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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

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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.*

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.

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.

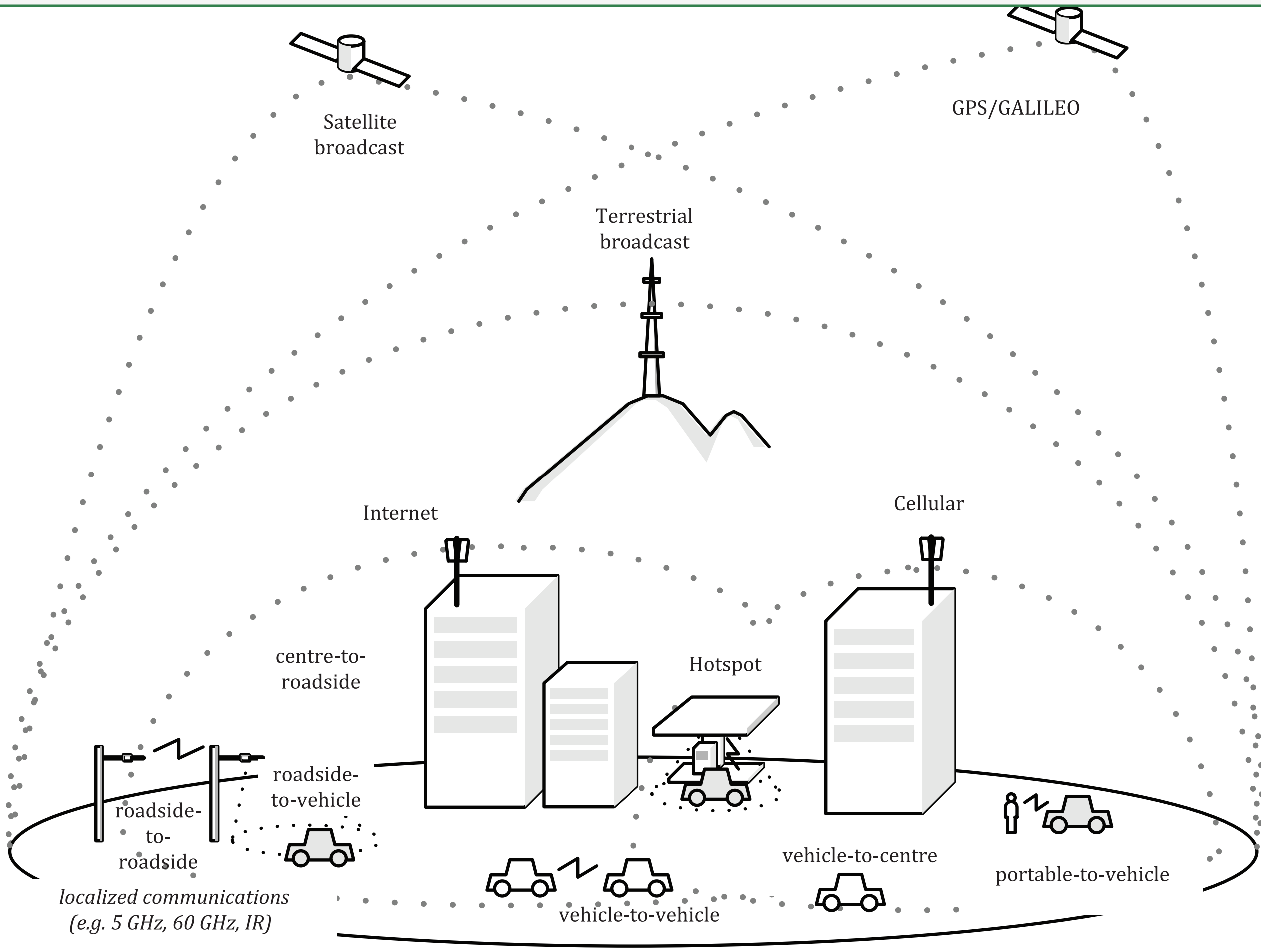

Figure 1 — Examples of ITS communications

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).

