TECHNICAL REPORT

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First edition

Cooperative intelligent transport systems (C-ITS) — Guidelines on the usage of standards —

Part 2: Hybrid communications

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Foreword

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This document was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 278, *Intelligent transport systems,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

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A list of all parts in the ISO 21186 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

This document is part of a family of deliverables from Standard Development Organizations (SDOs) for Cooperative Intelligent Transport Systems (C-ITS), which is a subset of standards for Intelligent Transport Systems (ITS).

ITS aims to improve surface transportation in terms of

— **safety**

e.g. crash avoidance, obstacle detection, emergency call, dangerous goods;

— **efficiency**

e.g. navigation, green wave, priority, lane access control, contextual speed limits, car sharing;

— **comfort**

e.g. telematics, parking, electric vehicle charging, infotainment;

— **sustainability,**

by applying information and communication technologies (ICT).

In the European Union, the legal framework is given by the European Commissions Mandate M/453 on C-ITS[51], the European Commission Directive 2010/40[50], and the European Commission Mandate M/546[52].

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The whole set of standards for deployment of C-ITS is difficult to understand by developers of equipment and software, especially ITS application software, and thus guidelines explaining a beneficial choice of standards (C-ITS Release), the purpose and interaction of standardized features, beneficial implementation approaches and guidance in developing ITS applications are a prerequisite for a fair and open market allowing early deployment of interoperable and future-proof solutions.

The ISO 21186 series provides necessary guidelines in multiple parts, each dedicated to a specific purpose:

— Part 1: Standardization landscape and releases;

— Part 2: Hybrid communications (this document);

— Part 3: Security.

This document can be complemented by further parts as required, for example:

— Usage of the service announcement protocol specified, e.g. in ISO 22418;

— Dynamically extendable data and protocol parameters ("Information Object Classes" and "Information Object Sets"; based on ASN.1 type CLASS);

— Usage of the GDTM framework specified in ISO/TS 21184.

The purpose of this document is thus to inform about relevant standards and to describe the functionalities of the ITS station architecture defined in support for hybrid communication technologies. It is intended to serve as a guideline to structure the development of new C-ITS standards and to harmonize the deployment of C-ITS services relying on the use of hybrid communication technologies. It also intends to give support to the developers of standards defining C-ITS services and to the developers of C-ITS solutions and ITS applications complying with the ITS station architecture and its set of functionalities supporting hybrid communications.

At time of writing this document, no applicable Intellectual Property Rights (IPR) issues were known related to this document. However, this document references standards, for which IPRs are known.

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Information on such IPRs is expected to be provided in those respective standards, which might be from any one of the Standards Development Organisations working on ITS or C-ITS.

Referencing other SDOs and their respective deliverables in no way is to be understood as an endorsement, but rather as an informative piece of information.

More details on the C-ITS domain can be found in the Brochure[56] produced by the CEN/TC 278 Project Team PT 1605.

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Cooperative intelligent transport systems (C-ITS) — Guidelines on the usage of standards —

Part 2: Hybrid communications

1 Scope

This document serves as a guideline explaining the concept of hybrid communications and support functionalities for Cooperative ITS services deployed in conformance with the ITS station architecture and related Cooperative ITS standards.

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 21217, *Intelligent transport systems — Station and communication architecture*

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3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 21217 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
ITS-S flow identifier
identifier, being unique within an ITS station unit, that identifies an ITS-S flow

[SOURCE: ISO 24102-6:2018, 3.9]

3.2
urban WiFi
short-range networked communications WiFi access technology used mostly in urban environments and in personal devices such as smartphones, tablets and laptops

Note 1 to entry: An example of urban WiFi is IEEE 802.11 Basic Service Set (BSS) for WLAN access used in 2,4 GHz or 5,4 GHz frequency range.

3.3
vehicular WiFi
short-range localized communications WiFi access technology specifically designed for vehicular localized communications

Note 1 to entry: An example of vehicular WiFi is IEEE 802.11 operating outside the context of a Basic Service (OCB), also known as IEEE 802.11p[49], used in the 5,9 GHz frequency range reserved for ITS services with profile standards named ITS-G5 (ETSI) in Europe and Australia, and US-DSRC in North America and their harmonization at ISO (ITS-M5).

