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Intelligent transport systems — Mobility integration — Mobility integration needs for vulnerable users and light modes of transport

Systèmes de transport intelligents — Intégration de la mobilité — Besoins d'intégration de la mobilité pour les usagers vulnérables et les modes de transport légers

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Foreword

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This document was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

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Introduction

In previous years, the development of intelligent transport system (ITS) standards has been focused on road vehicles and supporting traffic and transport systems. Although provisions in respect of accessibility and accommodation of all travellers, including people with disabilities and older adults, have been taken into consideration, related requirements for ITS have not been accommodated, primarily because of the lack of possibilities for communicating electronically with these travellers.

The more recent focus on Mobility as a Service (MaaS), cooperative, connected and automated mobility (CCAM), and multimodal end-to-end journey planning and management, incorporate travel means such as active modes (e.g. bicycles) and micromobility vehicles (MMV) such as powered bicycles, powered scooters, Segways, powered boards, etc. Often, they also involve device sharing. End-to-end multimodal journeys often also include part of the journey on foot.

ITS service provision has, to date, tended to agglomerate standards for “road users”, “drivers” and “vehicles” and is largely focused on car drivers and the systems that control or assist them. Some attention has also been focused on public service and commercial vehicles. But another group of light vehicle mode users are powered two-wheeled vehicle (P2WV) riders. With a few exceptions, there has been little appreciation of the different characteristics and behaviour of motorcycles, mopeds, trikes and quads and the requirements that they have that differ from those for other categories.

These categories of conveyances and travellers, at the least, have needs to be communicated in terms of ITS service provision. Conversely, many ITS services often need to communicate with, or be aware of the presence of, these actors. Yet, in previous years, there have generally not been any means for communicating with them individually.

However, during the last few years, smartphones and other nomadic devices have not only become available, but are already indispensable for multimodal journeys and assist in ITS service provision. Smartphone technology is also often used in devices assisting. The advent of low-cost communications and cooperative technologies can also assist in the provision of services.

Intelligent transport systems — Mobility integration — Mobility integration needs for vulnerable users and light modes of transport

1 Scope

This document provides a review of mobility integration standardization efforts supporting all travellers using active and light transport modes and identifies gaps where additional standardization is potentially required. The gap analysis is focused on cooperative intelligent transportation systems (C-ITS) for all users, including people with disabilities, as they plan, manage and carry out their “complete trip”, including all connections and transfers, from end-to-end.

The term “light mode conveyances" covers C-ITS for light power and active modes such as micromobililty vehicles (e.g. e-scooters), power or power-assisted vehicles (e.g. e-bikes, power wheelchairs), and full powered vehicles (e.g. motorcycles, mopeds).

This document identifies areas where standardization is potentially required to resolve problems and challenges, or to create opportunities, particularly with respect to enhancing safety and the provision of end-to-end multimodal journeys and support.

2 Normative references

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

No terms and definitions are listed in this document.

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

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

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

3.2 Abbreviated terms

AI	artificial intelligence
BSM	basic safety message
CCAM	cooperative, connected and automated mobility
CV	connected vehicles
DSRC	dedicated short-range communication
HMI	human machine interface
HSM	hardware security module

IMN	in mobility network
ITS	intelligent transport system
ITS-S	intelligent transport system station
MaaS	mobility as a service
MIB	management information base
ML	machine learning
MM	micromobility
MMCS	micromobility cloud server
MMCN	micromobility communication network
MMG	micromobility gateway
MMV	micromobility vehicle
MU	mobile unit
ND	nomadic device
PCN	public communication network
P2P	pedestrian to pedestrian
P2WV	powered two-wheel vehicle
P-ITS-S	personal intelligent transport system station
RoW	right of way
SMIB	security management information base
UTMS	universal traffic management systems
V2V	vehicle to vehicle
V2I	vehicle to infrastructure
V2P	vehicle to pedestrian
V2x	vehicle to everything
VAM	vulnerable road vehicle awareness message
V-ITS-S	vehicle intelligent transport system station
VRU	vulnerable road user
VRV	vulnerable road vehicle

4 Vulnerable road users (VRUs)

4.1 VRUs in standardization

This clause describes the current provisions and differences among regions and standardization organizations when defining VRUs, the eco-system in which VRUs exist, the devices used for detection, control and communication, information exchanged with other actors, and the haptic sensory approaches used for notification.

