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Intelligent transport systems (ITS) — Communications — ITS communication role and functional model

Systèmes de transport intelligents (ITS) — Communications — Rôle des communications et modèle fonctionnel des ITS

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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 document 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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This document was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

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

Currently, more than 70 % of the world's people live in cities. The proportion of people living in cities is rising around the world as civilizations develop and congregate around cities where employment opportunity most arises. Societies develop more innovatively and more rapidly in cities; and cities present better entertainment opportunities, all adding to their attraction and popularity; hence, the continuing trend. The Economist magazine recently forecast that by 2045 an extra two billion people will live in urban areas. Due to the concentration of the population that this causes, various issues arise such as road congestion due to increase in vehicle population, and environmental pollution due to exhaust gas and tire erosion. This has been attributed to increases in the number of delivery trucks, taxis, and town centre traffic which is further exacerbated by obstacles and effective use of urban space due to private ownership of cars (parking lots, street parking).

It is recognized that there is also road infrastructure deterioration, lack of provision of information on the use of public transportation, driver shortages, and inconvenience of multimodal fare payments. The action to improve this situation is urgently needed.

Changing consumer tastes are also calling for new types of infrastructure. Today's city dwellers, for example, increasingly shop online and expect ever faster delivery times. To meet their needs, modern urban areas need the support of last-minute distribution centres, backed by out-of-town warehouses.

In recent years, European studies on the development of mobility integration standards have been active to solve urban problems. Important key factors are the core architectural elements of smart cities, including urban intelligent transport system (ITS) sharing of probe data (also called sensor data), connected cars, automated driving, and communication infrastructure. In addition, current issues have been recognized with the introduction of the connected car to the real world in respect of privacy protection, the need to strengthen security measures, big data collection, and processing measures, which are becoming important considerations.

In terms of effective use of urban space, it is hoped that the introduction of connected cars and automated driving can significantly reduce the requirements for urban parking lots (redistribution of road space). If technology can eliminate congestion, city road area usage can also be minimized - reallocated (space utilization improvement) to improve the city living environment/quality of life. In addition, the environment around the road will be improved by improving enforcement (e.g. overloaded vehicles). Even in rural areas it is possible to introduce automated driving robot taxis and other shared mobility that saves labour (and is, therefore, more affordable) and improves mobility for those who do not drive (e.g. the elderly and those with disabilities). The communications will play a significant role.

Achieving this requires the realization of various issues. Some examples are as follows:

- cooperation with harmonization of standards such as ISO and existing industry standards;
- recognition of the significance of international standardization (for example, to reduce implementation costs);
- recognition of the significance of harmonization activities by countries around the world.

As mentioned previously, automated driving mobility is expected to play a significant role both in cities and in rural areas. The main effects are reduction of traffic accidents, reduction of environmental burden, elimination of traffic congestion, and realization of effective use of urban space.

ITS technology is a crucial element for realizing 'smart' cities; and it is important to clearly understand the role model of ITS application services when developing standards to achieve these objectives.

This document is intended to be an important guidebook for this objective. Considering the emerging direction of mobility electrification, automated driving, and the direction of an environmentally friendly society, incorporating other urban data such as traffic management into the city management will improve the mobility of urban society. It is important to identify the importance of the communication role that connects all related actors in the framework with necessary security measures. To consider this, the creation of a common open role model for communication platforms is important. The platforms will be necessary

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for the realization of the future mobility services such as automated driving vehicles. A common role model will be developed for all modes of vehicles, including public transport, general passenger vehicles, and heavy vehicles. The incorporation of electronic regulation is especially important for automated vehicles, and it is essential to incorporate it as a core element of urban ITS.

This document describes how ITS data can be presented, interchanged, and used by smart cities by using communications. This document does not describe smart city use cases for ITS data in detail, nor does it describe in detail any specific ITS use cases; instead, this document focuses on the generic role model for data exchange between ITS and smart cities.

ISO 21177 establishes the necessary security and data exchange protocols to provide a 'secure ITS interface' (i.e. exchange information with bi-directional protection).

ISO 21177 enables two devices to cooperate in a trusted way (i.e. exchange information in secure application sessions, and thus only access data or request data that it has the appropriate credentials to access).

