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Intelligent transport systems — Station and communication architecture

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National foreword

This British Standard is the UK implementation of ISO 21217:2020. It supersedes BS ISO 21217:2014, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EPL/278, Intelligent transport systems.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Third edition
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Intelligent transport systems — Station and communication architecture

Systèmes de transport intelligents — Architecture du station et du communication

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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.*

This third edition cancels and replaces the second edition (ISO 21217:2014), which has been technically revised.

The main changes compared to the previous edition are as follows:

— many general alignments with other standards (e.g. on terms and abbreviations, and on references) revised or developed since the publication of the second edition of this document;

— prioritization in the receive path added;

— more details on hybrid communications included;

— details on security requirements added.

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 provides the intelligent transport systems (ITS) station and communication reference architecture that is referenced in a family of deliverables from standard development organizations (SDOs) for cooperative intelligent transport systems (C-ITS), which is a subset of standards for 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; and

— **sustainability**,

by applying information and communication technologies (ICT).

ITS specifications are in general developed to address a specific ITS service domain (see ISO 14813-1), such as public transport, road safety, freight and logistics, public emergencies or electronic fee collection.

To support interoperability, C-ITS specifications are developed to exchange and share information amongst ITS applications of a given application domain and even between application domains.

C-ITS services are based on the exchange of data between vehicles of any category (cars, trucks, buses, emergency and specialized vehicles, etc.), the roadside and urban infrastructure (traffic lights, road tolls, variable message signs, etc.), control and services centres (traffic control centre, service providers, map providers, etc.), and other road users (pedestrians, cyclists, etc.).

Some ITS services require cooperation by vehicles with their surrounding environment (other vehicles, other road users, roadside and urban infrastructure, etc.) while other ITS services require connectivity to remote service platforms (road traffic control centres, map providers, service providers, fleet managers, equipment manufacturers, etc.).

In order to support:

— a large variety of C-ITS services with diverging requirements, and

— efficient sharing of information maintained by individual service applications,

it is necessary to combine multiple access technologies and communication protocols with distinct performance characteristics (communication range, available bandwidth, end-to-end transmission delay, quality of service, security, etc.); see Figure 1.

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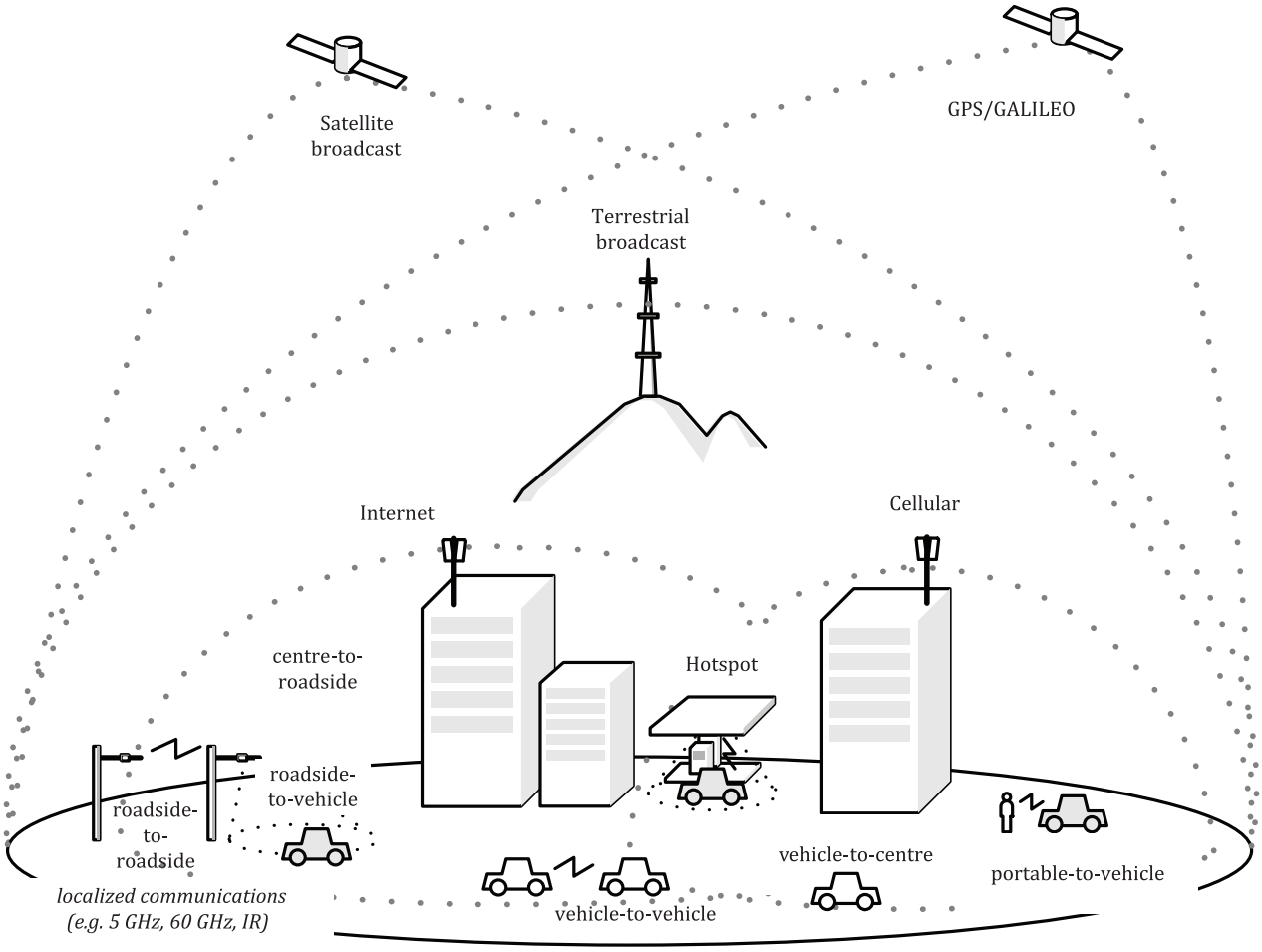