4.2 VRUs in the context of C-ITS

4.2.1 Overview

C-ITS and connected vehicle (CV) programmes typically characterize communications between vehicles (V2V), between vehicles and infrastructure (V2I) and between vehicles and pedestrians (V2P). “Pedestrians” in this context typically refers to VRUs including people walking, passengers embarking and disembarking buses and trains, animals, people in work zones, people riding bicycles and people riding low-powered mobility devices such as e-scooters, powered wheelchairs and power assisted bikes.

4.2.2 C-ITS safety processes

Standards for VRUs are derived from the needs associated with their travel safety requirements. Typical C-ITS activities follow a process flow as shown in Figure 1. The flow begins when a vehicle, pedestrian or infrastructure detects the presence of a threat (1. Detection). Once detected, the system identifies the type of threat (2. Identification). In some cases, the path taken by the “threat” can be assumed by way of path restrictions (3. Compliance with right of way). Examples of right of way restrictions include a railroad grade crossing with gates drawn, a bicycle blocking a walkway, or pedestrians crossing against a traffic signal. For any actor to take evasive action or be notified of the threat, the threat’s expected manoeuvre needs to be determined (4. Expected manoeuvre). Finally, the appropriate action can be taken to inform or alert the actor of the threat (5. Communicate). These processes apply to V2V, V2I and V2P processes, albeit via different ITS-S devices and applications.

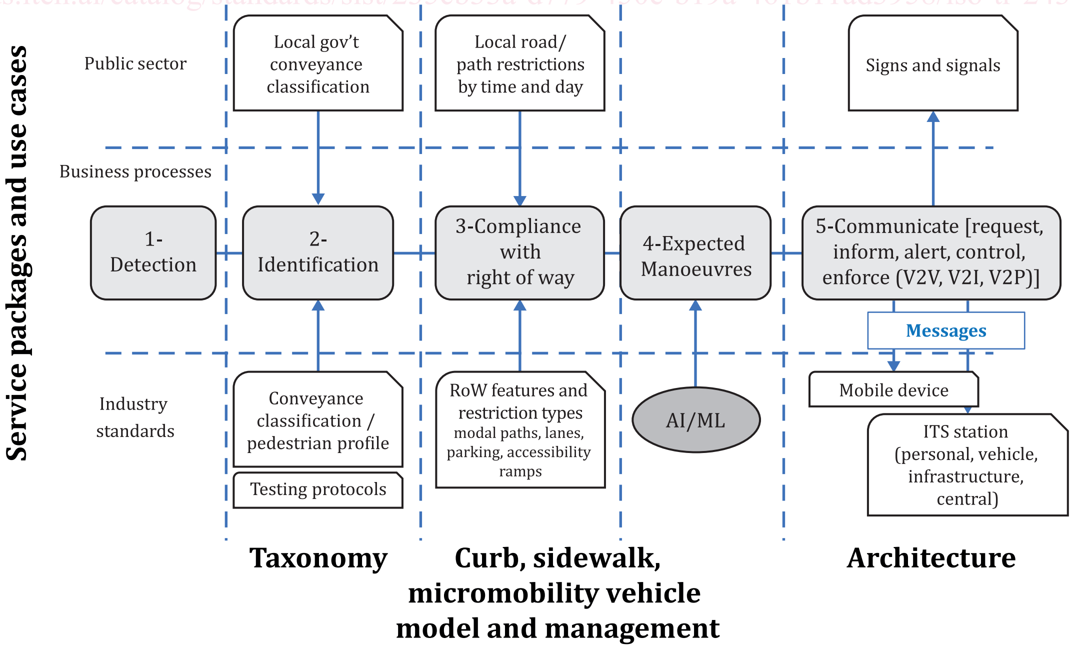

Figure 1 — General processes related to VRU detection and communications in the context of V2x, V2P and P2P

1) **Detection —** This process requires technologies to identify objects that are nearby. There are many such detection methods currently in use, including passive sensors that detect the presence of VRUs (e.g. lidar, wireless, and acoustic) or active communications between ITS-S devices (V2x or more appropriately VRU-2-x).

2) **Identification —** This process requires understanding the characteristics of the "threats". In this case, the process focuses on identifying the type of VRU. To aid in subsequent processes, such as determining compliance with rules and expected behaviours, the VRU characteristics are required to assess compliance and predict behaviour. These parameters include understanding maximum speed, dimensions, behavioural profile, restrictions and more. A VRU type and model will provide the appropriate information to feed these subsequent processes. See 5.1 for existing definitions and taxonomies that detail classification models for VRUs.

