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Intelligent transport systems — Cooperative ITS — Using V2I and I2V communications for applications related to signalized intersections

Systèmes intelligents de transport — Coopérative ITS — Utilisation de communications V2I et I2V pour des applications relatives aux intersections signalées

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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The committee responsible for this document is ISO/TC 204, *Intelligent transport systems*.

Introduction

Cooperative-ITS (C-ITS) is a promising and remarkable advancement of intelligent transport systems (ITS). Numerous cooperative applications are specified that open up new possibilities to make traffic safer, more efficient, and smarter. Technologies are developed and improved to realize and support those new services and applications. To enable those applications, information needs to be reliably communicated between the stationary infrastructure and mobile vehicles.

This document describes the use cases for several applications that address safety, mobility, and ecological sustainability. Each use case has information needs that communication between vehicles and the infrastructure facilitate. It then identifies the information needs for the applications and the requirements to satisfy them. In turn, it maps the requirements into data frames and data elements to fulfil the requirements within the specified message set.

ISO 22951 has a relationship to this document. PRESTO addresses its user needs through the implementation of a specific system architecture similar to that described in NTCIP 1211. This architecture includes traffic signals, message signs, routing systems, human machine interfaces, and fixed detection locations. Many of PRESTO's data value details are "left undefined to allow for discretional definition by each country." The PRESTO architecture detects priority requesting vehicles by installing specific detection equipment at these locations.

This document uses a similar set of user needs to develop the message set between vehicles and the roadside equipment they interface. This document does not address the system architecture other than data needed to fulfil the user needs that will be managed elsewhere in the architecture. It details data values and structures in order to define the interface between these two devices. Routing information is supported in the architecture through other mechanisms and is not a need supported by the vehicle to roadside equipment information flows. The user needs also provide for priority by approach, a preconfigured strategy, and ingress/egress lane requests. This document is based on vehicles periodically broadcasting their location and trajectory information to other vehicles and the roadside infrastructure. This document compliments ISO 22951 as it provides for vehicle location and request information directly from connected vehicles rather than the detection of the vehicles from other fixed sensing equipment. It does not address the architecture data flows and operations that are detailed within ISO 22951. In other terms, this document provides a connected vehicle alternative for request and status communication without impacting the back office or local intersection operations of priority management.

Intelligent transport systems — Cooperative ITS — Using V2I and I2V communications for applications related to signalized intersections

1 Scope

This document defines the message, data structures, and data elements to support exchanges between the roadside equipment and vehicles to address applications to improve safety, mobility and environmental efficiency. In order to verify that the defined messages will satisfy these applications, a systems engineering process has been employed that traces use cases to requirements and requirements to messages and data concepts.

This document consists of a single document that contains the base specification and a series of annexes. The base specification lists the derived information requirements (labelled informative) and references to other standards for message definitions where available. Annex A contains descriptions of the use cases addressed by this document. Annex B and Annex C contain traceability matrices that relate use cases to requirements and requirements to the message definitions (i.e. data frames and data elements). The next annexes list the base message requirements and application-oriented specific requirements (requirements traceability matrix) that map to the message and data concepts to be implemented. As such, an implementation consists of the base plus an additional group of extensions within this document.

Details on information requirements, for other than SPaT, MAP, SSM, and SRM messages are provided in other International Standards. The focus of this document is to specify the details of the SPaT, MAP, SSM, and SRM supporting the use cases defined in this document. Adoption of these messages varies by region and their adoption may occur over a significant time period.

This document covers the interface between roadside equipment and vehicles. Applications, their internal algorithms, and the logical distribution of application functionality over any specific system architecture are outside the scope of this document.