Figure 1 — Examples of ITS communications

Combining multiple access technologies and communication protocols requires a common approach to the way communications and data are securely managed, which is specified in this document (see Figure 2).

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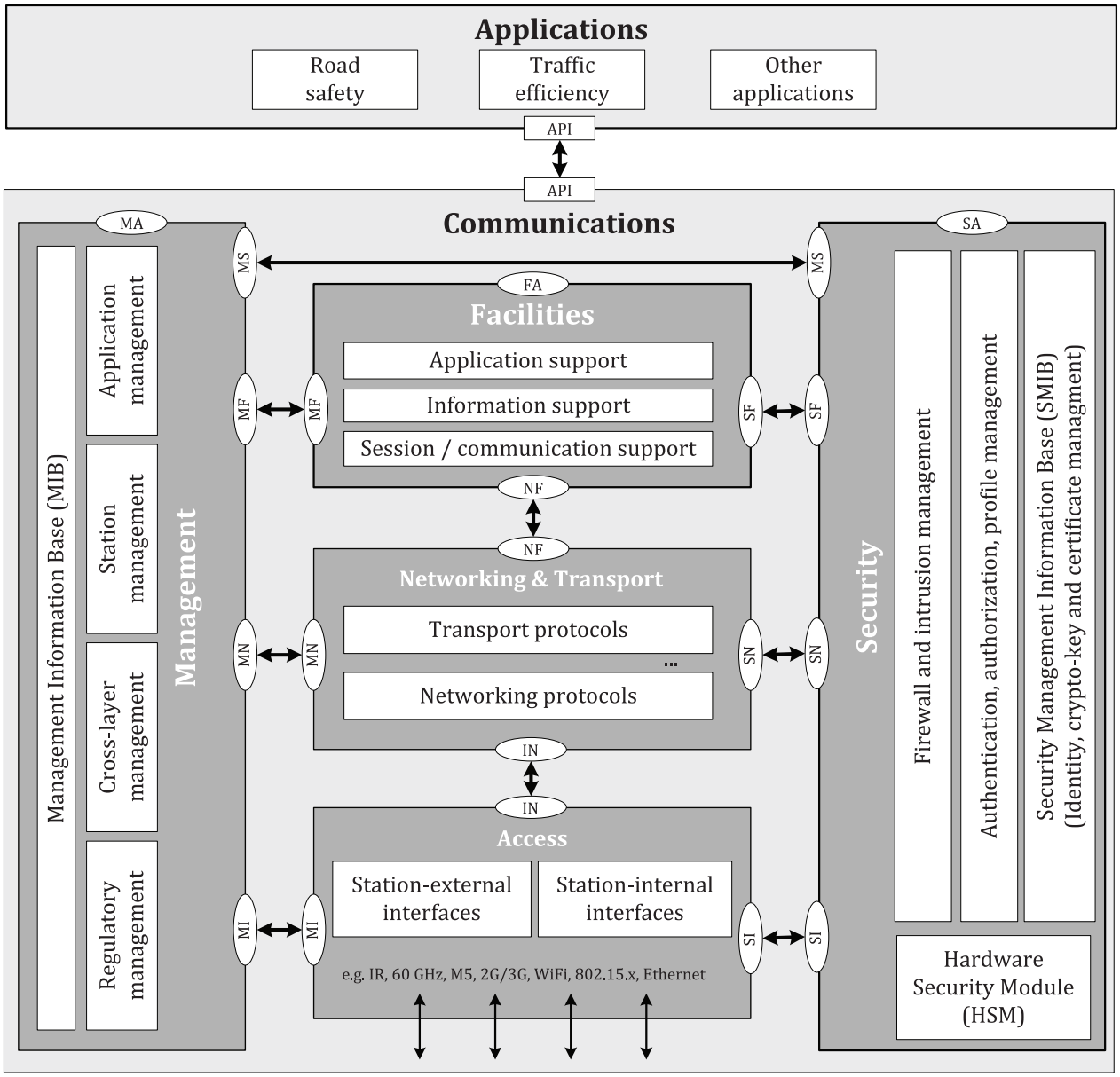