3) **Compliance with right of way** (RoW) **—** This process involves determining compliance with RoW restrictions. In some cases, this rule is targeted to the VRU, for example, no walk signals for people with a visual impairment. Compliance with RoW requires vehicles and VRUs to follow transport rules. For example, the infrastructure can detect a cyclist travelling on a restricted highway, an e-scooter parked in a pedestrian path impacting a person with visual disability, or a vehicle making a right turn onto a restricted road.

4) **Expected manoeuvres —** This process describes algorithms and models of VRU behaviour. These models provide scenarios which demonstrate, for example, the different expectations of intersection crossing by an adult walking with a young child versus a runner. Specific standards in this area are too new to determine. Research in "near miss collisions" particularly between VRUs (e.g. bikes/e-scooters and pedestrians) as well as predicting VRU behaviour (in groups as well as by individuals) using predictive analytics, machine learning and other artificial intelligence techniques will help identify information needed to support the emerging tools.

5) **Communicate —** This process describes the processes for alerting the ITS-S application associated with the appropriate threatened actor. For the VRU for example, this alert can be received and delivered by infrastructure (flashing sign), VRU vehicle (bicycle, scooter, motorcycle), or by a personal nomadic device.

Research, technologies and use case descriptions generally fall into these five categories. ETSI use cases describe additional complexities that augment understanding (see References [1], [2] and [3]).

4.2.3 C-ITS view of VRU

Many standards related to VRUs deal with vehicles or infrastructure sensing and avoiding the VRU. However, with new research and reduced costs of awareness sensors, an increasing number of VRUs are likely to possess personal devices with ITS-S applications. This document focuses on identifying the needs of the VRU including their integration into the C-ITS environment as an active rather than a passive participant.

At an early stage in the US Department of Transportation's "Vehicle to Pedestrian" program, the focus was on detection and communication. Three "technology categories" were used that included pedestrians (i.e. VRUs) as an active participant in the C-ITS environment:

1) **Unilateral pedestrian detection and driver notification:** Technologies that provide collision alerts only to the driver.

2) **Unilateral vehicle detection and pedestrian notification:** Technologies that provide collision alerts only to the pedestrian (i.e. VRUs).

3) **Bilateral detection and notification systems:** Technologies that provide collision alerts to both drivers and pedestrians (VRUs) in parallel.

Research in this area is listed in a related technology scan sponsored by the US Department of Transportation. The categories are in fact much more complex than the three listed above. For example, the unilateral vehicle detection and pedestrian notification category can include:

a) a personal device detecting and notifying the VRU of collision;

b) infrastructure detecting and notifying the VRU of collision (through audible or visual warnings);

c) infrastructure detecting and notifying the VRU's personal device of collision.

Existing standards have only addressed a limited subset of the needs identified. Furthermore, existing architectures (role-based and physical) have not fully embraced the categories or the complexities. In particular, the physical components, technologies and information flows vary for each of the three scenarios. To that end, the architecture needs to be technology and physical component agnostic. Even a VRU changes their role depending on travelling mode, and with them, the role of their personal ITS-S.

4.3 Definitions and taxonomy

4.3.1 Overview

The processes to detect and identify the VRU starts with understanding the type of VRU, and then determining the behaviour of that VRU. Identification is determined by a clear set of logical categories that describe critical characteristics of the observed VRU. This subclause describes various sets of taxonomies that relate to a VRU. These contribute to generating a comprehensive VRU profile that supports downstream processes. The areas include:

— definition and taxonomy for VRU (5.2.1);

— classification for VRU vehicles (VRV) and devices (5.2.2);

— combining VRU person and device/vehicle (5.2.3).

4.3.2 Definition of VRU

4.3.2.1 General

There is no consensus on terminology, classifications or scope in terms of a VRU. The only profiles of VRU found in automotive standards are for pedestrian and bicycle.[21],[16]

However, certain additional definitions are listed in the sources covered in the following subclauses.

4.3.2.2 SAE DSRC

SAE J2945/9 describes V2P safety warnings, where “P” implies a VRU. SAE J2945/9 defines the terms "VRU" and "VRU Device" as follows:

VRU

A road user, who is not occupying a vehicle such as a passenger car, a motorcycle, a public transit vehicle, or a train. Pedestrians, cyclists, children, elderly, people with disabilities and road workers are particularly vulnerable to serious injury or death if they are involved in a motor-vehicle-related collision.

VRU DEVICE

A device that transmits personal safety messages as defined in SAE J2735, and optionally can receive basic safety messages (BSM). The device can be capable of receiving other message types.

These definitions do not build a classification of a VRU. A VRU device is a connected device that is not associated with a specific class of VRU.

