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Road vehicles — Extended Vehicle (ExVe) time critical applications — General requirements, definitions and classification methodology of time-constrained situations related to Road and ExVe Safety (RExVeS)

Véhicules routiers — Applications temps critiques du véhicule étendu (ExVe) — Exigences générales, définitions et méthodologie de classification des situations sous contrainte de temps liées à la sécurité routière et à la sûreté du véhicule étendu (RExVeS)

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Foreword

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This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 31, *Data communication*.

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Introduction

Preventing death and serious injury in road traffic crashes is a global priority. With the advent of vehicular data communications, road vehicles become connected vehicles, and safety is one of the key issues in the development of such road vehicles. ISO 26262-1 defines the vehicle safety as the absence of unreasonable risks that arise from malfunctions of the E/E system. The absence of unreasonable risk due to these potentially hazardous behaviours related to specific limitations (identified in ISO/PAS 21448[7]) is defined as the safety of the intended functionality (SOTIF). Functional safety (addressed by the ISO 26262 series) and SOTIF are distinct and complementary aspects of safety.

This document defines a complementary methodology for the prioritization of safety-related external communication use-cases to help to design extended vehicle time-critical interfaces described in the ISO 20077-1.

NOTE 1 ISO 20077-1 defines the concepts and terms related to the extended vehicle (ExVe), whereas ISO 20077-2 specifies general rules and basic principles that the manufacturer of the ExVe considers when elaborating its own design method.

NOTE 2 ISO 20077-1 defines an "extended vehicle" (ExVe) as an "entity, still in accordance with the specifications of the vehicle manufacturer, that extends beyond the physical boundaries of the road vehicle and consists of the road vehicle, off-board systems, external interfaces, and the data communication between the road vehicle and the off-board systems". Road vehicles without off-board systems and road vehicles equipped with telematics units are extended vehicles.

Recent developments in the field of connected vehicles, in various parts of the world, bring hope of being able to improve road safety, e.g. by reducing the number of road fatalities through collision avoidance cooperation. Connected vehicles taking into account ISO 20077-1 and ISO 20077-2 take their part in this global effort.

Due to the limited per design embedded resources, a priority management is necessary to apply these resources to the function and request with the highest criticality.

For these connected vehicles, the use of the “ExVe time critical interfaces" is firstly associated with safety-critical functions (e.g. emergency braking, steering) that are functions for which the priorities are based on a criticality concept.

It is important that all the functions using the “ExVe time critical interfaces” take into account the capabilities of the vehicles in which they are installed.

During the design phase, the connected vehicle behaviour regarding all safety-critical situations and its interactions with the external environment should be defined. Its implementation can be based on the methodology proposed in this document.

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Road vehicles — Extended Vehicle (ExVe) time critical applications — General requirements, definitions and classification methodology of time-constrained situations related to Road and ExVe Safety (RExVeS)

1 Scope

This document defines the classification methodology of time-constrained situations and their requirements, that are to be addressed by the “ExVe time critical interfaces" described in ISO 20077-1. Time-constrained situations include safety-critical situations.

It is important for the design of the vehicle to have priority management of "ExVe time critical interface" resources in order to comply with time constrained situations requirements.

The methodology provides a classification, which determines application priorities for optimal vehicle resource allocation.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 20077-1, *Road Vehicles — Extended vehicle (ExVe) methodology — Part 1: General information*

ISO 20077-2, *Road Vehicles — Extended vehicle (ExVe) methodology — Part 2: Methodology for designing the extended vehicle*

ISO 26262-1, *Road vehicles — Functional safety — Part 1: Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 20077-1, ISO 20077-2, ISO 26262-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
road and ExVe safety
RExVeS
set of means (e.g. use cases), conditions and requirements to be considered by the “ExVe time-critical interfaces” described in ISO 20077-1, including time-constrained and *safety-critical situations* (3.4)

Note 1 to entry: The intent is to minimise risk of harm (as described in ISO 26262-1) in road safety-related situations.

Note 2 to entry: In the context of RExVeS, a use case is a set of *scenarios* (3.2) that have a common goal.

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3.2
scenario
<RExVeS> sequence of *connected vehicle* (3.11) actions, events, reactions, and interactions, in a road safety setting

3.3
time-constrained situation
<RExVeS> combination of a road safety-related *connected vehicle* (3.11) *scenario* (3.2) and RExVeS-related time constraints, in which lack of communication capability or excessive (communication) latency can lead to malfunctions or other injurious consequences

3.4
safety-critical situation
<RExVeS> combination of a road safety-related *connected vehicle* (3.11) *scenario* (3.2) and an unacceptable risk of harm

3.5
situation priority class
<RExVeS> one of six situation priority classes (P1, P2, P3, P4, P5 or P6) determined according to the severity, the probability of exposure, and the controllability associated with an evaluated *time-constrained situation* (3.3)

3.6
safety-critical situation priority class
<RExVeS> one of the four *situation priority classes* (3.5) (P3, P4, P5 or P6) determined according to the severity, the probability of exposure, and the controllability associated with an evaluated *safety-critical situation* (3.4)

3.7
time-constrained safety-related function
<RExVeS> function under strict time constraints that contributes to the achievement of safety objectives

EXAMPLE "CAM generation" (see ETSI EN 302 637-2[1]) and "BSM generation" (see SAE J2735[2] and SAE J2945[3]). "DENM generation" (see ETSI EN 302 637-3[4]) is another example of time-constrained safety-related function.

3.8
peri-vehicular
<RExVeS> near or around a vehicle

3.9
peri-vehicular data communication
<RExVeS> vehicular data communications in the geographic vicinity of a vehicle

3.10
safety-critical situation reaction time interval
<RExVeS> time interval from the detection of a *safety-critical situation* (3.4) to the broadcast to neighbouring road users at risk of an appropriate safety-critical message via *time-constrained safety-related functions* (3.7) and *peri-vehicular data communications* (3.9)

3.11
connected vehicle
<RExVeS> road vehicle using *peri-vehicular data communications* (3.9)

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4 Symbols and abbreviated terms

ADAS	Advanced Driver-Assistance Systems
BSM	Basic Safety Message
CAM	Cooperative Awareness Message
DENM	Decentralized Environmental Notification Message
ExVe	Extended Vehicle
RExVeS	Road and ExVe safety
TAI	International Atomic Time
UTC	Coordinated Universal Time

5 Conventions and guidelines for specifying RExVeS-related requirements

In this document, requirements are formalized as follow:

REQ	*Number*	**RExVeS** – *Name*
Description		

"Number" represents the individual requirement number.