Multiple standards have been published regarding communication media, communication security, networking, ITS Station architecture, and ITS station management. It is true that as these standards are used for ITS services to cooperate with various related services such as smart city and mobility as a service (MaaS), the role and functions of communication also have a tendency to be changed.

One of this document's purposes is to reorganize the role-function model of communication corresponding to the smart city/MaaS era from the viewpoint of standardization.

This document can contribute to the development of communications standards for the mobility system service business cases other than system services described within this document.

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Intelligent transport systems (ITS) — Communications — ITS communication role and functional model

1 Scope

This document describes a basic role model of communications as a common platform for ITS services including cooperative service in smart city areas:

a) a framework for the provision of a communication service;

b) a description of the concept of operations and the role models;

c) a conceptual architecture between actors involved in the provision/receipt of communication;

d) references for the key documents on which the architecture is based;

e) a taxonomy of the organization of generic procedures, with a focus on the basic role and functional model of service for the introduction of communications including infrastructure facilities to support mobility in urban and rural areas.

In-vehicle control system is not within the scope of this document.

The scope of this document is limited to the communications using physical and digital infrastructure.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

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

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

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

4 Abbreviated terms

EV electric vehicle

PKI public key infrastructure

5 ITS communication functions

5.1 General

The ITS communication, which connects various actors in ITS service framework, needs various functions to perform necessary capabilities for ITS application services.

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5.2 Cyber security in ITS application services

In the past decades, ITS services have been provided through dedicated communication media such as dedicated short-range communication (DSRC). In this case, cyber security is maintained by an ITS service provider and a publicly created/maintained security management system. Using a dedicated low earth orbit satellite system is a viable candidate for future communication platform.

In recent years, cellular mobile telecommunication networks provided by private enterprise's communication providers are emerging to be used in ITS services. Although the communication service providers provide cyber security measures, ITS service needs its own additional cyber security system.

Regarding cyber security in ITS services, which has become more important in recent years, there are a set of standards (ISO 21177, ISO/TS 21184, ISO/TS 21185) created for ITS station security services, connection interfaces, and communication protocols. This is the method to use a secure digital certificate exchange using PKI.

For designing ITS service cyber security systems, there are necessary measures to be taken. The vehicle cyber security design engineering standard, ISO/SAE 21434 and UN-R155 created by UNECE WP.29 are good guidebooks to be referenced.

5.3 Moving data between actors

When it comes to moving data between actors, the major function is large transmission capability. Using edge computing helps decrease overload on the central system. For the safety applications, moving data with low latency is minimum; and distribution of edge computing functions is the key to success.

5.4 Connected vehicle/device environment

5.4.1 General

Depending on the requirement of each service performance, the communication used in ITS service requires all or some of low latency, high capacity, and multi device access capabilities.

5.4.2 Low latency

The safety application function/performance is expected to be accomplished using the minimum communication latency created by the entire application system, including the conversion steps in various stages (analogue/digital conversion, compression, decompression). Latency in communication links is a crucial factor. Current long-term evolution (LTE) used by major cellular networks is not favourable for safety applications due to its large latency. The 5G technology and emerging 6G and beyond cellular communication/low earth orbit (LEO) satellite communication system can be a favourable selection because of their low latency performance. Inter-LEO satellite communication using laser communications can cut latency in half, thanks to the vacuum environment in the optical fibre on the ground level, due to its short propagation path. The selection of communication media is important when designing an entire ITS system service; but the selection of media and radio frequency spectrum is out of the scope of this document.

5.4.3 Multi-device access capability

In connected vehicle or device environments, multi-device access capability of communication is important. To effectively make use of the resource of communication infrastructure, the communication service provider must provide a network slicing service.

5.4.4 Network slicing

When the ITS user device downloads/uploads various data from the network infrastructure, the data volume becomes huge and certain services need a low latency data transmission pipe. The network slicing by the communication service provider is important for assigning best quality of service (QoS) for each service. The network slicing technology has been deployed since 5G emerged, but the selection of network slicing is out of the scope of this document.

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5.4.5 Carrier aggregation

The communication service provider provides a large capacity data pipe by using a carrier aggregation service. By using this, they can provide various network slicing service capabilities.

5.4.6 Propagation speed difference between wired and wireless environments

Lasers propagate twice as fast in a vacuumed space wireless environment than fibre transmission, due to propagation distance differences. Radio wave propagation speed is almost identical in both environments.