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4 Symbols and abbreviated terms

CAM	cooperative awareness message
C-ITS	cooperative intelligent transport systems
CPH	communication profile handler
CSH	content subscription handler
DENM	decentralized environmental notification message
DSRC	dedicated short-range communication
ETSI	European Telecommunication Standards Institute
FSH	facilities service handler
IEEE	Institute of Electrical and Electronics Engineers
IPv6	internet protocol version 6
ITS	intelligent transport systems
ITS-S	ITS station
ITS-SU	ITS station unit
LDM	local dynamic map
LiFi	light fidelity
LoRA	long range
LTE-V2X	long term evolution based vehicle-to-everything
OCB	outside the context of a basic-service set
OSI	open systems interconnection
PVT	position, velocity and time
SDO	standards development organization
US-DSRC	american dedicated short range communication
V2X	vehicle-to-vehicle and vehicle-to-roadside
WiFi	wireless fidelity
WSMP	wave short message protocol

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5 Motivations for hybrid communications support

5.1 Connected and cooperative mobility

Intelligent transport systems (ITS) services are traditionally ranged into three categories: road traffic safety, traffic efficiency and comfort (infotainment, value added services, etc.).

ITS services were initially deployed either in the roadside infrastructure (variable message signs, etc.), in vehicles (telematics) or nomadic devices (navigation, traffic alerts, etc.) with little or no interaction

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between the vehicles, other road users and the roadside infrastructure. With the advent of short-range communication technologies, ITS services using the exchange of data between vehicles and the roadside infrastructure then started to appear (electronic fee collection[2],[34]-[36], electric-vehicle charging[3], emergency call[37], etc.). These ITS services are specified to operate in a very controlled environment, with a very specific radio technology, and for a very specific purpose.

While recent generations of vehicles are deployed with built-in communication systems providing connectivity to remote platforms providing services (navigation, software update, telematics, electric vehicle charging, emergency call, etc.), the forthcoming generation of vehicles will cooperate with their surrounding environment (other vehicles, other road users, roadside infrastructure and urban infrastructure). This localized exchange of data improves road safety (crash avoidance, obstacle detection, etc.) and traffic efficiency (traffic information, green wave, lane access control, contextual speed limit, etc.).

Cooperative ITS (C-ITS) services, i.e. ITS services for connected and cooperative mobility that rely on the data exchanged between vehicles (cars, trucks, buses, etc.), other road users (pedestrians, cyclists, etc.), the roadside and urban infrastructure (traffic lights, road tolls, etc.) and control and services centres in the cloud (traffic control centre, service providers, map providers, etc.), and especially on the sharing of data amongst service domains and applications of the same service domain, are thus being developed. See Figure 1.

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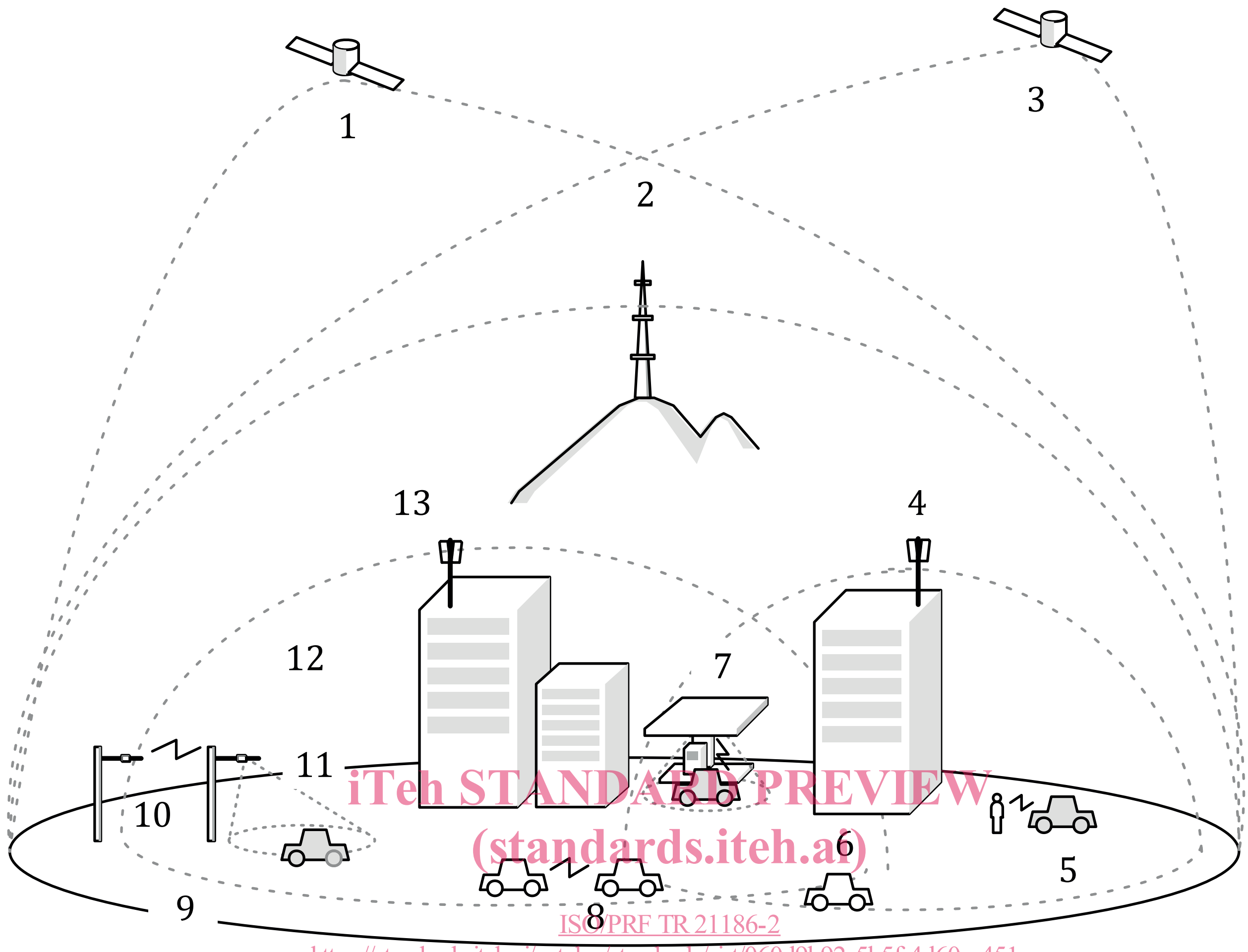