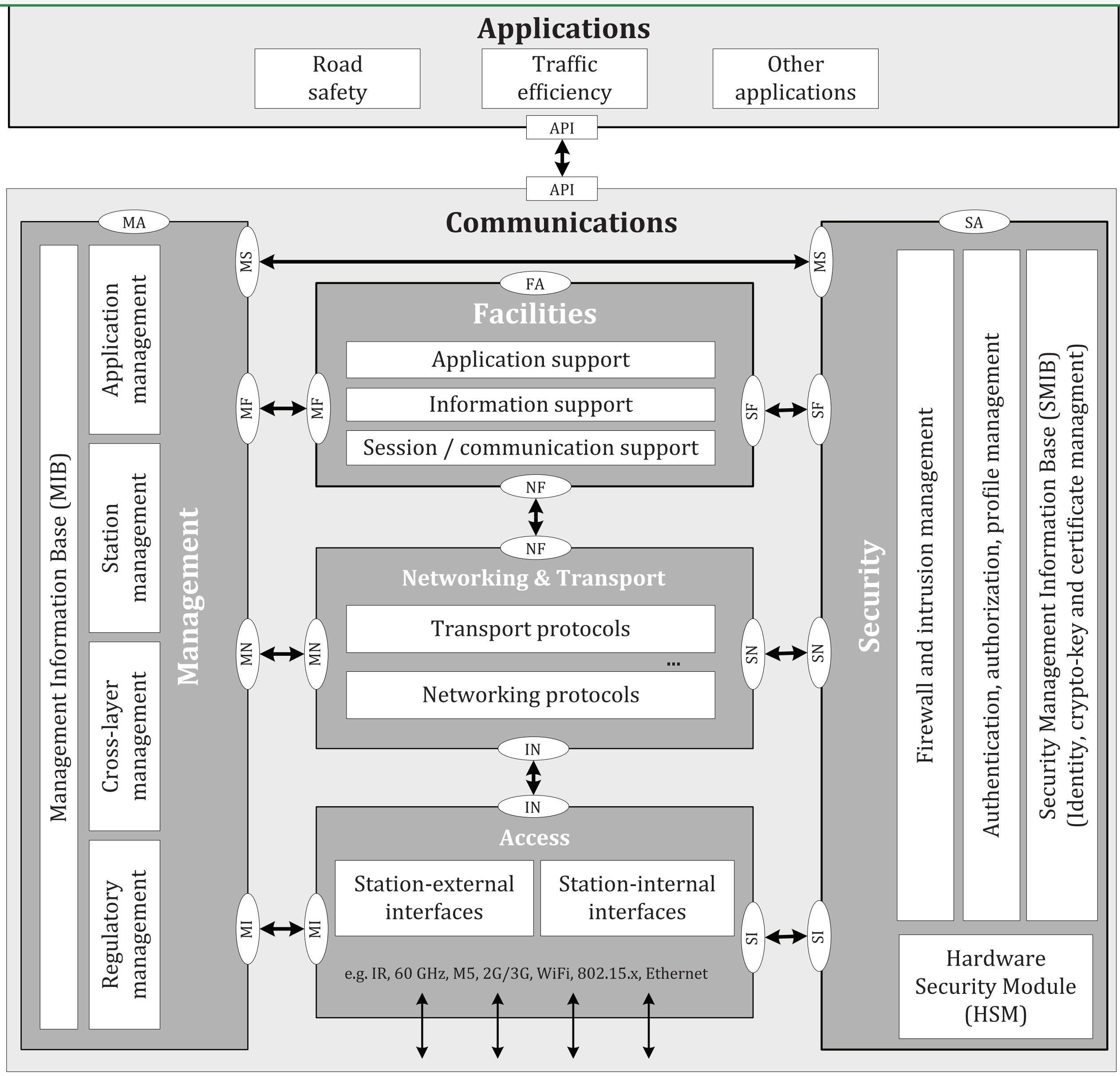

Figure 2 — ITS-S reference architecture

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.