5.4.7 Radio frequency spectrum sharing

Because the resources of a radio wave frequency spectrum are limited, spectrum sharing is deployed. Interference mitigation technologies are adopted when spectrum sharing is deployed.

5.4.8 Open radio access network

The emerging concept in 5G is open radio access network (O-RAN). O-RAN is a concept based on interoperability and standardization of RAN elements to avoid vender lock in issues. O-RAN includes a unified interconnection standard for white-box hardware and open-source software elements from different vendors. O-RAN architecture integrates a modular base station software stack on off-the-shelf hardware which allows baseband and radio unit components from discrete suppliers to operate seamlessly together. This concept helps realize/create open source-based communication network.

5.4.9 Cloud network

Cloud network concept is a type of IT infrastructure in which some or all of an organization's network capabilities and resources are hosted in a public or private cloud platform, managed in-house or by a service provider, and available on demand. Past ITS services tended to have the system composed of an ITS controlled network, data storage, and security services. It can be transitioned to a cloud-based service to avoid increasing cost of having all hardware controlled by ITS sectors.

6 Role and function model

6.1 Objective

This clause describes a generic role and functional model for the provision of ITS services. It provides the general concept of role and functional model operations. 6.2 to 6.5 provide a role and functional model definition and elaboration of the model at a conceptual level.

6.2 National variations

The definition of what comprises an ITS application service is an issue for national decision and can vary from country to country. The instantiation of interoperable on-board (or nomadic device such as smart phone) platforms for application service with common features is ideal, but it can vary from country to country as does the provision of services. It is possible that certain countries mandate the use of such a platform, but others offer it as an option to meet the requirements of the ITS application service with minimum administration and paperwork (providing a good business case for operators to fit and use the equipment). Certain countries can implement a single, government operated, controlled, or contracted service provider, which is the single communication manager between the user and the service. Other countries can provide a market-based solution with multiple service providers competing for the business of vehicle operators.

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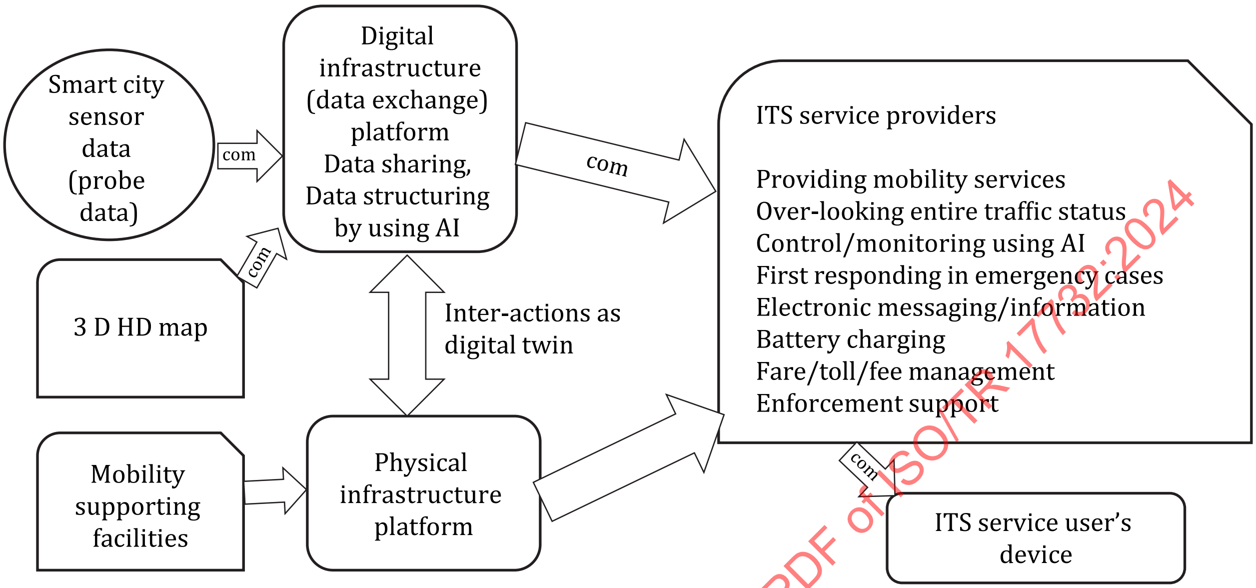
6.3 Basic role model architecture

6.3.1 General

The role model concept architecture defined in ISO/TR 4445 is considered as baseline standard. Figure 1 shows the basic role model for ITS service for smart cities and communities.



