



**Intelligent Transport System (ITS);  
Vulnerable Road Users (VRU) awareness;  
Part 1: Use Cases definition;  
Release 2**

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**ETSI**

650 Route des Lucioles  
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C  
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# Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Intelligent Transport Systems (ITS).

The present document is part 1 of a multi-part deliverable covering Vulnerable Road Users (VRU) awareness as identified below:

- Part 1: "Use Cases definition";
- Part 2: "Functional Architecture and Requirements definition";
- Part 3: "Specification of VRU awareness basic service".

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# Modal verbs terminology

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# Executive summary

Technological developments and research activities in C-ITS have primarily focused on motorized transport to improve safety and environmental impacts by advancing equipment of vehicles and infrastructure. For this C-ITS, V2V, I2V and V2I use cases and applications have been identified in the Basic Set of Applications (BSA).

Additional use cases are being developed to cover applications such as Platooning, Cooperative Adaptive Cruise Control (C-ACC), Cooperative Perception Service (CPS) and Manoeuvre Coordination Service (MCS). Vulnerable Road Users (VRUs) related use cases can make use of these specifications and applications and should be taken into account. Interoperability between vehicle-based and portable safety devices is of paramount importance to improve the overall safety and decrease the fatalities in both urban and non-urban areas. There is therefore the need to develop VRU related specifications in order to allow the deployment of VRU safety applications.



The objective of the present document is to provide the material to help identify improvements of current specifications and the content of additional specifications based on ongoing VRU developments. VRU applications extend the awareness of and/or about Vulnerable Road Users such as motorcycles, bicycles, pedestrians and more impaired traffic participants in the neighbourhood of other traffic participants. They enable further improvement of traffic safety and management based on both direct ITS station-to-ITS station communications and via a third party ITS station (e.g. vehicle or road-side equipment).

The present document is the first part of a three-part standard:

- Part 1 (the present document) describes the VRU system and the use cases related to Vulnerable Road Users such as pedestrians, bicyclists and road workers.
- Part 2 [i.17] specifies the VRU related requirements; as well as the functional architecture of the VRU system. In addition, it analyses the impact on existing standards (for instance the CAM European Norm).
- Part 3 [i.18] specifies the communication protocols, message format, semantics and syntax as well as key interfaces and protocol operation for the VRU awareness service.

The present document starts with a definition of what is considered as a VRU, its possible configurations and its environment.

The next clause introduces a categorization of the potential use cases involving VRUs, classified based on the different stakeholders involved in the C-ITS system which could contribute to prevent a risk of collision with the VRU. Each of these categories has its own specificities. The categories will help develop the structure and prepare the specification of the VRU system functional architecture in ETSI TS 103 300-2 [i.17].

A set of exemplary use cases is then described, where VRUs encounter a risk of collision and how this risk could be mitigated by the C-ITS system. These use cases have been analysed and one of the outcomes of this analysis is that depending on the use case and the actors involved, different elements of the architecture may be mandatory or optional (for example functions in the cloud). This is also closely linked to the deployment level of the different features of the C-ITS system.

Finally, the deliverable concludes with the outcome of the analysis of the use cases, discussing the different challenges identified in the use case descriptions that need to be taken into account when specifying the VRU basic awareness service in ETSI TS 103 300-2 [i.17] and ETSI TS 103 300-3 [i.18]. Part of the main challenges are the unpredictable behaviour from the VRU and a VRU profiling proposal, positioning aspects, resource usage, in terms of spectrum, power and functions, performance parameters, security and privacy and roadmap for a progressive system development of the VRU architecture.

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## Introduction

VRU applications extend the awareness of and/or about Vulnerable Road Users such as motorcycles, bicycles, pedestrians and more impaired traffic participants in the neighbourhood of other traffic participants. They enable further improvement of traffic safety and management based on both direct ITS station-to-ITS station communications and via a third party ITS station (e.g. vehicle or road-side equipment).