"Name" is the name of requirement, if needed.

"Description" is the requirement itself.

Requirements in this document are generic and technology agnostic. No actual testing is to be done against them, but they should be used as a guide to define the technology-dependent requirements.

Some technology-dependent requirements may not enable to address all priority classes of RExVeS-related time-constrained situations (see 6.3.5).

Unless otherwise stated, the requirements in this document apply to all priority classes.

6 The RExVeS methodology

6.1 General

The RExVeS methodology brings forward means to identify and classify time-constrained situations (safety-critical or not) that are addressed by the "ExVe time critical interfaces" described in ISO 20077-1. The methodology provides an automotive-specific risk-based approach to determine the priority class of a RExVeS-related time-constrained situation. It is adapted from ISO 26262-3[5] hazard analysis and risk assessment (HARA) and enriched with systems-theoretic process analysis (STPA) insights. The major difference is that in ISO 26262-3[5], the results of the analysis are ASILs while in this document the results are time-constrained situation priority classes.

NOTE 1 The appropriate use of the RExVeS methodology is intended to fulfil RExVeS-related requirements and a set of connected vehicle design prerequisites (see Clause 7).

NOTE 2 Unless otherwise stated, in this document, connected vehicle means connected vehicle taking into account ISO 20077-1 and ISO 20077-2.

The RExVeS methodology starts with the analysis of road safety-related connected vehicle scenarios in which time-constrained situations (safety-critical or not) may occur. Then, a systematic evaluation

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of each identified time-constrained situation is performed to determine the RExVeS-related situation priority class to which it pertains. The RExVeS-related situation priority class is determined by considering severity, probability of exposure and controllability criteria.

Figure 1 provides an example of use of the RExVeS methodology in the context of the ExVe design methodology.

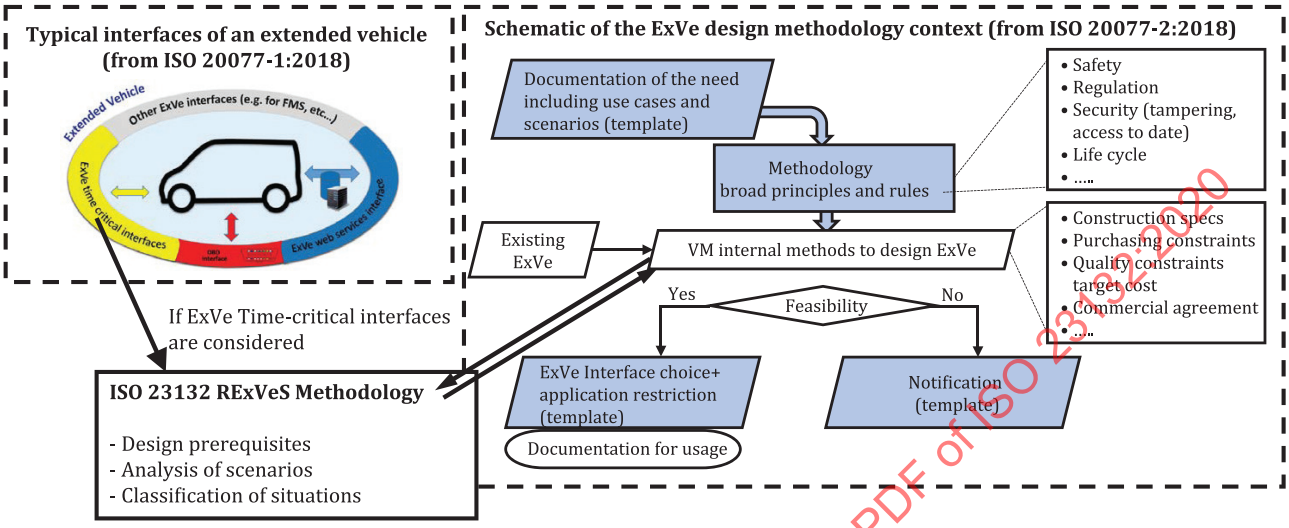

Figure 1 — The RExVeS methodology in the ExVe design methodology context (example)

The RExVeS methodology complements ISO 20077-1 and ISO 20077-2 guidelines for the design of an extended vehicle, from which a vehicle manufacturer can derive its own methods and procedures to design an extended vehicle that addresses a specific set of use cases and scenarios. These methods and procedures remain part of the know-how of each vehicle manufacturer.

According to ISO 20077-2, any ExVe functionality request is described through use cases and scenarios (see ISO 20077-2 template for technical request), in order to support a precise description of the need. Detailed descriptions of relevant RExVeS-related scenarios are important in this respect.

According to ISO 20077-2, for a given use case and scenario, the ExVe manufacturer is responsible for defining the appropriate extended vehicle's interfaces for the considered functionality (see ISO 20077-2). When an ExVe time critical interface is considered, the identified time-constrained situations can be analysed with the RExVeS methodology. As a result, the criticality of the situations is evaluated (severity, probability of exposure, controllability) and, along with any applicable regulations, it gives an indication of relevance and priority to the vehicle manufacturer considering the development of the functionality with an ExVe time-critical interface.

NOTE 3 As RExVeS-related scenarios with safety-critical situations give the biggest causes for concern, they are considered first in the methodology description and dealt with in more detail.

6.2 Analysis of RExVeS-related scenarios

Complex and dynamic processes and interactions are often involved in road accidents. RExVeS-related safety-critical situations may occur when processes or interactions do not meet safety objectives, e.g. because appropriate objectives have not been selected.

The goal of the analysis of RExVeS-related scenarios is to identify time-constrained situations (safety-critical or not) that are to be addressed by the "ExVe time critical interfaces" described in ISO 20077-1. This requires accumulating information about how such situations can occur.

A RExVeS-related time-constrained situation is a combination of a road safety-related connected vehicle scenario and RExVeS-related time constraints, in which a lack of communication capability or excessive

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(communication) latency can lead to malfunctions or other injurious consequences. In a RExVeS-related safety-critical situation, there is additionally an unacceptable risk of harm.