NOTE "com" means communication infrastructure provided by communication service provider role.

Figure 1 — Role model related to communications

6.3.2 Smart city sensor data (probe data)

Smart city sensor data are collected by a smart city data aggregator, who feeds those data to the digital infrastructure (data exchange platforms). The following are the candidates for smart city sensor data:

— Vehicle probe data from infrastructure sensors, vehicle onboard sensors/ITS devices

— Traffic counter data

— Weighing in motion (and onboard weighing motion) data and other enforcement data

— Toll data

— CCTV (close caption TV) camera captured video data

— Loop coil data

— Other smart city sensor data

6.3.3 3D HD map

A three-dimensional high definition (3D HD) point cloud map is created by a digital map provider in smart cities, who feeds those maps to the digital infrastructure.

6.3.4 Digital infrastructure

Digital infrastructure is created by public funds and operated by public/private partnership. At this role, the smart city sensor data, static, semi-dynamic and dynamic are automatically structured onto a 3D HD map by the support of artificial intelligence (AI) and other automated data aggregation tools. The sensor

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data collected have different timing, unit, and format; therefore, such automated tools are employed. The terminology and definition of each data are standardized for data aggregation and; if different terminology or definition are used, automated tools such as ontology automated software are used before data aggregation. The digital infrastructure interacts with the physical infrastructure. For data accuracy, the location referencing data and clock timing mythologies such as global navigation systems broadcasting data and clock timing are essential. Other location referencing technologies are available such as radio frequency identification markings. The digital infrastructure is created by using open application interface standard digital platform so standardized tools can be utilized for easy access by users.

6.3.5 Mobility supporting facility

Mobility supporting facilities are battery charging facilities, dynamic charging facilities for electric vehicle batteries, physical infrastructure markings, physical traffic regulation signs, mobility monitoring facilities, emergency responding service support facilities, traffic operation control centre facilities, fee collection service facilities such as road usage fee, online reservation and online mobility usage fee payment facilities, and other infrastructure platform facilities to support automated mobility services. For the air/water-born systems, an AI traffic control centre is a key facility; and each air/water-born vehicle broadcasts identification signals. For heavy air/water traffic, vehicle to vehicle location data exchange becomes effective.

6.3.6 Physical infrastructure platform

The physical infrastructure is land space for mobility such as roads and guided ways, as well as water space and air space. The mobility-supporting facilities described in 6.3.5, battery charging facilities, dynamic charging, facilities for electric vehicle batteries, physical infrastructure markings, physical traffic regulation signs, mobility monitoring facilities, emergency responding service support facilities, traffic operation control centre facilities, fee collection service facilities such as road usage fee, EV battery charging facilities, online reservation and online mobility usage fee payment facilities, other infrastructure platform facilities to support automated mobility services, are part of the physical infrastructure. The physical infrastructure interacts with the digital infrastructure.

6.3.7 ITS service providers

The ITS service provider is a role to provide ITS service to users in the smart cities and communities. This service can be provided by the up and running digital infrastructure which is refreshed and enriched by the digital infrastructure role in the smart cities and communities. The AI is an effective tool to be used for automated mobility data structuring. An enforcement report is produced for enforcing agencies' use. For the sustainability of service provider operation, a service user fee is a key factor; and a subscription-type business model is used.

6.3.8 Communication (communication service provider)

Communication is a vital role that connects relevant actors and roles in the entire framework. The recent emerging 5G technologies is a candidate for a smart city communications role which has low latency, high data capacity and multiple device access. The LEO satellite system and 6G and beyond cellular system are also an important candidate for smart city communication media. Communication needs secure cyber security functions. The security credential management system is prepared in each region and publishes digital certificates and black/allowed lists to ITS devices.

6.3.9 Mobility users

Smart city mobility ITS user's devices are connected physically and digitally with ITS service providers.

6.4 Application layer role and functional model for ITS application service

6.4.1 General

The role model concept defined in ISO/TR 4445, ISO/TR 7878 or ISO/TR 12770 is shown in Figure 2. This figure describes major roles in smart city ITS service.