# 1 Scope

The present document describes and categorizes typical use cases relevant to traffic safety that involve Vulnerable Road Users (VRUs) i.e. road users such as pedestrians, bicyclists, e-scooters, motorcycles and road workers and are enabled by Cooperative Intelligent Transport Systems.

Each use case contains an associated flow chart which shows the interaction between the involved actors, i.e. at least one VRU and other ITS stations.

# 2 References

## 2.1 Normative references

Normative references are not applicable in the present document.

## 2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long-term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- [i.1] ETSI TR 102 638: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Definitions".
  - [i.2] ETSI EN 302 637-2: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service".
  - [i.3] ETSI EN 302 637-3: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service".
  - [i.4] SAE J2735 (March 2016): "Dedicated Short Range Communications (DSRC) Message Set Dictionary".
  - [i.5] ISO/TS 19091: "Intelligent transport systems -- Cooperative ITS - Using V2I and I2V communications for applications related to signalized intersections".
  - [i.6] ETSI EN 302 665: "Intelligent Transport Systems (ITS); Communications Architecture".
  - [i.7] SAE J2945/9 (March 2017): "Vulnerable Road User Safety Message Minimum Performance Requirements".
  - [i.8] Regulation (EU) No 168/2013 of the European Parliament and of the Council of 15 January 2013 on the approval and market surveillance of two- or three-wheel vehicles and quadricycles.
- NOTE: Available at <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R0168&from=EN>.
- [i.9] ETSI TS 103 301: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services".
  - [i.10] ETSI TS 101 539-1: "Intelligent Transport Systems (ITS); V2X Applications; Part 1: Road Hazard Signalling (RHS) application requirements specification".

- [i.11] Regulation (EC) No 661/2009 of the European Parliament and of the Council of 13 July 2009 concerning type-approval requirements for the general safety of motor vehicles, their trailers and systems, components and separate technical units intended therefore. Article 10: Advanced vehicle systems.
- [i.12] Commission Regulation (EU) No 347/2012 of 16 April 2012 implementing Regulation (EC) No 661/2009 of the European Parliament and of the Council with respect to type-approval requirements for certain categories of motor vehicles with regard to advanced emergency braking systems.
- [i.13] ISO/TS 17426: "Intelligent Transport Systems (ITS) -- Cooperative systems -- Contextual speed".
- [i.14] VRUITS Deliverable D2.1: "Technology potential of ITS addressing the needs of Vulnerable Road Users".
- [i.15] PROSPECT Deliverable D2.1: "Accident Analysis, Naturalistic Observations and Project Implications".
- [i.16] ETSI TS 103 097: "Intelligent Transport Systems (ITS); Security; Security header and certificate formats".
- [i.17] ETSI TS 103 300-2: "Intelligent Transport System (ITS); Vulnerable Road Users (VRU) awareness; Part 2: Functional Architecture and Requirements definition; Release 2".
- [i.18] ETSI TS 103 300-3: "Intelligent Transport System (ITS); Vulnerable Road Users (VRU) awareness; Part 3: Specification of VRU awareness basic service; Release 2".
- [i.19] IEEE 802.11n™: "IEEE Standard for Information technology-- Local and metropolitan area networks-- Specific requirements-- Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 5: Enhancements for Higher Throughput".
- [i.20] M/546 Commission Implementing Decision C(2016)808 of 12.2.2016 on a standardisation request to the European standardisation organisations as regards Intelligent Transport Systems (ITS) in urban areas in support of Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport.

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## 3 Definition of terms, symbols and abbreviations

### 3.1 Terms

For the purposes of the present document, the following terms apply:

**emergency braking:** phase directly starting when the AEBS emits demand for at least 4 m/s<sup>2</sup> deceleration to the service braking system of the vehicle

**manoeuvres:** specific and recognized movements bringing an actor, e.g. pedestrian, vehicle or any other form of transport, from one position to another within some momentum (velocity, velocity variations and vehicle mass)

**Post-Encroachment-Time (PET):** time between the passing of first road user and arrival of second road user at a conflicting space. It measures the potential risk of collision