NOTE 1 There is not necessarily an unacceptable risk of harm in all time-constrained situations.

Rapidly changing environments where there is a potential for safety-critical situations are examples of RExVeS-related scenarios. "Imminent collision" is a characteristic of many RExVeS-related problematic scenarios. "Loss of vehicle control" is a less recurring one, but it is important to take it into account.

An imminent front collision with another vehicle at high speed on a country road is an example of a RExVeS-related safety-critical situation.

Even when the vehicle is stationary, a RExVeS-related safety-critical situation can be present if it is stopped in an unsafe location.

RExVeS-related use cases and scenarios where safety-critical situations can happen, and where a worst-case set of environmental conditions may lead to "loss of vehicle control" or "imminent collision", should be analysed before taking action.

NOTE 2 RExVeS-related use cases encompass all connected vehicle use cases (including cooperative collision avoidance use cases) where at least one RExVeS-related problematic scenario exists. As a result, RExVeS-related use cases are not limited to already identified and standardized connected vehicle and road safety use cases (in ISO, SAE, ETSI etc.). The potential applicability of RExVeS-related requirements is much broader.

NOTE 3 ISO 26262-3:2018[5], Annex B provides examples of REXVeS-related scenarios and of safety-critical situations.

Factors to be considered in the hazard analysis and risk assessment of RExVeS-related scenarios include:

— vehicle usage scenarios, for example high speed driving, urban driving, parking, off-road;

— environmental conditions, for example rain, snow, wind, road surface condition;

— reasonably foreseeable driver use and misuse;

— interactions between operational systems, particularly those implementing RExVeS-related time-constrained safety-related functions;

— cybersecurity attacks leading to malicious communications or default of the vehicle ITS station. See also ISO/SAE 21434[6][1];

— if there is an impact, timing constraints resulting from functional safety, “safety of the intended functionality” and cybersecurity activities;

— in this analysis, the vehicle and its communication capabilities are considered by default in working order. See also ISO/PAS 21448[7].

REQ	23132-01	**RExVeS** – 01
The consequences of each evaluated RExVeS-related time-constrained situation shall be identified, focusing on the harm to each person potentially at risk, including the driver and the passengers of the vehicle, but also the other persons potentially at risk such as cyclists, pedestrians or occupants of other vehicles.		

6.3 Classification of RExVeS-related time-constrained and safety-critical situations

6.3.1 Classification scheme

The classification scheme comprises the determination of the severity, the probability of exposure, and the controllability associated with the RExVeS-related time-constrained situations (safety-critical or not).

1) Under preparation. Stage at the time of publication: ISO/SAE DIS 21434:2020.

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The severity represents an estimate of the potential harm in a particular situation, while the probability of exposure depends on how frequently and for how long individuals find themselves in such a RExVeS-related scenario. The controllability rates how easy or difficult it is for the driver or other road traffic participant to avoid the considered accident type in the considered scenario. It is the intention that severity, probability of exposure and controllability estimates are consistent with those coming from functional safety activities.

NOTE Depending on the number of related hazardous events, the classification can result in one or more combinations of severity, probability of exposure, and controllability.

6.3.2 Classes of severity

The potential injuries that result from a time-constrained situation (safety-critical or not) are evaluated for the driver, passengers and people around the vehicle, or in surrounding vehicles to determine the severity class.

The severity of potential harm is estimated based on a defined rationale for each evaluated situation and is assigned to one of the severity classes: S0 (no injuries), S1 (light and moderate injuries), S2 (severe and life-threatening injuries with survival probable) or S3 (life-threatening injuries with survival uncertain or fatal injuries).

NOTE ISO 26262-3:2018[5], Annex B presents examples of consequences which can occur for a given safety-critical situation, together with the corresponding severity class for each consequence.

For instance, a pedestrian accident with low speed, that can result in severe and life-threatening injuries with survival probable, may be classified S2.

6.3.3 Classes of probability of exposure

The probability of exposure to a RExVeS-related scenario is estimated based on a defined rationale for each evaluated situation (safety-critical or not). The probability of exposure is assigned to one of the probability classes: E1 (very low probability, e.g. occurs less often than once a year for the great majority of drivers), E2 (low probability, e.g. occurs a few times a year for the great majority of drivers), E3 (medium probability, e.g. occurs once a month or more often for an average driver) or E4 (high probability, e.g. occurs during almost every drive on average).

NOTE ISO 26262-3:2018[5], Annex B presents examples of scenarios classified by duration and frequency, together with typical exposure rankings.

For instance, driving a vehicle on a wet city street with heavy "stop and go" traffic may be classified E3 (occurs once a month or more often for an average driver).

6.3.4 Classes of controllability

The controllability class for a given time-constrained situation (safety-critical or not) is determined by estimating the likelihood that representative drivers, potentially assisted by advanced driver-assistance systems (ADAS), will be able to retain or regain control of the vehicle if the situation were to occur, or that individuals in the vicinity will contribute to the avoidance of the situation by their actions.

NOTE 1 Controllability is influenced by a number of factors including use of ADAS, driver profiles for the target market, individuals' age, eye-hand coordination, driving experience, cultural background, etc.

NOTE 2 Estimations take into account local laws and regulations, as well as reasonably foreseeable misuse (e.g. not keeping the required distance to the vehicle in front).

The controllability of each evaluated situation, by the driver or other persons involved in the situation, is estimated based on a defined rationale for each situation. The controllability is assigned to one of the controllability classes: C0 (controllable in general), C1 (simply controllable, e.g. more than 99 % of the average drivers or other traffic participants are able to avoid harm), C2 (normally controllable, e.g. between 90 % an 99 % of the average drivers or other traffic participants are able to avoid harm)

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or C3 (difficult to control or uncontrollable, e.g. less than 90 % of the average drivers or other traffic participants are able to avoid harm).

NOTE 3 If class C0 is assigned, there is no requirement to assign a priority class to the evaluated situation and therefore, Table 1 does not take C0 into account.

NOTE 4 ISO 26262-3:2018[5], Annex B provides examples of driving situations and the assumptions about the corresponding control behaviours that would avoid harm. These situations are mapped to the controllability rankings, clarifying the 90 % and 99 % breakpoint levels for judging controllability.

For instance, maintaining intended driving path while being distracted may be classified C1 (simply controllable).