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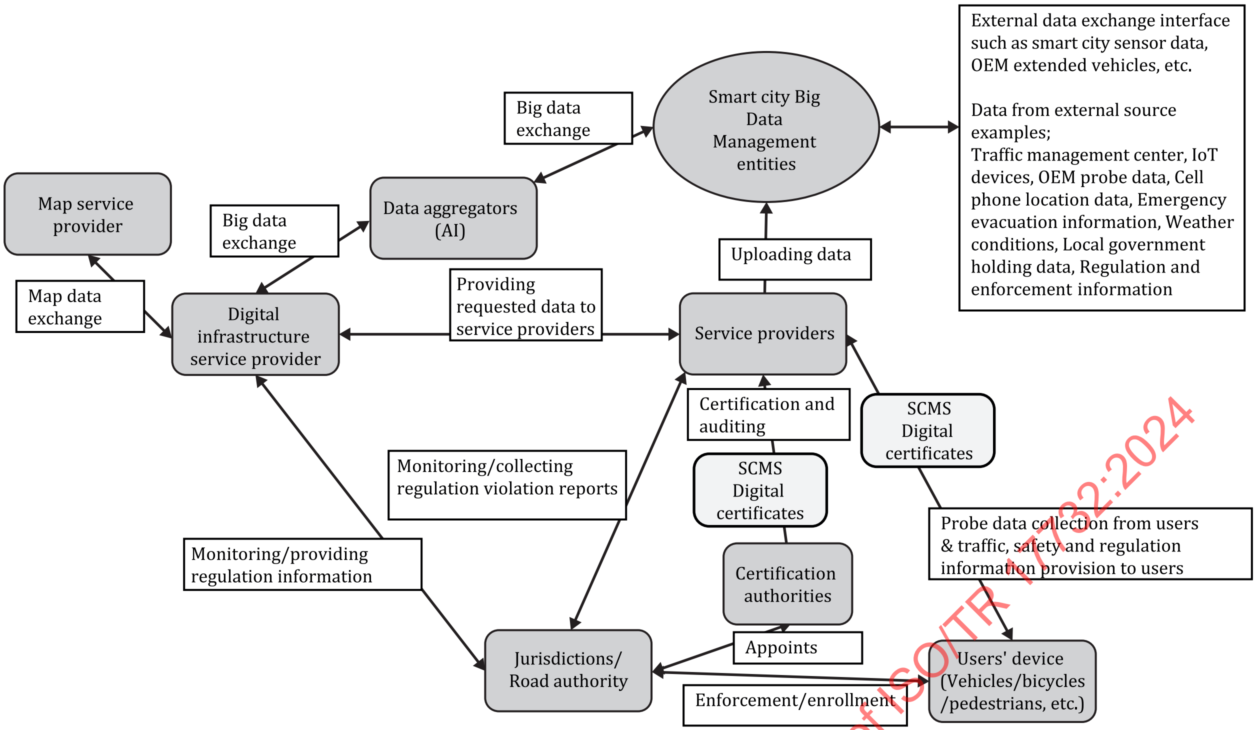

Figure 2 — Role and functional model architecture using ISO/TR 4445, ISO/TR 7878 or ISO/TR 12770

6.4.2 Role and functional model options

An ITS application service user can use the services of different service providers in different geographical areas; or different services can be provided within the same geographical area. In these circumstances, where there is a market of competing service providers, the solution can be expected to be that the user will choose a single service provider who will provide and maintain the ITS application service into nomadic device (such as smart phone) and deliver all services of which the user chooses to subscribe. Other options that support peer conceptual role and functional model are possible.

6.4.3 Certification of service providers

As determined by the jurisdictions/road authority/regulator, the ITS service provider is certified by them; so some form of certification authority (regulatory) role forms an essential part of the role and functional model. However, the role can and will be instantiated differently by different jurisdictions. ITS device inspection and certification are performed by certain parties per regional authority defined regulations.

6.5 ITS service role and functional model

Generic concept of operations which the relevant actors and classes enact to provide the application service(s) are provided in this subclause. To specify a generic framework standard of the mobility service platform exchange of data with smart cities, this framework standardization deliverable identifies core actors.

ISO/TR 4445 describes a role model where the roles and responsibilities of three key actor classes are defined to provide an entity known as an 'application service':

a) the service users

b) the service provider

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