TECHNICAL REPORT

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

Part 2: Hybrid communications

Systèmes de transport intelligents coopératifs (C-ITS) - Lignes directrices sur l'utilisation des normes —
Partie 2: Communications hybrides

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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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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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).

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.

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 calls, 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[53], the European Commission Directive 2010/40[52], and the European Commission Mandate M/546[54].

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[14];

— Part 2: Hybrid communications (this document);

— Part 3: Security[15].

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

— Usage of the service announcement protocol specified, for example, 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 GTDM framework specified in ISO/TS 21184[1)].

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.

1) Under preparation. Stage at the time of publication: ISO/PRF TS 21184:2021.

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. 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 cited in Reference [58].

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

There are no normative references in this document.

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:

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

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

3.1
access technology
technology employed in a communication interface to access a specific medium

[SOURCE: ISO 21217:2020, 3.1]

3.2
communication adaptation layer
CAL
set of protocols and functions to adapt access technologies to the *ITS-S networking and transport layer* (3.20)

[SOURCE: ISO 21217:2020, 3.3]

3.3
hybrid communications
composition of multiple access technologies and communication protocols combined to provide complementary or redundant communication channels

[SOURCE: ISO 21217:2020, 3.7]

3.4
hybrid communication support
feature of an ITS station used to combine multiple access technologies and protocols

[SOURCE: ISO 21217:2020, 3.8]

3.5
hybrid ITS service
ITS service that relies on *hybrid communications* (3.3)

[SOURCE: ISO 21217:2020, 3.9]

3.6
ITS station
ITS-S
functional entity comprised of an *ITS-S facilities layer* (3.13), *ITS-S networking and transport layer* (3.20), *ITS-S access layer* (3.7), ITS-S management entity, ITS-S security entity and *ITS-S applications* (3.9) entity providing ITS services

Note 1 to entry: From an abstract point of view, the term "ITS station" refers to a set of functionalities. The term is often used to refer to an instantiation of these functionalities in a physical unit. Often, the appropriate interpretation is obvious from the context. The proper name of the physical instantiation of an ITS-S is ITS station unit (ITS-SU).

[SOURCE: ISO 21217:2020, 3.15]

3.7
ITS-S access layer
protocol layer in the ITS-S reference architecture containing the OSI physical and data link layer protocols for ITS communications

[SOURCE: ISO 21217:2020, 3.16]

3.8
ITS-S access technology
access technology (3.1) dedicated to operation in an *ITS station* (3.6)

[SOURCE: ISO 21217:2020, 3.20]

3.9
ITS-S application
ITS-S application process (3.10) residing in the ITS-S application entity

[SOURCE: ISO 21217:2020, 3.21]

3.10
ITS-S application process
element in an *ITS station* (3.6) that performs information processing for a particular application and uses ITS-S services to transmit and receive information

[SOURCE: ISO 21217:2020, 3.22]

3.11
ITS-S capability
uniquely addressable protocol or functionality that is part of an *ITS-S managed service entity* (3.19)

Note 1 to entry: Examples of ITS-S capabilities in the *ITS station* (3.6) facilities layer are generic *ITS-S facilities layer* (3.13) services specified in ISO/TS 17429 (Communication Profile Handler, Facilities Services Handler, Content Subscription Handler), the position and time service defined in ISO/TS 21176, the security services defined in ISO/TS 21177; examples of ITS-S capabilities in the *ITS-S networking and transport layer* (3.20) are IPv6 functionalities defined in ISO 21210 (IPv6 neighbour discovery, IPv6 forwarding, IPv6 mobility support, etc.), the fast service announcement protocol defined in ISO 22418, etc.

[SOURCE: ISO 21217:2020, 3.24]

3.12
ITS-S communication profile
ITS-SCP
parameterized ITS-S communication protocol stack (set of protocols composing all the *ITS station* (3.6) layers) that allows communication end points to communicate with one another

[SOURCE: ISO 21217:2020, 3.25, modified.]

3.13
ITS-S facilities layer
layer in the ITS-S reference architecture containing OSI layers 5, 6 and 7 that connects applications to the *ITS-S networking and transport layer* (3.20)

[SOURCE: ISO 21217:2020, 3.31]

3.14
ITS-S flow
identifiable sequence of packets of a given *ITS-S flow type* (3.16) transmitted between a source node and a destination node.

[SOURCE: ISO 21217:2020, 3.36]

3.15
ITS-S flow identifier
identifier, being unique within an *ITS station* (3.6) unit, that identifies an *ITS-S flow* (3.14)

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

3.16
ITS-S flow type
set of characteristics describing a data flow

[SOURCE: ISO 21217:2020, 3.37]

3.17
ITS-S flow type identifier
identifier being unique within the *ITS station* (3.6) that identifies an *ITS-S flow type* (3.16)

[SOURCE: ISO 24102-6:2018, 3.11]

3.18
ITS-S host
ITS-S node (3.21) comprised of ITS-S functionalities other than the functionalities of an *ITS-S router* (3.23), ITS-S border router, ITS-S mobile router, or an ITS-S gateway

[SOURCE: ISO 21217:2020, 3.39]

3.19
ITS-S managed service entity
MSE
uniquely addressable entity in an ITS-S layer comprised of a set of related ITS-S capabilities

Note 1 to entry: Examples of ITS-S managed service entities are: a communication module in the ITS-S access technologies layer (M5, cellular, etc.), a protocol suite in the ITS-S networking & transport layer (IPv6, FNTP, GeoNetworking, 6LoWPAN, etc.), the generic facilities at the *ITS-S facilities layer* (3.13) (COH, FSH, CSH).