6.3.5 Determination of the priority class of a RExVeS-related time-constrained situation

To classify the RExVeS-related time-constrained situations (safety-critical or not), six priority classes (P1, P2, P3, P4, P5 and P6) are defined according to the risks of harm involved, with P6 representing the most stringent class (i.e. used to protect against the highest risks).

To determine the priority class of an evaluated situation, the classification of the time-constrained situation for the criteria of severity, probability of exposure and controllability is used, in accordance with Table 1.

Table 1 — Priority class determination

Severity class	Exposure class	Controllability class		
		Simply controllable (C1)	Normally controllable (C2)	Difficult to control (C3)
No injuries (S0)	Low probability (E1 or E2)	P1	P1	P1
	High probability (E3 or E4)	P2	P2	P2
Light and moderate injuries (S1)	Very low probability (E1)	P3	P3	P3
	Low probability (E2)	P3	P3	P3
	Medium probability (E3)	P3	P3	P4
	High probability (E4)	P3	P4	P4
Severe and life-threatening injuries with survival probable (S2)	Very low probability (E1)	P4	P4	P4
	Low probability (E2)	P4	P4	P5
	Medium probability (E3)	P4	P5	P5
	High probability (E4)	P5	P5	P5
Life-threatening injuries with survival uncertain or fatal injuries (S3)	Very low probability (E1)	P5	P5	P5
	Low probability (E2)	P5	P5	P6
	Medium probability (E3)	P5	P6	P6
	High probability (E4)	P6	P6	P6

A priority class gives an indication of the criticality of a given RExVeS-related time-constrained situation. The priority classes P3 to P6, also called the safety-critical situation priority classes, indicate RExVeS-related safety-critical situations.

If classification of a given RExVeS-related situation with respect to severity, probability of exposure or controllability is difficult to make, it should be classified conservatively, i.e. whenever there is a reasonable doubt, a higher classification should be chosen.

Examples of priority class assignment are described in Annexes B, C, and D.

NOTE Annex E provides a non-exhaustive list of use cases and scenarios, which can be supported by an "ExVe time critical interface".

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6.3.6 Template for the description and priority class assignment of a RExVeS-related situation

The template for the description and priority class assignment of RExVeS-related situations (including safety-critical situations) can be found in Annex A.

REQ	23132-02	**RExVeS** – 02
The description and priority class assignment of a RExVeS-related time-constrained situation shall be made using the appropriate template in Annex A.		

NOTE For further information and examples of use of the RExVeS template, see Annexes B, C and D.

7 Connected vehicle design prerequisites

The appropriate use of the RExVeS methodology assumes the fulfilment of the following connected vehicle design requirements. A vehicle manufacturer may impose additional requirements, derived from context-specific safety objectives.

REQ	23132-03	**RExVeS** – 03
In response to a safety-critical situation, applications that implement relevant RExVeS-related functions shall be prioritized on "ExVe Time critical interfaces" according to the result of the priority class assignment (see Table 1).		

To be considered a safe and secure RExVeS-related function for a given safety-critical situation, a road safety-related connected vehicle function should implement RExVeS-related applicable requirements which are designed to avoid or to mitigate the risks of harm involved in a given safety-critical situation.

Appropriate RExVeS-related design safety objectives should be determined for each evaluated RExVeS-related time-constrained situation. The consistency of the RExVeS-related design safety objectives with the assigned priority class and with the evaluated time-constrained situation should be verified.

For RExVeS, a time-constrained safety-related function respects common rules for the specification of time and location estimation including how such data are encoded in safety-critical messages.

NOTE 1 According to SAE standards, safety related functions use UTC for time synchronisation.

NOTE 2 In 2018, TAI, the primary international time standard, is exactly 37 seconds ahead of UTC.

REQ	23132-04	**RExVeS** – 04
The safety-critical situation reaction time interval shall enable to alert accurately and timely the connected vehicle driver and to broadcast appropriately accurate and timely safety-critical messages to avoid or to mitigate imminent collisions.		

REQ	23132-05	**RExVeS** – 05
The communication system for peri-vehicular data communication shall be designed to ensure appropriate levels of availability and latency so that safety-critical messages can be received by neighbouring road users at risk in a timely manner.		

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Annex A
(normative)

Template for the description and priority class assignment of RExVeS-related situations (including safety-critical situations)

USE CASE	**Name and source:** **Drawing** (if useful)**:**
SCENARIO	☐ Loss of control ☐ Imminent collision ☐ Other **Description** (text + drawing)**:**

TIME-CONSTRAINED SITUATION	
Name	
Safety-critical situation ☐ YES ☐ NO	
Description (text + drawing, including time constraints)**:**	

ASSIGNMENT OF PRIORITY CLASS		
Severity class (Sx)		**Rationale** (including used assumptions)**:**
Exposure class (Ex)		**Rationale** (including used assumptions)**:**
Controllability class (Cx)		**Rationale** (including used assumptions)**:**
Priority class (Px) =		
Remarks (including conclusions on time constraints)**:**		
Consequences for the safety-critical situation reaction time interval (if relevant)**:**		