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 22951, *Data dictionary and message sets for preemption and prioritization signal systems for emergency and public transport vehicles (PRESTO)*

ISO 26684, *Intelligent transport systems (ITS) — Cooperative intersection signal information and violation warning systems (CIWS) — Performance requirements and test procedures*

SAE J2735™:2016, *Dedicated Short Range Communications (DSRC) Message Set Dictionary*

EN 302 637-2 V1.3.2, *Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service*

ARIB STD-T109, *700 MHz Band Intelligent Transport Systems*

ITS FORUM RC-010, *700 MHz Band Intelligent Transport Systems — Extended Functions Guideline, published on March 15, 2012*

ETSI/TS 102 894-2 V1.2.2, *Intelligent Transport Systems (ITS); Users and applications requirements; Part 2: Applications and facilities layer; common data dictionary*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

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

NOTE This document requires the understanding of the terminology used in the context of C-ITS and the various devices involved in its implementation. As a result, the following terms contain important information to set the context of the discussions which follow in the remaining sections of this document.

3.1
active manoeuvre
traveller paths (vehicles, pedestrians, bicyclists, etc.) that are allowed and have the right of way to enter and move through the path

Note 1 to entry: This term supersedes allowed movements which meant, in the context of this document, the directions of manoeuvre that are legally allowed at a specific point in time based upon the state of the intersection signals.

Note 2 to entry: Formerly known as active movement.

3.2
aftermarket safety device
ASD
connected device (3.8) in a *vehicle* (3.50) that operates while the vehicle is mobile, but which is not fully integrated into the vehicle systems (as opposed to an OEM device that is pre-installed into the vehicle systems)

3.3
allowed manoeuvre
traveller paths (vehicles, pedestrians, bicyclists, etc.) legally permitted to be performed when moving from/into a *lane* (3.21) or between lanes

3.4
application
software designed to help users perform particular tasks or handle particular types of problems, as distinct from software that controls the computer itself

Note 1 to entry: In the context of this document, it is a software program that provides functionality to realize safety, mobility, and environmental benefits.

[SOURCE: ISO/IEC 26514:2008, 4.5, modified.]

3.5
Barnes dance
signal phase that stops vehicular manoeuvres and allows pedestrian manoeuvres to exclusively occur across the *intersection* (3.17) including diagonally moving between corners

Note 1 to entry: Also referred to as a scramble, or "X" crossing. The term refers to Henry Barnes, a deceased traffic engineer.

3.6
commercial motor vehicle
self-propelled or towed motor *vehicle* (3.50) used on a highway in interstate commerce to transport passengers or property when the vehicle

a) has a gross vehicle weight rating or gross combination weight rating, or gross vehicle weight or gross combination weight, of 4 536 kg (10 001 pounds) or more, whichever is greater,

b) is designed or used to transport more than 8 passengers (including the driver) for compensation,

c) is designed or used to transport more than 15 passengers, including the driver, and is not used to transport passengers for compensation, or

d) is used in transporting material found by the Secretary of Transportation to be hazardous under 49 USC 5103 and transported in a quantity requiring placarding under regulations prescribed by the Secretary under 49 CFR, subtitle B, chapter I, subchapter C

[SOURCE: 49 USC 31132]

3.7
commercial motor vehicle on-board equipment
OBE (3.29) or *ASD* (3.2) mounted or in a *vehicle* (3.50) moving goods, heavy equipment, or people

Note 1 to entry: Vehicles include tractor-trailer combinations, panel trucks, and motor coaches.

3.8
connected device
device used to transmit to or receive messages from another device

Note 1 to entry: A connected device can be sub-categorized as an *OBE* (3.29), *ASD* (3.2), or *RSE* (3.39).

Note 2 to entry: In many cases, the connected device will be a *DSRC* (3.10) device, but other types of communications could be supported.

3.9
connected vehicle
vehicle that contains a *connected device* (3.8)

3.10
dedicated short range communications
DSRC
technology for the transmission of information between multiple *vehicles* (3.50) (V2V) and between vehicles and the transportation infrastructure (V2I and I2V) using wireless technologies

Note 1 to entry: It is characterized as having a limited distance (approximately 300 m) but is assumed to be low latency to establish a connection and exchange information.