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Key

1 satellite broadcast
2 terrestrial broadcast
3 GPS/GALILEO
4 cellular
5 portable-to-vehicle
6 vehicle-to-centre
7 hot-spot
8 vehicle-to-vehicle
9 localized communications (e.g. 5 GHz, 60 GHz, IR)
10 roadside-to-roadside
11 roadside-to-vehicle
12 centre-to-roadside
13 internet

Figure 1 — Connected and Cooperative Mobility

However, distinct C-ITS services have diverging communication requirements (distribution area, amount of data, delivery delay, privacy, confidentiality, etc.). No single communication technology is able to fulfil all of these requirements at once.

Many communication technologies are available today on the market (cellular 3G/4G, infrared, LiFi, satellite, urban WiFi, vehicular WiFi, LoRA, etc.) and new promising technologies appear regularly. They have very different characteristics (radio coverage range, bandwidth, propagation delay, reliability, price, transmission power), and are more or less prone to security threats (denial of service, intrusion, impersonation, observation). Each of these access technologies has its own benefits and drawbacks with respect to the type of service that is to be delivered.

Due to their diverging characteristics, their geographic penetration, and regional regulations, the combination of several access technologies and protocols is beneficial or even necessary for ensuring reliability, interoperability and sustainable development of C-ITS services. This requires a common approach to the way security, communications and data are handled.

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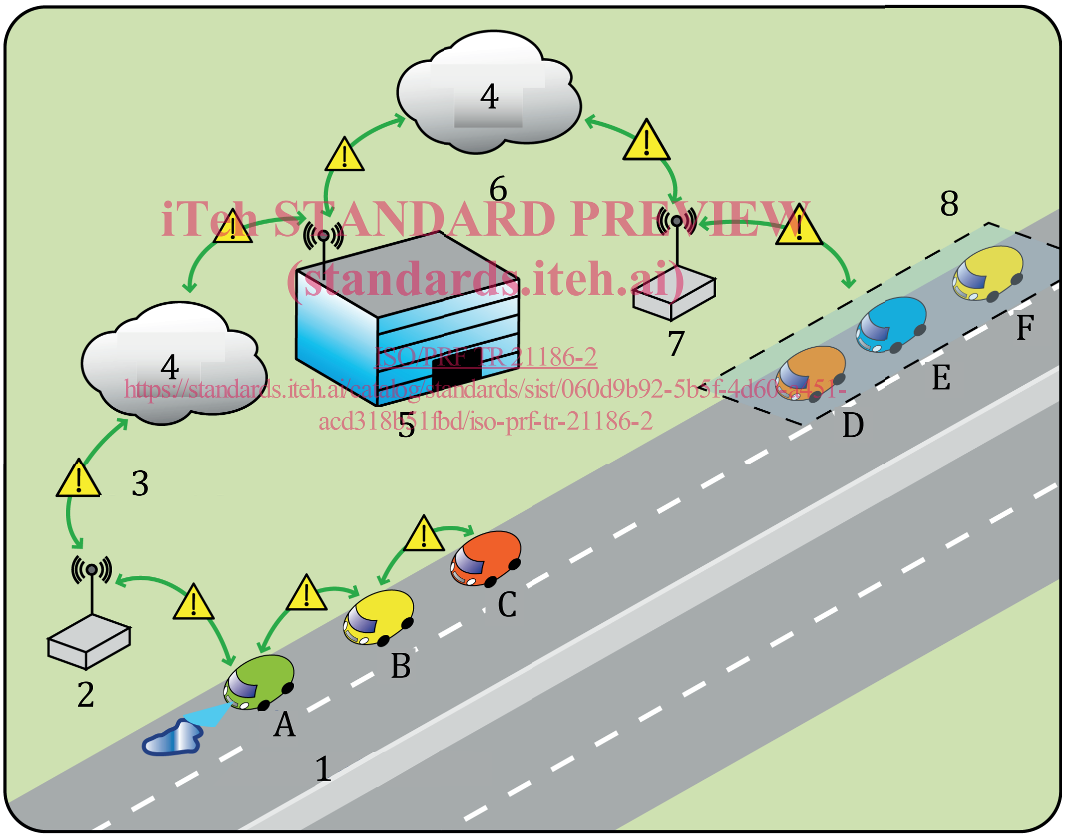
Before requirements for this common approach are discussed in 5.3, subclause 5.2 presents examples illustrating the need to combine a diversity of access technologies.