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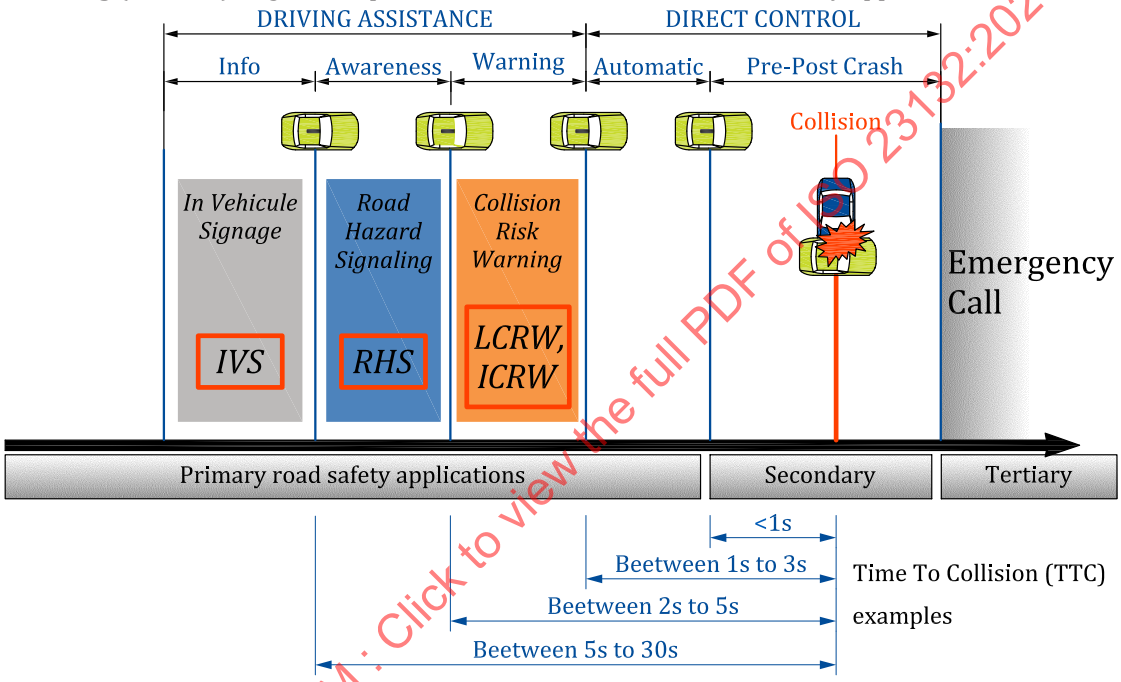
Annex B
(informative)

Example 1 of use of the RExVeS template

USE CASE	**Name and source:** "Longitudinal Collision Risk Warning" (LCRW) (source ETSI TS 101 539-3 v1.1.1 2013-11[8]) **Drawing** (if useful)**:** Figure B.1 provides an ETSI overview of road safety applications.  **Figure B.1 — Overview of road safety applications (from ETSI TS 101 539-3:2013[8])**
SCENARIO	☐ Loss of control ☒ Imminent collision ☐ Other **Description** (text + drawing): The objective of the scenario is to warn of a collision risk by broadcasting a safety-critical message which signals the presence of the vehicle (speed, location, etc.) to the other road users. ETSI TS 101 539-3:2013[8] lists LCRW scenarios where a collision can occur (see Figures B.2 and B.3). The scenario analysed here is part of the "safety relevant vehicle overtaking" use case in ETSI TS 101 539-3:2013[8], Table 2. According to ETSI TS 101 539-3:2013[8], the subject vehicle (SV) signals its intent to overtake a slow vehicle and detects a collision risk with an oncoming vehicle on the opposite traffic direction. The oncoming vehicle may also be SV and may achieve an action to avoid the frontal collision. The objective of the LCRW application is to warn the SVs' drivers to stay in lane or to brake in order to avoid a frontal collision. Figure B.2 lists relevant use cases description for forward and forward / side collision risk warning (ETSI TS 101 539-3:2013[8], Table 1).

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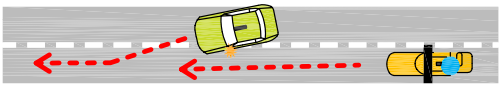
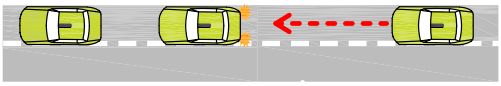
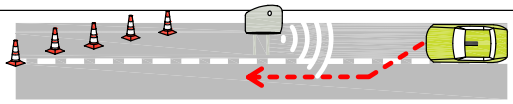
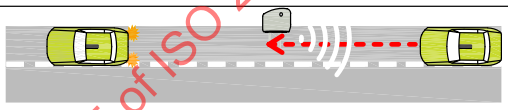
Use case	Scenario illustration
Safety relevant lane change	
Emergency electronic brake light / Traffic condition	
Roadworks	
Stationary vehicle	
Stability problem	
Collision risk warning from a third party	

Figure B.2 — Relevant use cases description for forward and forward / side collision risk warning (from ETSI TS 101 539-3:2013[8])

Figure B.3 lists relevant use cases description for frontal collision risk (ETSI TS 101 539-3:2013[8], Table 2).

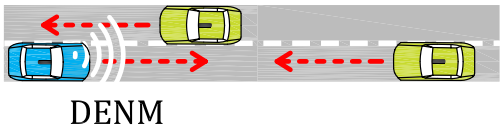
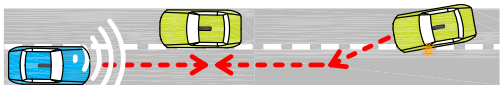
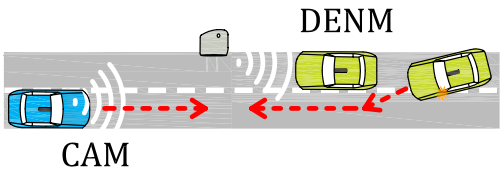
Use case	Scenario illustration
Wrong way vehicle driving	
Safety relevant vehicle overtaking	
Collision risk warning from third party	

Figure B.3 — Relevant use cases description for frontal collision risk (from ETSI TS 101 539-3:2013[8])

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TIME-CONSTRAINED SITUATION	
Name	Unwanted delay in sending a DENM indicating a LCRW collision risk
Safety-critical situation ☒ YES ☐ NO	