Figure 2 — ITS-S reference architecture

Similarly to the ISO Open Systems Interconnection (OSI) 7-layer architecture, the ITS station architecture is divided into three independent communication layers (namely the ITS station access layer, the ITS station networking and transport layer and the ITS station facilities layer) on top of which the ITS Applications entity is located. Additional cross-layer entities in charge of the management activities (management of ITS station units, of communications and security) support communications and applications.

An implementation of this ITS station architecture is referred to as an “ITS station unit" (ITS-SU). The functionalities available in an ITS-SU can be implemented in one or multiple physical units, referred to as “ITS station communication units” (ITS-SCUs). The various ITS-SCUs of one single ITS-SU may even be split over a large geographical area, e.g. along a motorway several tens of kilometres in length.

ITS-SUs conformant with this document may be deployed in various environments, including vehicles of any kind (vehicle ITS station), on the roadside infrastructure (roadside ITS station), in data centres (central ITS station) or in nomadic devices (personal ITS station), as illustrated in Figure 3.

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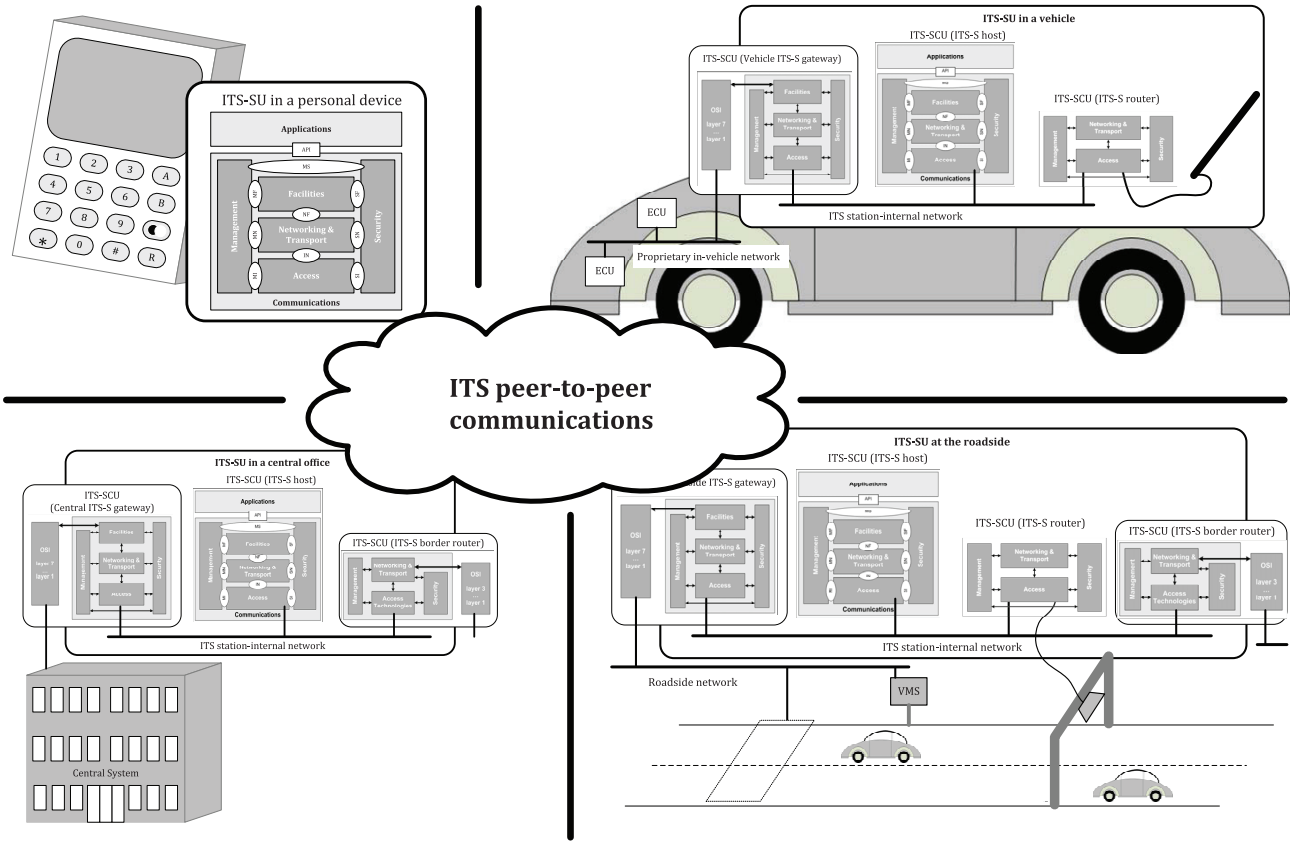