5.2 Examples of use cases requiring a diversity of access technologies

5.2.1 Road hazard notification (use case 1)

Road hazards present road safety risks that could be leveraged using localized communications (using vehicular WiFi in the 5,9 GHz frequency band, for example) and networked communications (using 3G/4G cellular technology, for example). A typical example is black ice on the road as illustrated on Figure 2.

A vehicle equipped with sensors can detect black ice. If it is equipped with localized communications capabilities it can inform subsequently following vehicles so that they reduce speed in due time and take other automatic actions to ensure safety. All equipped vehicles can relay this alert from vehicle to vehicle, but at some point, there will not be any vehicle able to relay this message further. Consequently, an approaching vehicle still kilometres away will not be informed.



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Key

1 V2V GeoBroadcast
2 RSU 1
3 vehicle A to control centre
4 internet IPv6
5 control centre
6 control centre to vehicles in GeoArea
7 RSU 2
8 roadside unit to vehicles in GeoArea

Figure 2 — Black ice notification using hybrid communications (FP7 GeoNet[54])

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To ensure wide transmission of the alert, vehicles that detect the hazard could transmit a road hazard alert to the road traffic control centre, either directly using networked communications, or through a nearby roadside ITS station unit ("RSU" on Figure 2) using localized communications. The road traffic control centre can thus take necessary actions, like sending a patrol vehicle to secure the area, and inform road users.

In turn, the road traffic centre could inform vehicles approaching the risk area through a roadside ITS station unit located on the road upstream of the risk area that would repetitively broadcast the alert using localized communications or display the hazard through a variable message sign board. Alternatively, the road traffic centre could directly inform each of the vehicles subscribed to a road hazard alert service through networked communications. Such notification could be used to advise vehicles on alternative itineraries.

This example shows the value of using both localized and networked communications to inform vehicles and the control centres about road hazards so that the road hazard alert can be transmitted more widely and effectively. Localized communications are used to inform about an immediate time-critical danger, whereas networked communications are used to inform about dangers upstream of time and location.

5.2.2 Emergency call (use case 2)

A new series of vehicles are now placed on the market with an "emergency call" service which alerts public safety services in case of an accident.

At the time of writing this document, this road safety service relies on a 2nd generation cellular technology with limited capabilities and limited coverage. However, there will continuously be geographical areas not covered by the cellular network, either because there is no base station in the vicinity or because the service is disrupted or overloaded. In such a situation, the emergency call cannot be issued, although access technologies alternatives are available that could replace or complement the cellular network.

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A case in which localized communications technologies could be useful is a situation in which a vehicle has driven off the road and has fallen into a canyon. The passengers are still alive, but unable to get out of the vehicle. There is no cellular coverage, so the emergency call cannot be transmitted. However, the vehicle is not far from the road and is in radio coverage using localized communications. If the emergency call could be supplied over that localized communications link in addition to the cellular network, passing-by vehicles could get the emergency call and relay it to public safety services as soon as they are in cellular radio coverage, or when they reach a roadside ITS station unit ("RSU").

A first related standard on "eCall via an ITS station" is CEN/TS 17182[37].

5.2.3 Public transport (use case 3)

Recent fleets of buses are deployed with communication technologies providing different types of services: buses are usually equipped with tracking capabilities to monitor the progress of the bus on the itinerary and inform passengers waiting at bus stops. They are also often equipped with a video capability in order to inform the control centre in an emergency situation; and sometimes with a system allowing priority of buses at crossroads. The newest generations of buses would of course also be equipped with with road safety services (see 5.2.1) and with emergency call (see 5.2.2).

As a consequence, buses are equipped with multiple communication systems. Each service is deployed using its own antenna, radio technology, hardware, software and screen, and has its own proprietary or standardized data format. These frequently duplicate one another, as there could be several communication systems deployed using the same access technology, e.g. cellular. This is not efficient in terms of cost, complexity and reliability. Overall, all of these communication systems are unable to exchange data between one another. An emergency call can thus not be transmitted using an alternative access technology if one fails or if the bus is out of cellular network coverage.

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