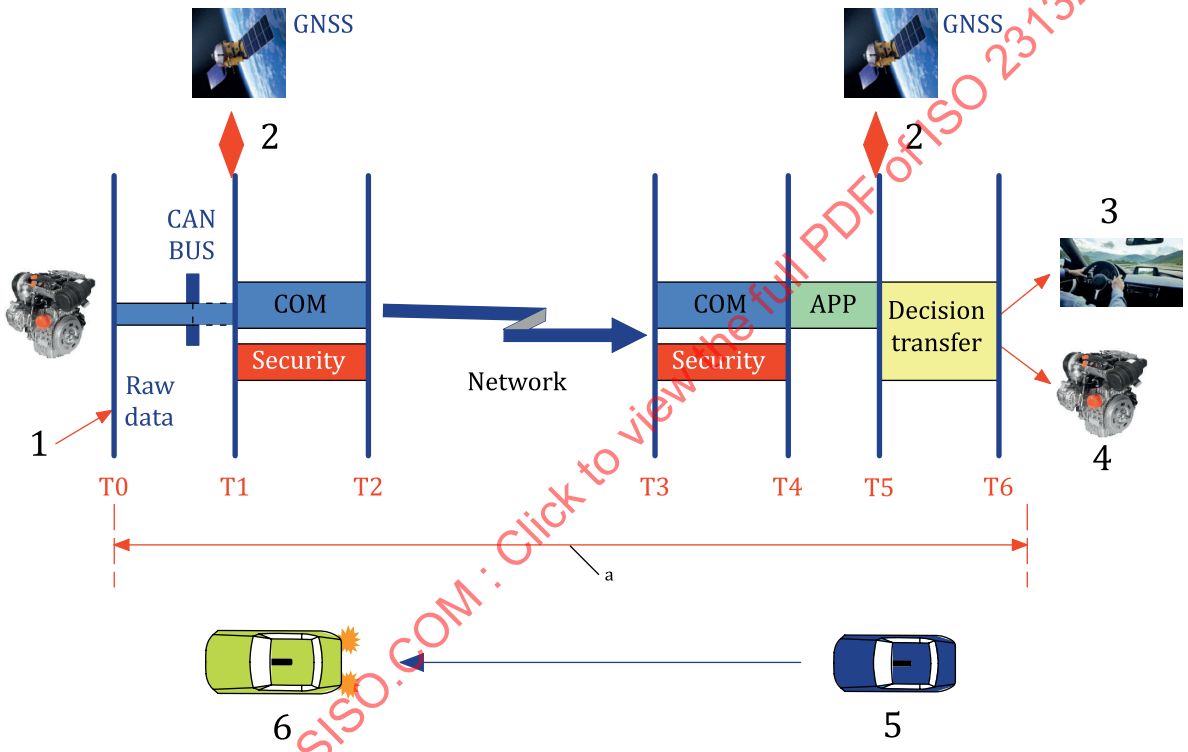
Description (text + drawing, including time constraints)**:**

A DENM is sent too late after the detection of the LCRW safety-critical situation.

According to ETSI TS 101 539-3:2013[8], performance class A shall be used for LCRW. Performance class A shall guarantee a T0 to T1 less than 150 ms. T0 - T1 reflects the freshness of in-vehicle data with regards to the message time stamp.

According to ETSI TS 101 539-3:2013[8], 300 ms end to end latency time may be required for LCRW to avoid false decision due to old data.

Figure B.4 illustrates ETSI views on end to end latency time for road safety applications.



Key

1	data acquisition from sensors	5	subject vehicle
2	time stamping	6	target vehicle
3	required action	a	End to end latency time < e.g. 300 ms.
4	automatic action		

Figure B.4 — Application end to end latency time (from ETSI TS 101 539-3:2013[8])

ASSIGNMENT OF PRIORITY CLASS		
Severity class (Sx)	Life-threatening injuries (S3)	**Rationale** (including used assumptions)**:** Front collision with another vehicle with medium speed.
Exposure class (Ex)	Medium probability (E3)	**Rationale** (including used assumptions)**:** Overtaking on a country road occurs once a month or more often for an average driver.

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Controllability class (Cx)	Normally controllable (C2)	**Rationale** (including used assumptions)**:** During driving phases, the drivers shall apply the road safety rules and therefore should be able to anticipate a collision. Between 90 % and 99 % of the average drivers or other traffic participants are able to avoid harm.

Priority class (Px) = P6

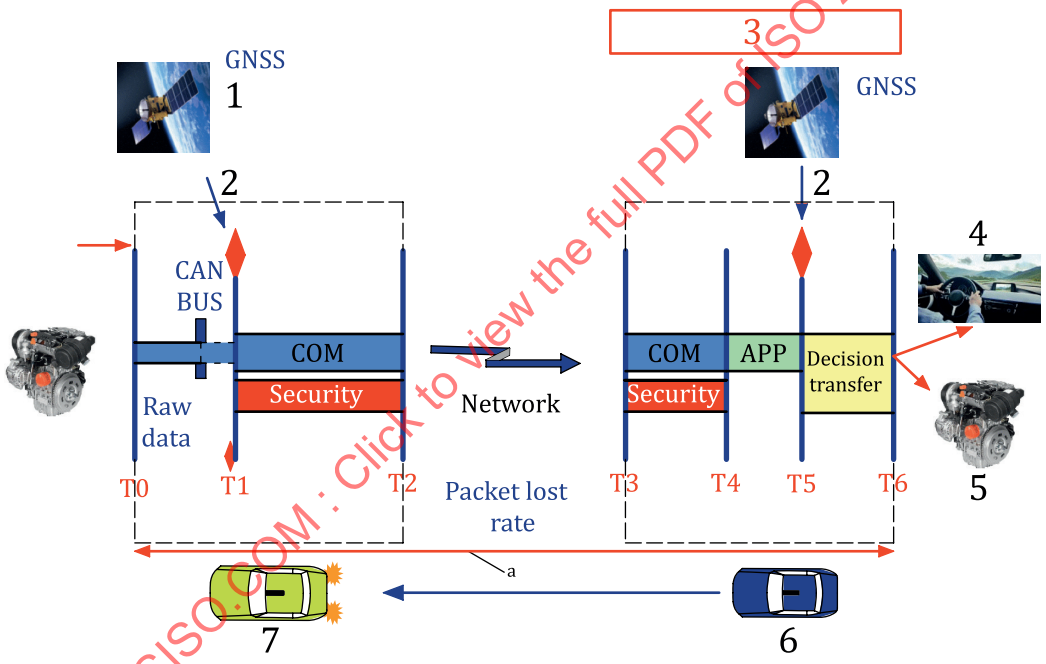
Remarks (including conclusions on time constraints)**:**

The proposer of the application shall be able to manage the situations of this type.

The vehicle manufacturer should check during the design phase the existence of a commitment of maximum time latency between the detection of the safety-critical situation and the message emission.

Additionally, according to ETSI TS 101 539-1:2013[9], dealing with "Road Hazard Signalling" (RHS), to be able to respect a 300 ms end to end latency time, the total latency time between T0 and T2 shall be less than 220 ms in 95 % of the cases during critical traffic safety situations. T2 is measured when the messages are transmitted over the air while T0 is measured at the vehicle electronic sensors' level.

Figure B.5 illustrates ETSI views on the age of the target vehicle data at consideration in the subject vehicle application.