[SOURCE: ISO 21217:2020, 3.42]

3.20
ITS-S networking and transport layer
layer in the ITS-S reference architecture containing OSI layers three and four that connects the *ITS-S facilities layer* (3.13) to the *ITS-S access layer* (3.7)

[SOURCE: ISO 21217:2020, 3.46]

3.21
ITS-S node
node comprised of a set of functionalities in an *ITS station* (3.6) unit that is connected to the ITS station-internal network or comprises an entire ITS station unit

[SOURCE: ISO 21217:2020, 3.47]

3.22
ITS-S path
directed sequence of nodes connected by links starting at a source node, traversing a communication interface of the source ITS-S, an ITS-S ingress anchor node and an ITS-S egress anchor node, ending at a destination node

[SOURCE: ISO 21217:2020, 3.48]

3.23
ITS-S router
ITS-S node (3.21) comprised of routing functionalities of an *ITS station* (3.6) unit used to connect two networks and to forward packets not explicitly addressed to itself

[SOURCE: ISO 21217:2020, 3.49]

3.24
localized communications
communications with nearby stations without involving support of an infrastructure network

[SOURCE: ISO 21217:2020, 3.53]

3.25
networked communications
communications using support of an infrastructure network

[SOURCE: ISO 21217:2020, 3.60]

3.26
urban WiFi
short-range *networked communications* (3.25) WiFi *access technology* (3.1) 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.

3.27
vehicular WiFi
short-range *localized communications* (3.24) WiFi *access technology* (3.1) 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[51], 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).

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-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

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 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],[36]-[38], electric-vehicle charging[3], emergency call[39], 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.

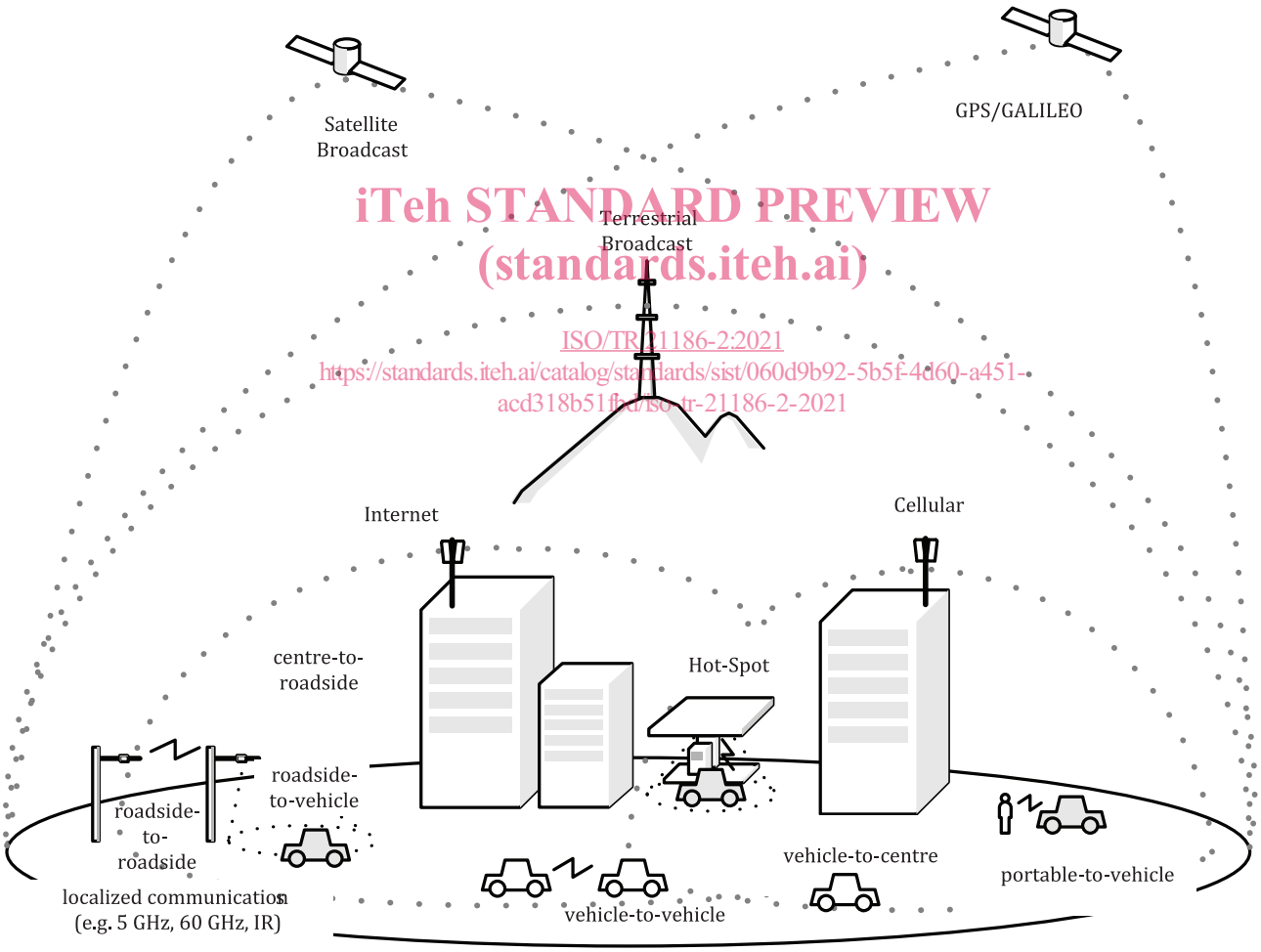

Figure 1 — Connected and Cooperative Mobility

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