Figure 3 — Typical implementations of ITS station units

Details of the following functional building blocks of the ITS station architecture are specified in a set of related standards:

— ITS station management,

— ITS communication, application (service) and station security,

— ITS station facilities layer protocols,

— ITS station networking and transport layer protocols,

— communication interfaces (CIs) designed specifically for ITS applications and services such as those designed specifically for safety of life and property,

— interfacing existing access technologies into ITS stations,

— distributed implementations of ITS stations, and

— interfacing ITS stations to existing communication networks and communicating with nodes thereon.

As C-ITS deals with safety of human life and property, ITS station units are designed for supporting the secure provision of the C-ITS services and secure allocation of resources with prioritized access. Security means covering the two essential operational modes:

a) Authentication of the sender of a broadcast message used for information dissemination.

b) Secure session establishment and maintenance.

Due to the diverging requirements from the multiplicity of already known and continuously emerging ITS applications, multiple communication technologies that are fundamentally different may be

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supported in a specific ITS-SU. Supporting multiple access technologies and communication protocols, also referred to as "hybrid communications", is a design principle of the ITS station architecture. The ITS station architecture is thus specified with no pre-defined mandatory communication technologies. It can support any type of existing and forthcoming technology, on the condition that:

1) it respects the same design principles;

2) its integration into the ITS station architecture is specified in a support standard, and

3) it preserves backward compatibility with existing standards.

Presently, specifications have been developed to support a number of access technologies, for example:

— all kinds of cellular access technologies (e.g. specified at 3GPP with profile standards from other SDOs tailoring them to the ITS station reference architecture);

— satellite communications;

— other technologies such as infrared, millimetre wave (ultra wideband communications), vehicular Wi-Fi (ITS-G5/US-DSRC/ITS-M5: all profiles of IEEE 802.11 OCB) and optical light communications;

and several flavours of communication protocol suites:

— GeoNetworking / Basic Transport Protocol from ETSI;

— FNTP from ISO;

— WSMP from IEEE; and

— the suite of IPv6 protocols from IETF with supporting specifications from ISO.

The ITS station architecture actually combines:

a) localized communications,

   i.e. communications to nearby stations without involving networking from a source station through nodes of a network to a final destination station – also referred to as "ad-hoc communications", and

b) networked communications.

NOTE While networked communications (e.g. cellular communications and access to internet) can apply the principle of "Technology Neutrality" (allowing simultaneous usage of a mix of incompatible access technologies), it is necessary for localized communication between ITS station units to be based on a specific access technology per service (or service domain) in order to enable interoperability.

EXAMPLE ITS-M5 (ISO 21215) with FNTP (ISO 29281-1) is an example of a protocol stack for localized communications. Cellular network access to internet (ISO 17515-1) with IPv6 (ISO 21210) is an example of a protocol stack for networked communications.

Unlike many legacy applications, the choice of the access technology and communication protocol can be made transparent to the applications, i.e. ITS applications are technology-agnostic. This is achieved through a number of functionalities across the ITS station architecture in support of hybrid communications, and is illustrated in Figure 4.