Key

1	position accuracy 1 meter	5	automatic action
2	time stamping	6	subject vehicle
3	fault tolerant system	7	target vehicle
4	required action	a	End to end latency time < 300 ms.

Figure B.5 — Age of the target vehicle data at consideration in the subject vehicle application (from ETSI TS 101 539-1:2013[9])

Consequences for the safety-critical situation reaction time interval (if relevant)**:** In the evaluated LCRW safety-critical situation, ETSI "T0 – T2" corresponds to the safety-critical situation reaction time interval related to RExVeS.

The ETSI TS 101 539-1:2013[9] "T0 – T2" requirement mentioned above shall be respected, but a better performance is expected. ETSI TR 102 638:2009[10], dealing with "Basic Set of Applications" (BSA), speaks of a maximum latency time of 100 ms with a relative positioning accuracy <1 m (see ETSI TR 102 638:2009[10] C.1.5.5, dealing with cooperative forward collision warning).

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Annex C
(informative)

Example 2 of use of the RExVeS template

USE CASE	**Name and source:** Alert temporary slippery road (V2V – V2I) (description based on Reference [11]) A vehicle detects that the road is slipping and broadcasts an alert message to other vehicles and to the infrastructure manager. Depending on the cause of the slippery section, this use-case can concern both directions of roads, even for dual carriageways. However, the vehicle might not be able to detect the difference. Causes: snow, ice, black ice, wet road, aquaplaning, mud, gravels, other "rolling" elements on the road, oil, chemical products. Description: The sender is the vehicle detecting the slippery road. End-receivers are all vehicles around and the infrastructure manager. The source is the vehicle and its equipment. 1. A vehicle detects a slippery section of the road and broadcasts the information. This detection is done by analysing automatically the different systems of the vehicle combined with contextual data: ABS, ASR, ESC, vehicle data, etc. 2. The information transmits the localization of the event, along with the identified cause (as far as possible). 3. The vehicles around and the infrastructure manager receive the information and display it to their drivers. **Drawing** (if useful)**:** Figure C.1 shows the loss of control in a curve due to a slippery road.

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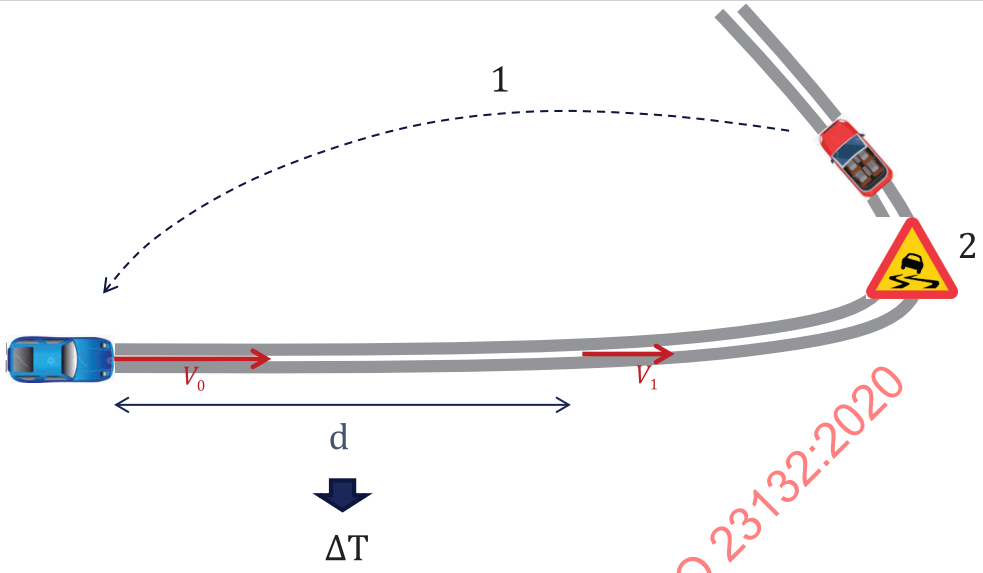

Key

1	V2V communication "slippery road warning"
2	slippery road associated to a specific μ level
d	braking distance required to reach the adequate speed
ΔT	time latency required to receive the info "slippery road warning" to have time to adjust the speed at the right level

Figure C.1 — Loss of control in a curve due to a slippery road (black ice, aquaplaning...)

SCENARIO

☒ Loss of control ☒ Imminent collision ☐ Other

Description (text + drawing)**:**

The impact of the loss of control of the vehicle or collision on a slippery road depends on the following circumstances:

— density of the traffic (number of vehicles and inter-vehicle distance);

— average speed of the traffic (severity of the collision);

— type of infrastructure (severity of the collision):

  — width and number of lanes, sinuosity;

  — double sense / central physical separation;

  — road environment;

  — type of road surface (track, asphalt, polished concrete, etc.).

— geographical location (latitude for type and occurrence of precipitation).

The combination of these circumstances generates different problematic scenarios.

We chose to quote 3 different criticalities (see below).

Description of the time constraints concerns:

Generally speaking, the state of adherence of the roadway varies slowly with a few exceptions as punctual as aquaplaning, mud, fuel on the road, etc. There are at least two conditions for the information "slippery road" to be treated in a relevant way by the vehicle:

— the level of grip of the road is actually a problem for the vehicle and its tires equipment,

— the information is received sufficiently in advance so that the vehicle has the time to adapt its speed to the situation.

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SCENARIO	This is particularly the case in winter (icy road) and it takes between 1 s and 10 s for the vehicle to adjust its speed to get safe in a slippery corner. If the information is not already available, depending on the distance between the vehicles, the previous vehicle will have the time or not to warn the next vehicle in a relevant way. There is no minimum latency in this case, since even if the information is sent and processed immediately, it will not prevent an accident in 100 % of cases: success depends on the speed of the vehicle, the state of the road and the distance between vehicles. To maximize the probability of success the information should be sent with the lowest latency possible at that time.

TIME-CONSTRAINED SITUATION (1)	
Name	The signal is received too late or is not taken into account while driving on a highway at high speed and with a low traffic density (no other vehicle around).
Safety-critical situation ☒ YES ☐ NO	
Description (text + drawing, including time constraints)**:** Not aware of the slippery road, the driver loses control of his vehicle at high speed and leaves the road. The causes can be many: aquaplaning, diesel on the road, ice plate. The low density of the traffic increases the effect of surprise but limits the severity of the impact.	