Note 2 to entry: Alternative definition - means of effecting (short-range) transactions between fixed equipment and OBE(s) using an “air interface” comprising inductive or propagated signals between the fixed equipment and OBE(s)

[SOURCE: ISO 17687:2007, 3.10 and ISO 17261:2012, 3.15]

3.11
eco-driving
practice of driving in such a way as to minimize fuel consumption and emissions

3.12
eco-lane
dedicated *lane(s)* (3.21) optimized for *eco-driving* (3.11) similar to high-occupancy vehicle lanes

Note 1 to entry: However, these lanes are optimized for the environment using connected vehicle data.

Note 2 to entry: These lanes would be targeted toward low-emission, high-occupancy freight, public transport, and alternative-fuel vehicles (AFV).

Note 3 to entry: Drivers would be able to opt-in to these dedicated eco-lanes to take advantage of eco-friendly applications such as eco-speed limits, eco-cooperative adaptive cruise control, and connected eco-driving applications.

3.13
electronic on-board recorders
device on-board a commercial *vehicle* (3.50) used to record driver information such as hours of service

3.14
inactive manoeuvre
traveller paths (vehicles, pedestrians, bicyclists, etc.) that are allowed and do not have the right of way to enter and move through the path

3.15
intelligent transportation systems
ITS
transport system in which advanced information, communication, sensor, and control technologies, including the Internet, are applied to increase safety, sustainability, efficiency, and comfort

Note 1 to entry: Another appropriate meaning of the ITS acronym is integrated transportation systems, which stresses that ITS systems will often integrate components and users from many domains, both public and private.

[SOURCE: ISO/TR 17465-1:2014, 2.3]

3.16
interoperability
ability of two or more systems or components to exchange information and to use the information that has been exchanged

[SOURCE: IEEE 610.12-1990]

3.17
intersection
nexus where two or more approaches (*links*) (3.26) meet and *vehicles* (3.50) and other type of users may travel between the connecting links

Note 1 to entry: Typically, this is a signalized intersection when considered by this document, and as such, the modes of allowed manoeuvre are reflected in the signal phases, the geometry of the intersection, and the local regulatory environment.

Note 2 to entry: The messages of J2735™ convey some of this intersection information to the travelling public. Specifically, the *MAP message* (3.28) conveys the relevant road geometry, while the *SPaT* (3.44) message conveys the current allowed manoeuvres and timing which control movements within the intersection.

Note 3 to entry: Alternative definition - GDF level 2 representation of a crossing which bounds a road or a ferry as a complex feature composed of one or more GDF level 1 junctions, road elements and enclosed traffic areas

[SOURCE: ISO/TS 20452:2007, 3.14]

3.18
interval
part of a traffic signal cycle during which, *signal indications* (3.43) are stable and do not change

Note 1 to entry: In the *SPaT* (3.44) message, the current timing value for the remaining interval time estimate, as well as the anticipated interval for yellow change (clearance) interval, is provided for each lane.

Note 2 to entry: Because signal interval times commonly change based on triggering events in many types of signalling systems, the value provided in the SPaT message may represent a minimal value that is extended and updated as the message is re-transmitted in real time.

3.19
interval sequence
order of appearance of *signal indications* (3.43) during successive periods of a traffic signal cycle

3.20
international traveller information system
ITIS
standard for incident phrases developed by the SAE ATIS Committee in conjunction with ITE TMDD and other standards

Note 1 to entry: The ITIS documentation contains a wide variety of standard phrases to describe incidents and is expected to be used throughout the *ITS* (3.15) industry. The codes found there can be used for sorting and classifying types of incident events, as well as creating uniform human readable phrases. In the capacity of classifying incident types, ITIS phrases are used in many areas. ITIS phrases can also be freely mixed with text and used to describe many incidents.