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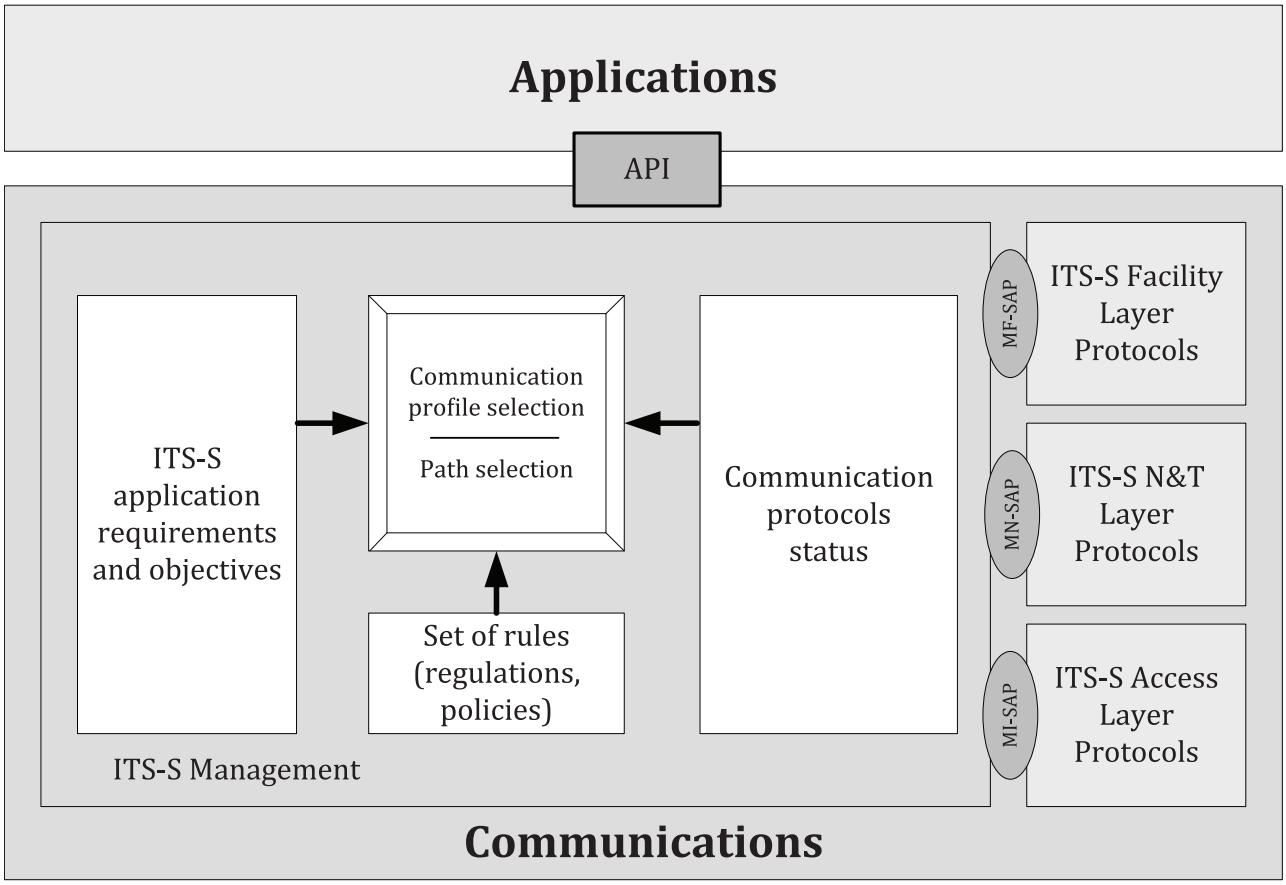

Figure 4 — Architecture of communication profile and path selection

Before transmitting data, applications provide their communication requirements (level of priority, amount of data to be transmitted, expected level of security, expected end-to-end transmission delay, etc.) to the management entity of the ITS-SU for each type of communication flow. In the meantime, the management entity maintains various elements of information (local regulation enforcing the use of a specific communication profile, existing capabilities of the ITS-SU and their status, characteristics and load of available radio technologies, current load of the ITS-SU, etc.). Based on the communication requirement and the current view of the management, the uppermost relevant communication profile (uniquely identified by an ITS-S communication profile identifier) is selected and ITS station resources are securely committed for identified communication flow.

The ITS station architecture serves as a reference for numerous C-ITS services developed around the world, and more particularly, in Europe. Early deployments of C-ITS services conforming to the ITS station architecture have been initiated in Europe under the framework of the C-ROADS[115] and InterCor initiatives supported by the European Commission. National pilot deployments are underway all across Europe (for example, SCOOP in France, NordicWay in Scandinavia, the C-ITS corridor project between The Netherlands, Germany, and Austria) and in other regions such as Austroads in Australia and New Zealand, and in Israel. These early deployment projects are typically focused on road safety and traffic efficiency services that rely on the exchange of data between vehicles and the roadside infrastructure. This data exchange is performed through both localized communications and networked communications.