**road:** way allowing the passage of vehicles, people and/or animals. It is made of none, one or a combination of the following lanes: driving lane, bicycle lane and pavement

**personal ITS-S:** ITS-Station in a nomadic ITS sub-system in the context of a portable device

**Time to Collision (TTC):** value of time obtained by dividing the distance between the subject vehicle and the target (e.g. VRU) by the relative speed of the subject vehicle and the target at an instant of time

**traffic conflict:** situation involving two or more moving users or vehicles approaching each other at given velocities in such a way that a traffic collision would occur unless at least one of the users or vehicles performs an emergency manoeuvre

NOTE: Traffic conflicts are defined by the following parameters:

- traffic conflict point (time and space) where the trajectories intersect;
- time-to-collision, distance-to-collision, post-encroachment time, and angle of conflict.

**vehicle:** road vehicle designed to legally carry people or cargo on public roads and highways such as busses, cars, trucks, vans, motor homes, and motorcycles

NOTE: This does not include motor driven vehicles not approved for use of the road, such as forklifts or marine vehicles.

**velocity:** momentum (in physics)

NOTE: The velocity takes into account the mass of the vehicle and its speed. The braking distance will therefore be more a function of the velocity than of the speed.

**Vulnerable Road Users (VRU):** non-motorized road users as well as L class of vehicles (for example mopeds or motorcycles, etc.), as defined in Annex I of EU regulation 168/2013 [i.8]

**VRU application:** application extending the awareness of and/or about Vulnerable Road Users such as motorcycles, bicycles, pedestrians and less impaired traffic participants in the neighbourhood of other traffic participants

**VRU device:** portable device used by a VRU integrating a standard ITS station

NOTE: The definition of an ITS station is given in ETSI EN 302 665 [i.6]. A VRU device can also integrate applications interfacing the ITS-S. For example, an application can improve the VRU trajectory prediction by learning continuously from its behaviour when sharing the space with other road users.

**VRU system:** ensemble of ITS stations interacting with each other to support VRU use cases, e.g. personal ITS-S, vehicle ITS-S, roadside ITS-S or Central ITS-S

**user:** equipped or un-equipped road user such as driver, pedestrian, service provider or authority

## 3.2 Symbols

Void.

## 3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ABS	Antilock Braking System
AD	(vehicles)
AEBS	Advanced Emergency Braking System
AI	Artificial Intelligence
BSA	Basic Set of Applications
C-ACC	Cooperative Adaptive Cruise Control
CAM	Cooperative Awareness Message
CEN	Comité Européen de Normalisation (European Committee for Standardization)
C-ITS	Cooperative ITS
CPM	Cooperative Perception Message
CPS	Cooperative Perception Service
CSM	Contextual Speed limit Messages
DENM	Decentralized Environmental Notification Message
DoS	Denial of Service
EEBL	Emergency Electronic Brake Light
FVRU	Few VRUs
FYL	Functional Years Lost

GN	GeoNetworking
GNSS	Global Navigation Satellite System
HMI	Human-Machine Interface
ISA	Intelligent Speed Adaptation
ISO	International Organisation for Standardization
ITS	Intelligent Transport System
ITS-S	ITS Station
LOS	Line of Sight
MAI	Motorcycle Approach Indication
MAW	Motorcycle Approach Warning
MCM	Manoeuvre Coordination Message
MCS	Manoeuvre Coordination Service
MEC	Mobile Edge Computing
MVRU	Many VRUs
NLOS	Non-Line of Sight
PAC	Perception Augmentée par Coopération
PET	Post-Encroachment-Time
PHY	Physical (layer)
PoTi	Position Time
PSM	Personal Safety Messages
PTW	Powered Two Wheelers
R-ITS-S	Roadside ITS Station
RLAN	Radio Local Area Network
RSE	Road Side Equipment
RX	Receive
SAE	Society of Automotive Engineers
SDO	Standards Developing Organization
SPaT	Signal Phase and Timing
TRO	Transport Regulation Order
TTC	Time-To-Collision
TX	Transmit
UC	Use Case
UWB	Ultra WideBand
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
V2X	Vehicle-to-everything
V-ITS-S	Vehicle ITS Station
VRU	Vulnerable Road User

