used here.	

3.4.2. Vulnerable road users crossing a road, based on environment analyses – 10a-2

Case Name	Vulnerable road users crossing a road, based on environment analyses
Case ID	SP4_UC_VRUAccidentAvoidance – 10a-2
Status	Final - V1.2 (The final version of UC10a has been divided on two new different UC)
Short description	This scenario aims to inform/warn/recommend vehicle driver about the presence of a vulnerable road user who is crossing a road and is hidden by a vehicle. The vehicle V1 is not equipped with a detection system. The approach from V2 is to analyze the vehicle environment and <u>deduce</u> that there is a possible risk due to VRU presence. <u>Road with two lanes on the same direction</u>  <u>Road with one lane in each direction</u> 
Purpose	Avoid collision between vehicle and vulnerable road user (VRU), for instance pedestrian or bicycle
Rationale	Especially in urban and extra-urban roads with two or more lanes, the presence of vulnerable road user can be not detected by other vehicle drivers (V2) which are approaching. Several reasons for this: - VRU are hidden by a vehicle (especially bus and trucks) - There is bad visibility like sun reflection, bad weather, or just during the night.
Authors	Volvo – Laurent Jacques Renault SA – Javier Ibanez-Guzmàn
Level	Level of priority: 2
Driving environment	Urban and Inter-urban area Road with several lanes on the same direction, one lane in each direction. Are excluded from this use case, VRU detection in motorway This scenario can take place near a zebra crossing This scenario can take place near a bicycle crossing This scenario can take place near an intersection
Vehicle probe type	V1: Truck, Bus, Car, PTW V2: Truck, Bus, Car, PTW

Risk's source	Some false alert can be observed. This approach is based on the hypothesis that a vehicle V1 decelerate or stops just before an area reserved to pedestrian or bicycle, it can be a due to the presence of VRU. This is a possibility but it can also be for another reason.	
Successful end condition	The vehicle V2 driver is informed in time about the presence of a VRU in front that represent a possible risk of collision. He is able in time to adapt his behaviour.	
Failed end condition	The environment analyse is wrong and it will generate a false alert. The driver receives the information too late about a VRU presence in front	
Trigger	There is no detection system in V1, so the approach is to analyze the vehicle environment and deduce that there is a possible risk of a presence of VRU. For instance, the algorithms can be: - V1 decelerate and stop just before a zebra or bicycle crossing –> there is a risk - V1 decelerate and stop near a zebra or bicycle crossing at an intersection. The traffic light for the V1 and V2 is green -> there is a risk - V1 decelerate and stop near a zebra or bicycle crossing, an intersection is also detected at this location and traffic light is red -> there is no specific risk, it is a normal situation	
Frequency of occurrence	Most of pedestrian accidents are in urban and inter-urban areas. The location is not always on the zebra crossing, so this approach will not cover all the case.	
Primary Actor	Vehicle V1	
Secondary Actor(s)	Vehicle V2 VRU	
Scenario Description	**Step**	**Action**
	1	V1 decelerate and/or stop and broadcast information about its position, speed….
	2	V2 receive this information and request its on board information (map) - Is there a pedestrian crossing in front of the vehicle V1? - Is there an intersection in front of the driver? - What is the status of the traffic light?
	3	V2 analyses the safety margin regarding the situation
	4	The SAFESPOT systems informs/warns or recommends the driver
Exceptions	**Step**	**Action**
	1	V1 can also request its map and broadcast information on zebra crossing presence, intersection, traffic light status. This alternative option is interesting if V2 is not equipped with map data but only GPS and communication platform. It depends if we consider different type of SAFESPOT equipments on the vehicle
	2	As exception 1, V2 can receive all the relevant information and don't need information from his map.
Super ordinates		
Subordinates		
Open issues		
Comments		

3.4.3. Vulnerable road users in blind spots of a truck – 10b

Case Name	Vulnerable road users in blind spots of a truck
Case ID	SP4_UC_VRUAccidentAvoidance – 10b
Status	Final - V1.2
Short description	This scenario aims to inform and/or warn truck driver (V1) about the presence of a VRU (V2) in a blind spot of a truck. Both vehicles are equipped with SAFESPOT systems. This scenario occurs at low speed during manoeuvres. Three examples can be interesting: - Truck is stopped and the driver aims to go on. A VRU is just in front of the vehicle, the driver is warned about the situation - Truck is stopped and driver aims to go reverse. A VRU is just at the back of the vehicle, the driver is warned about the situation. - Trucks at low speed turn right or left. A VRU is just in the side of the vehicle, the driver is warned about the situation. 
Purpose	Avoid accident due to blind spot around the truck
Rationale	Trucks have large blind spots on the side, back and in front. There is a safety interest to evaluate such concept based on cooperation between vehicles equipped with SAFESPOT system. Level of priority: 2
Authors	Volvo – Andreas Ekfjorden – Laurent Jacques
Level	
Driving environment	Urban and inter-urban
Vehicle probe type	V1: Truck, Bus V2: Car, motorcycle
Risk's source	Time latency has to be very short. The driver could be warned too late. Restriction because we only consider V1 and V2 equipped with SAFESPOT system
Successful end condition	The driver of V1 is informed in time about the presence of a VRU and can wait until it safe to make a manoeuvre.
Failed end condition	The driver of V1 is not informed on presences of a VRU
Trigger	The trigger could be: - The vehicle is stopped and the driver changes gear to go reverse or go on. - The driver uses turn indicator or turn steering wheel