In these European deployments, localized communications, also known as V2X, are performed using the ITS-G5 access technology within the 5.9 GHz frequency band, a Wi-Fi profile designed for vehicular communications. Networked communications are typically performed using a cellular technology (e.g. LTE). Other technologies may of course be used in the future (e.g. 5G, infrared, etc.) provided that they conform to the ITS station architecture and related standards defining technology building blocks.

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Early deployments have proven the need to deploy C-ITS services using a range of access technologies, for example either ITS-G5 or LTE, or a combination of both. For instance, the French pilot deployment (SCOOP) uses ITS-G5 between vehicle and roadside ITS stations to inform about immediate dangers (CAM, DENM) and LTE is used by patrol vehicles to provide information to road control centres. In Scandinavia, the scarce population has driven NordicWay to deploy roadside ITS stations only at critical locations and to rely on LTE to deliver environmental information (DENM) from road control centres to vehicles.

Further on, at the early stage of deployment of C-ITS services, the density of vehicle ITS stations equipped with ITS-G5 capabilities is scarce, whereas roadside ITS stations are only deployed in critical areas. Similarly, many areas anywhere in the world do not have the benefit of sufficient cellular network coverage. While some time critical road safety C-ITS services are best served by localized communications (e.g. notification of immediate danger requiring emergency breaking), there are not always vehicles equipped with the ITS-G5 technology or roadside equipment in the vicinity able to relay the notification immediately to nearby vehicles. In such a situation, using networked communications (e.g. cellular) to provide the information to road control centres, and then from them back to vehicles in a specific area, prevents the successive occurrence of road accidents.

All of these experiences, gained through early deployments, demonstrate that it is not possible to provide the same level of services to all vehicles in all locations. The type of service and the performance of the service depends on national decisions, the local road environment, the density of population, the density of vehicles equipped, cellular coverage, and numerous other factors. In addition, and importantly, the roadside infrastructure equipment and vehicles have a life expectancy that far exceeds the innovation cycle of new radio and communication technologies. Equipment at the roadside and in vehicles is therefore likely to have to accommodate new communications technologies during its lifetime.

The ITS station and communication architecture specified in this document and its functionalities in support of hybrid communications provide an answer to these concerns and enable a future-proof and sustainable deployment of C-ITS services.

This architecture document is complemented by

— a business-oriented architecture specified in ISO 17427-1;

— testing architectures specified in ISO/TS 20026 and ETSI EG 202 798; and

— data registration procedures for ITS safety and emergency messages specified in ISO 24978.

Further on, guidelines on the topics related to this document are provided in the ISO 17427 series and in the ISO 21186 series.

The Bibliography at the end of this document provides information on standards, draft standards and new standard work items from various SDOs, and about other documentation relevant to ITS. The information given there does not claim to be complete. There can be further standards and documentation relevant to ITS, either already in existence, or available in the future.

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Intelligent transport systems — Station and communication architecture

1 Scope

This document describes the communications reference architecture of nodes called "ITS station units" designed for deployment in intelligent transport systems (ITS) communication networks. The ITS station reference architecture is described in an abstract manner. While this document describes a number of ITS station elements, whether or not a particular element is implemented in an ITS station unit depends on the specific communication requirements of the implementation.

This document also describes the various communication modes for peer-to-peer communications over various networks between ITS communication nodes. These nodes can be ITS station units as described in this document or any other reachable nodes.

This document specifies the minimum set of normative requirements for a physical instantiation of the ITS station based on the principles of a bounded secured managed domain.

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/TS 21177, *Intelligent transport systems — ITS station security services for secure session establishment and authentication between trusted devices*

NOTE Document also available as CEN/TS 21177.

ETSI TS 103 097, *Intelligent Transport Systems (ITS); Security; Security header and certificate formats*

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* (3.4) to access a specific *medium* (3.55)

3.2
application data unit
ADU
data unit exchanged between *ITS-S application processes* (3.22)

3.3
communication adaptation layer
CAL
set of protocols and functions to adapt access technologies to the ITS-S networking & transport layer

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3.4
communication interface
CI
instantiation of a specific *access technology* (3.1) and ITS-S access layer protocol

3.5
communication path
directed sequence of nodes connected by links, starting at a source node and ending at one or more destination nodes

3.6
FA Interface
interface between the ITS-S facilities layer and the *ITS-S applications* (3.21) entity

3.7
hybrid communications
composition of multiple access technologies and communication protocols combined to provide complementary or redundant communication channels

3.8
hybrid communication support
feature of an *ITS station* (3.15) used to combine multiple access technologies and protocols

3.9
hybrid ITS services
ITS service that relies on *hybrid communications* (3.7)

3.10
IN Interface
interface between the ITS-S access layer and the ITS-S networking & transport layer

3.11
in-vehicle network
IVN
generic term for a network in a vehicle which is not an ITS station-internal network

3.12
ITS application
instantiation of an ITS service that involves an association of two or more complementary *ITS-S application* (3.21) processes

Note 1 to entry: Fragments of an application can also reside in nodes that are not *ITS stations* (3.15).