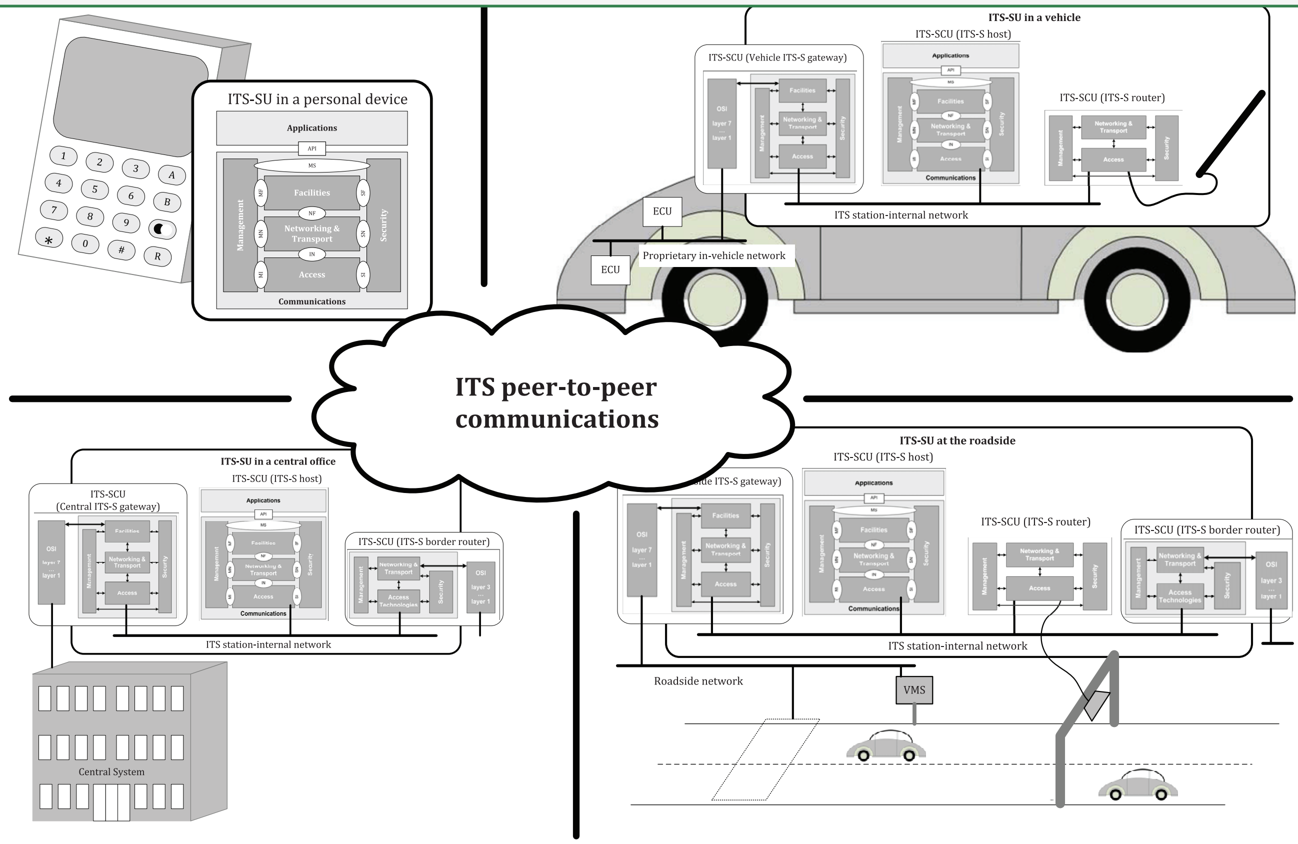

Figure 3 — Typical implementations of ITS station units

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 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.