ASSIGNMENT OF PRIORITY CLASS (1)		
Severity class (Sx)	S3	**Rationale** (including used assumptions)**:** Side impact with a stationary object with high speed.
Exposure class (Ex)	E1	**Rationale** (including used assumptions)**:** Highways are generally well maintained specifically on paying portions and the probability to have to adapt the speed to enter a curve is low.
Controllability class (Cx)	C3	**Rationale** (including used assumptions)**:** Professional pilots are in situation to control only (surprise and high speed).
Priority class (Px) = P5		
Remarks (including conclusions on time constraints)**:**		
Consequences for the safety-critical situation reaction time interval (if relevant)**:** Having the information "the road is slippery" before arriving on the critical point is key to adapt the speed of the vehicle to the adhesion conditions.		

TIME-CONSTRAINED SITUATION (2)	
Name	The signal is received too late or is not taken into account while driving on a national two-way road with dense but fluid traffic (average speed high).
Safety-critical situation ☒ YES ☐ NO	
Description (text + drawing, including time constraints)**:** Not aware of the slippery road, the driver loses control of his vehicle and collides with a car in the opposite direction. The following vehicles do not have the possibility of stopping early enough and aggravate the first accident. Ex: N118 while snowing or RCEA in winter.	

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ASSIGNMENT OF PRIORITY CLASS (2)		
Severity class (Sx)	S3	**Rationale** (including used assumptions)**:** Front collision with another vehicle with high speed.
Exposure class (Ex)	E2	**Rationale** (including used assumptions)**:** In northern Europe, the road is slippery 50 % of the year. The probability of having to adapt the speed before entering a curve increases with ice presence on old infrastructure portions (curvature not adapted to speed limitation).
Controllability class (Cx)	C3	**Rationale** (including used assumptions)**:** Difficult to manage the braking distance on a slippery road.
Priority class (Px) = P6		
Remarks (including conclusions on time constraints)**:** Inter-vehicular distance management is very important in that case and should be adapted to road adhesion, vehicle speed and tire fitment.		
Consequences for the safety-critical situation reaction time interval (if relevant)**:** See above.		

TIME-CONSTRAINED SITUATION (3)	
Name	The signal is received too late or is not taken into account while driving in the city centre at low speed and low traffic.
Safety-critical situation ☒ YES ☐ NO	
Description (text + drawing, including time constraints)**:**	
The road is slippery (wet pavement for example), a pedestrian crosses unexpectedly, the uninformed vehicle brakes too late and too hard and slips. It hits the pedestrian or bumps in street furniture or in vehicles parked around.	

ASSIGNMENT OF PRIORITY CLASS (3)		
Severity class (Sx)	S2	**Rationale** (including used assumptions)**:** A pedestrian may be involved in the collision.
Exposure class (Ex)	E2 to 3	**Rationale** (including used assumptions)**:** In northern Europe, the road is slippery 50 % of the year.
Controllability class (Cx)	C2	**Rationale** (including used assumptions)**:** Low speed, and sensitized drivers in winter.
Priority class (Px) = P4 to 5		
Remarks (including conclusions on time constraints)**:** Having the information “the road is slippery” before arriving on the critical point is key to adapt the speed of the vehicle to the road grip conditions.		
Consequences for the safety-critical situation reaction time interval (if relevant)**:** See above.		

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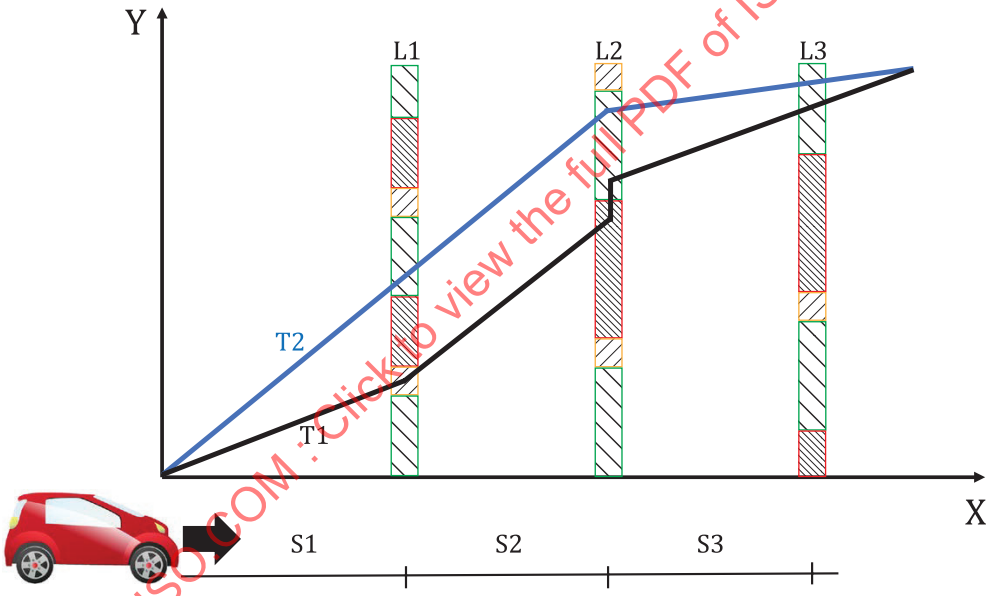
Annex D
(informative)

Example 3 of use of the RExVeS template

USE CASE	**Name and source:** GLOSA "Green Light Optimal Speed Advisory" The objective of GLOSA is to provide to the driver the optimal speed to cross the next intersection with a green phase. The intersection sends data to the approaching vehicles such as the intersection topology, the location, the traffic lights current phases and their duration. The on-board system processes these data to calculate the optimal approaching speed of the vehicle to reach the intersection. GLOSA is included in the "Day 1" applications of the European C-ITS Directive. It is important to be aware of its required implementation in case of C-ITS deployment in any European member state. **Drawing** (if useful)**:** Figure D.1 shows a comparison of GLOSA approaches.  **Key** X distance Y time T1 - trajectory with single-segment GLOSA T2 - trajectory with multi-segment GLOSA red phase yellow phase green phase **Figure D.1 — Comparison of GLOSA approaches (See Reference [12])**

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