3.13
ITS message set
set of messages designed for an ITS-related purpose

3.14
ITS service
functionality provided to users of intelligent transport systems designed to increase safety, sustainability, efficiency, or comfort, for example

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3.15
ITS station
functional entity comprised of an ITS-S facilities layer, ITS-S networking & transport layer, ITS-S access layer, ITS-S management entity, ITS-S security entity and *ITS-S applications* (3.21) entity providing *ITS services* (3.14)

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 physical instantiation of an ITS-S is *ITS station unit (ITS-SU)* (3.52).

3.16
ITS-S access layer
protocol layer in the ITS-S reference architecture containing the OSI physical and data link layer protocols for ITS communications

3.17
ITS-S access layer protocol data unit
ITS-APDU
protocol data unit exchanged between peer *ITS-S access layers* (3.16)

3.18
ITS-S access layer service data unit
ITS-ASDU
service data unit exchanged between *ITS-S access layer* (3.16) and ITS-S networking & transport layer

3.19
ITS-S access router
ITS-S border router (3.23) with additional functionality that provides other ITS communication nodes a point of attachment to an external network

3.20
ITS-S access technology
access technology (3.1) dedicated to operation in an *ITS station* (3.15)

3.21
ITS-S application
ITS-S application process (3.22) residing in the ITS-S application entity

3.22
ITS-S application process
element in an *ITS station* (3.15) that performs information processing for a particular application and uses *ITS-S services* (3.51) to transmit and receive information

3.23
ITS-S border router
ITS-S router with additional functionality that provides connectivity to other ITS communication nodes over external networks

3.24
ITS-S capability
uniquely addressable protocol or functionality that is part of an *ITS-S managed service entity* (3.42)

Note 1 to entry: Examples of ITS-S capabilities in the *ITS station* (3.15) facilities layer are generic ITS-S facilities layer 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 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.

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3.25
ITS-S communication profile
parameterized *ITS-S communication protocol stack* (3.28)

3.26
ITS-S communication profile identifier
globally unique, registered reference number identifying an *ITS-S communication profile* (3.25)

3.27
ITS-S communication protocol
protocol used in a communication protocol stack of an *ITS station* (3.15)

3.28
ITS-S communication protocol stack
consistent set of *ITS-S communication protocols* (3.27) enabling communications between an *ITS-SCU* (3.30) and other nodes which may be identified by a registered globally unique reference number

3.29
ITS-S communication protocol stack identifier
globally unique, registered reference number identifying a non-parameterized communications protocol stack

3.30
ITS-S communication unit
ITS-SCU
physical unit in an *ITS station unit* (3.52) containing a part or all of the functionality of an *ITS station* (3.15)

Note 1 to entry: If an ITS-SU consists of a single physical unit, the ITS-SU and the ITS-SCU are identical. If an ITS-SU consists of more than one ITS-SCU, then these ITS-SCUs are interconnected via the ITS station-internal network of the ITS-SU.

3.31
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 & transport layer

3.32
ITS-S facilities layer protocol data unit
ITS-FPDU
protocol data unit exchanged between peer ITS-S facility layers

3.33
ITS-S facilities layer service data unit
ITS-FSDU
service data unit exchanged between *ITS-S facilities layer* (3.31) and *ITS-S application* (3.21) entity

3.34
ITS-S facilities service
ITS-S capability (3.24) of the *ITS-S facilities layer* (3.31) providing a service that may be applied to *ADUs* (3.2) at the request of the source ITS-S-AP

3.35
ITS-S facility application
ITS-S application process (3.22) residing in the *ITS-S facilities layer* (3.31)

3.36
ITS-S flow
identifiable sequence of packets of a given *ITS-S flow type* (3.37) transmitted between a source node and a destination node

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3.37
ITS-S flow type
set of characteristics describing a data flow

3.38
ITS-S gateway
ITS-S node (3.47) used to interconnect two different OSI protocol stacks at layers 5 through to 7

Note 1 to entry: An ITS-S gateway can convert between different protocols

3.39
ITS-S host
ITS-S node (3.47) comprised of ITS-S functionalities other than the functionalities of an ITS-S router, *ITS-S border router* (3.23), *ITS-S mobile router* (3.43), or an *ITS-S gateway* (3.38)

3.40
ITS-S internal router
ITS-S router (3.49) that connects two or more ITS station-internal networks

3.41
ITS-S management application
ITS-S application process (3.22) residing in the ITS-S management entity

3.42
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 and transport layer (IPv6, FNTP, GeoNetworking, 6LoWPAN, etc.), the generic facilities at the *ITS-S facilities layer* (3.31) (CPH, FSH, CSH).