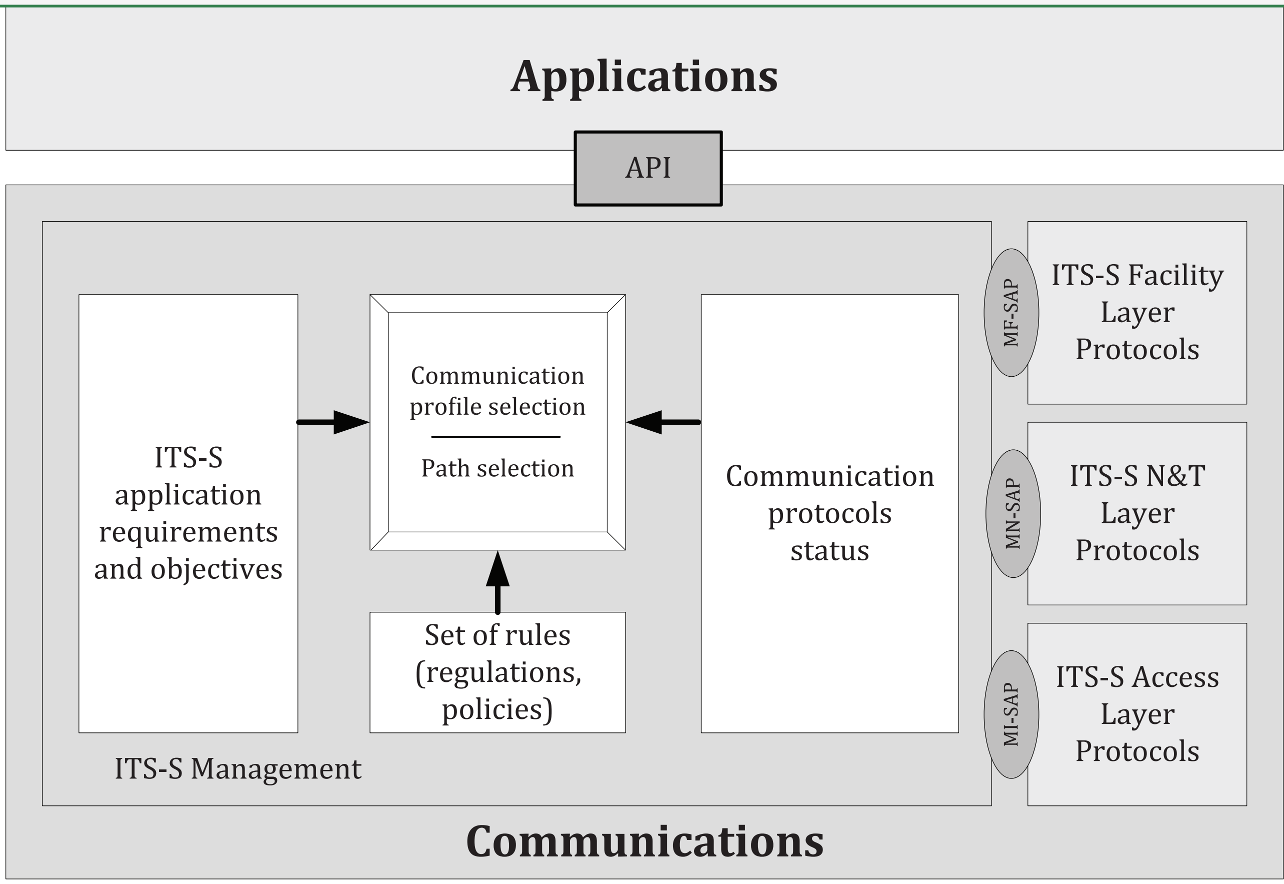

Figure 4 — Architecture of communication profile and path selection

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.

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.