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 Full standard:  
<https://standards.iteh.ai/catalog/standards/sist/8b7acf23-d5b3-4e9b-ae81-4865b45f22a5/etsi-tr-103-300-1-v2.1.1-2019-09>

## 4 Vulnerable Road User system description

### 4.1 Background

Cooperative Intelligent Transport Systems (C-ITS) have been developed to enable an increase in traffic safety and efficiency, and to reduce emissions and fuel consumption.

Initial focus was on road traffic safety and especially on vehicle safety. For this C-ITS, V2V, I2V and V2I use-cases and applications have been identified in the Basic Set of Applications (BSA), ETSI TR 102 638 [i.1]. Specification and information exchanges such as ETSI EN 302 637-2 [i.2] (CAM), ETSI EN 302 637-3 [i.3] (DENM), SAE J2735 [i.4] (SPaT-MAP), ISO/TS 19091 [i.5] and ETSI TS 103 301 [i.9] have been developed as part of ETSI ITS Release 1.

Additional use cases are being developed to cover applications such as Platooning, Cooperative Adaptive Cruise Control (C-ACC), Cooperative Perception Service (CPS) and Manoeuvre Coordination Service (MCS). VRU related use cases can make use of these specifications and applications. The objective of the present document is to provide the material to help identify improvements of current specifications and the content of additional specifications based on ongoing VRU developments.

## 4.2 Vulnerable Road Users

The following types of road users are considered as Vulnerable Road Users (see also the classification in Annex 1 of Regulation (EU) 168/2013 [i.8]):

- Pedestrians (including children, elderly, joggers).
- Emergency responders, safety workers, road workers.
- Animals such as horses, dogs down to relevant wild animals (see note below).
- Wheelchairs users, prams.
- Skaters, Skateboards, Segway, potentially equipped with an electric engine.
- Bikes and e-bikes with speed limited to 25 km/h (e-bikes, class L1e-A [i.8]).
- High speed e-bikes speed higher than 25 km/h, class L1e-B [i.8].
- Powered Two Wheelers (PTW), mopeds (scooters), class L1e [i.8].
- PTW, motorcycles, class L3e [i.8];
- PTW, tricycles, class L2e, L4e and L5e [i.8] limited to 45 km/h;
- PTW, quadricycles, class L5e and L6e [i.8] limited to 45 km/h.

NOTE: Relevant wild animals are only those which present a safety risk to other road users (VRUs, vehicles).

Persons carrying a personal device and transported as driver or passenger in a vehicle not listed above, such as a car (equipped with C-ITS or not), a truck, a public transport (i.e. bus, urban train, train, etc.) are not considered as VRUs and are out of scope of the present document. However, there is a grey zone during the time when the user is entering a vehicle and should be still considered as a VRU. For example, a person entering a car with the car presents a safety risk while the car door is open. The challenge associated with the change of role of the VRU device and this grey zone is considered in clause 7.2 and will be further analysed in ETSI TS 103 300-2 [i.17].

Use cases defined in ETSI ITS protocols already consider motorbikes as vehicle ITS stations, together with other motorized road vehicles such as cars, trucks or buses. However, they can also be considered as VRUs. Accordingly, VRUs may belong to both categories of vehicle ITS stations or personal ITS stations, as defined in ETSI EN 302 665 [i.6].

A VRU is described by its type, vulnerability state, legal state and situation.

## 4.3 VRU system

The Vulnerable Road User system (VRU system) defines the ITS artefacts that are relevant for the use cases and scenarios of clause 6, including the primary components and their configuration, the actors and their equipment, relevant traffic situations and operating environments.

The present document considers use cases and scenarios in which VRUs are particularly vulnerable to road hazards due to potential traffic conflicts with other road users, and in which VRU applications, as a subset of C-ITS applications, can increase the safety of the VRUs.