3.43
ITS-S mobile router
ITS-S border router (3.23) with additional functionality that allows a change of point of attachment to an external network while maintaining session continuity

3.44
ITS-S networking & transport layer protocol data unit
ITS-NTPDU
protocol data unit exchanged between peer ITS-S networking & transport layers

Note 1 to entry: The deprecated term ITS-NPDU is in use in published standards with the same meaning as ITS-NTPDU.

3.45
ITS-S networking & transport layer service data unit
ITS-NTSDU
service data unit exchanged between *ITS-S networking & transport layer* (3.46) and *ITS-S facilities layer* (3.31)

3.46
ITS-S networking & transport layer
layer in the ITS-S reference architecture containing OSI layers three and four that connects the *ITS-S facilities layer* (3.31) to the *ITS-S access layer* (3.16)

3.47
ITS-S node
node comprised of a set of functionalities in an *ITS station* (3.15) unit that is connected to the ITS station-internal network or comprises an entire *ITS station unit* (3.52)

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3.48
ITS-S path
directed sequence of nodes connected by links starting at a source node, traversing a *communication interface* (3.4) of the source ITS-S, an ITS-S ingress anchor node and an ITS-S egress anchor node, ending at a destination node

3.49
ITS-S router
ITS-S node (3.47) comprised of routing functionalities of an *ITS station unit* (3.52) used to connect two networks and to forward packets not explicitly addressed to itself

3.50
ITS-S security application
ITS-S application process (3.22) residing in the ITS-S security entity

3.51
ITS-S service
communication functionality of an *ITS station* (3.15) that provides the capability to connect to other nodes

3.52
ITS station unit
implementation of an *ITS station* (3.15)

3.53
localized communications
communications with nearby stations without involving support of an infrastructure network

3.54
MA Interface
interface between the ITS-S management entity and *ITS-S applications* (3.21)

3.55
medium
physical entity that supports the transmission of signals carrying information between ITS communication nodes

EXAMPLE A set of wires supporting Ethernet signals or the space between two antennas that supports electromagnetic, optical or acoustical transmissions.

3.56
MF Interface
interface between the ITS-S management entity and the *ITS-S facilities layer* (3.31)

3.57
MI Interface
interface between the ITS-S management entity and the *ITS-S access layer* (3.16)

3.58
MN Interface
interface between the ITS-S management entity and the *ITS-S networking & transport layer* (3.46)

3.59
MS Interface
interface between the ITS-S management entity and the ITS-S security entity

3.60
networked communications
communications using support of an infrastructure network

3.61
NF Interface
interface between the *ITS-S networking & transport layer* (3.46) and the *ITS-S facilities layer* (3.31)

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3.62
SA Interface
interface between the ITS-S security entity and *ITS-S applications* (3.21)

3.63
SF Interface
interface between the ITS-S security entity and the *ITS-S facilities layer* (3.31)

3.64
SI Interface
interface between the ITS-S security entity and the *ITS-S access layer* (3.16)

3.65
SN Interface
interface between the ITS-S security entity and the *ITS-S networking & transport layer* (3.46)

4 Symbols and abbreviated terms

API	application programming interface
BSM	basic safety message
BSMD	bounded secured managed domain
BSME	bounded secured managed entity
BTP	Basic Transport Protocol
CAM	cooperative awareness message
CCH	control channel
CEN	European Committee for Standardization (Commission Européenne de Normalization)
C-ITS	cooperative ITS
C-ITS-SU	central ITS-SU
DCC	distributed congestion control
DENM	decentralized environmental notification message
DLL	data link layer (OSI)
DSRC	dedicated short range communication
ETSI	European Telecommunications Standards Institute
FA	name of interface between ITS-S facilities layer and ITS-S application entity
FlowID	identifier, being unique within an ITS station unit, that identifies an ITS-S flow
FNTP	Fast Networking & Transport Layer Protocol
FSAP	Fast Service Announcement Protocol
HMI	human machine interface
HSM	hardware security modules

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