3.21
lane
portion of the transportation network (typically a section of roadway geometry) which is being described (its paths and various attributes about it) or referred to

Note 1 to entry: In the DSRC message set, the lane object is widely used. Lanes consist not only of sections of drivable roadway traversed by motor vehicles, but other types of lanes including pedestrian and bicycle walkways, trains and public transport lanes, and certain types of dividers and barriers.

Note 2 to entry: When used in describing an intersection, a lane is defined for each possible path into and out of the intersection (in the MAP message). The current allowed manoeuvres applicable to the lane or its approach are provided in the *SPaT* (3.44) message.

3.22
lane-use control signal
signal face displaying *signal indications* (3.43) to permit or prohibit the use of specific *lanes* (3.21) of a roadway or to indicate the impending prohibition of such use

Note 1 to entry: Typically, these are arrow displays of varying colours.

Note 2 to entry: This document does not attempt to use signal colours/indications to reflect the allowed vehicle operation, rather, the permitted movements are indicated and the state of the movement as explained later herein. Each region has unique mechanisms for using the display signals to indicate the movement(s) allowed.

3.23
latency
<system> time interval between the instant at which an instruction control unit issues a call for data and the instant at which the transfer of data is started

Note 1 to entry: The reader is advised to select the appropriate definition based on the context.

[SOURCE: ISO/IEC IEEE 24765:2010, 3.1565]

3.24
latency
<communication> time delay between sending a signal from one device and receiving it by another device

Note 1 to entry: The reader is advised to select the appropriate definition based on the context.

[SOURCE: ISO/IEEE 11073-10201:2004, 3.31]

3.25
link
<radio frequency> communications channel being used in support of application data transfer needs

3.26
link
<traffic> segment of a road network

Note 1 to entry: While highway links are generally separated by one data collection node (such as an RSE or a vehicle detector station), local road links tend to be limited by intersections with cross streets.

Note 2 to entry: Other common usages of the word “link,” such as those used in telecommunications, may also appear in this document.

3.27
low-emissions zone
geographically defined area that seeks to restrict or deter access by specific categories of high-polluting *vehicles* (3.50) to improve the air quality within the geographic area

Note 1 to entry: The low-emissions zone can be dynamic, allowing the operating entity to change the location, boundaries, or time of the low-emissions zone.

3.28
MAP data message
MAP
data elements and frames comprising a message, the contents of which describe the geometry of a roadway *intersection* (3.17)

Note 1 to entry: In the context of USDOT J2735™ SE Candidate, the MAP message provides the road geometry at an intersection.

Note 2 to entry: It is broadcast from the infrastructure to the vehicle.

Note 3 to entry: The MAP message contains geographic intersection description (GID) data.

3.29
on-board equipment
OBE
compliment of equipment located in the *vehicle* (3.50) for the purpose of supporting the vehicle side of the C-ITS applications

Note 1 to entry: It is likely to include the DSRC radios, other radio equipment, message processing, driver interface, and other applications to support the use cases described herein.

Note 2 to entry: It is also referred to as the vehicle ITS station.

Note 3 to entry: Alternative definition - device on board or attached to the vehicle/equipment to perform the functionality of AVI/AEI

[SOURCE: ISO 17687:2007]

3.30
prohibited manoeuvre
traveller paths (vehicles, pedestrians, bicyclists, etc.) legally disallowed from being performed when moving from/into a *lane* (3.21) or between lanes

3.31
traffic signal phase
set of manoeuvres being allowed by the roadside traffic signal controller

Note 1 to entry: This term is commonly used in North America to refer to a specific manoeuvre that is allowed (e.g. main street left turn to a side street, main street north bound through manoeuvre, side street pedestrian walk.)

3.32
platoon
collection of vehicles travelling together, coordinating their operation (e.g. speed, headway) using V2V communications

Note 1 to entry: Platoons may consist of a mixture of *vehicle types* (3.51) or in special circumstances, a single vehicle type such as freight vehicles (e.g. lorries), public safety vehicles, or *public transport vehicles* (3.35).

3.33
precondition
condition that must exist or be established before something can occur or be considered