Frequency of occurrence		
Primary Actor	Truck or bus Driver (V1)	
Secondary Actor(s)	VRU (V2) (Car or and Motorcycle)	
Scenario Description	**Step**	**Action**
	1	Vehicle deceleration or slow speed (before a manoeuvre) and approach of vehicle V2 near V1 can be used as a first trigger to broadcast V2 position to V1
	2	One of the trigger defined above is detected (see trigger field)
	3	The driver of V1 is informed/warned about the presence of a VRU with its location is indicated.
Extensions	**Step**	**Action**
		See open issue as an alternative approach.
Super ordinates		
Subordinates	Can be linked to UC Lane Change Manoeuvre for Trucks	
Open issues	The short reaction time is critical in this use case. The first approach is to start broadcast V2 position before a detection of manoeuvre from V1. So if we detect a start of manoeuvre from V1, the indication of V2 position will be already available in V1 system and the time needed to warn the driver will be shorter. This first approach is the one described in the scenario description. The second approach is to detect a start of manoeuvre from V1 and so request the V1 position. The time needed before warn the driver will be longer. This approach could be considered as an alternative approach.	
Comments		

4. Conclusions

Use Cases produced inside the SP4 subproject of SAFESPOT have been presented, and the method used to build up these UC has been described.

In the adopted approach, cross checks and common evaluations have been carried out in order to generate consistent UC among all of the SP in charge for the purpose inside SAFESPOT (i.e. SP1, SP4 and SP5). From the perspective of SP4, these UC are related to precise sample scenarios, representing the expected way of handling potentially critical situations, for the specific vehicle based applications to develop inside SP4.

Major reason for the production of the SP4 UC has been the possibility to apply a standardized process, based on solid criteria, leading to the system requirements – and in a following step, to the specifications - for the applications to develop. The process adopted in the compilation of the collected UC is based on an incremental approach, starting from the collection of the basic user needs, and making explicit – with clear samples and pictograms – the expected behaviors in the given road scenarios.

This way the parameters of the system under development (functional and contextual) are evidenced, in terms of examples enabling the deployment of the proper behaviors in each one of the SP4 applications.

Twenty eight UC have been presented, covering situations of particular relevance for each one of the ten applications addressed in the subproject. The density of the selected UC (as a reference please note that six out of twenty height are related to intersection scenarios) reflects out-comings where accidentology data indicates an higher impact in terms of expected benefits for the road safety.

Next steps after this deliverable, that are enabled by the availability of the SP4 UC, are the building up of requirements for the SP4 applications, and the start of the activities related to the application specification phase. Finally, a specific care is recommended on the manner in which the UC of the present document will be selected (and exploited) in the future activities of SAFESPOT, highlighting the most promising candidates for the implementation into the SAFESPOT test sites.

5. References

SAFESPOT project deliverables of specific relevance

SP1 – SAFEPROBE → D1.2.1 Vehicle Probe Use Cases and Test Scenarios
SP3 – SINTECH → D3.2.1 Technical Scenario Description for Positioning, Local Dynamic Maps and Vehicle Ad Hoc Networks
SP4 – SCOVA → D4.2.1 Actual safety application V2V based
SP5 – COSSIB → D5.2.1 Definition of use case and user requirements
→ D5.2.4 Accident data review and potential impact of each function

Web Sites, world wide references on road safety

http://europa.eu.int/information_society/activities/esafety/index_en.htm

http://www.dot.gov/safety.html

http://www.mlit.go.jp/english/

Web Sites, references on Use Cases

http://alistair.cockburn.us

http://midwatch.org/design/ucindex.html

www.UseCases.org

http://www.pols.co.uk/use-case-zone/index.html

www.ForUse.com

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Wirfs-Brock, R., Wilkerson, B., and Wiener, L., Designing Object-Oriented Software, Prentice Hall, 1990.

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Constantine, L., Lockwood, L., Design for Use, Addison Wesley, 1999.

Armour, F., Miller, G., Advanced Use Case Modeling: Software Systems, Addison Wesley, 2000.

Cockburn, A., Writing Effective Use Cases, Addison-Wesley, 2000.

Kulak, D., Guiney, E., Use Cases: Requirements in Context, Addison Wesley, 2000.

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Jacobson, I., "Object oriented development in an industrial environment," OOPSLA '87: Object-Oriented Programming Systems, Languages and Applications. ACM SIGPLAN, pp. 183-191.

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