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Electronic fee collection — Guidelines for EFC applications based on in-vehicle ITS stations

National foreword

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**Electronic fee collection - Guidelines for EFC applications based
on in-vehicle ITS stations**

Perception de télépéage - Lignes directrices pour les
applications de télépéage installées dans les stations de
systèmes de transport intelligents (ITS) embarquées dans
les véhicules

Elektronische Gebührenerhebung - Richtlinien für
Anwendungen der Elektronischen Gebührenerhebung
basierend auf fahrzeuginternen IVS Geräten

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Foreword

This document (CEN/TR 16690:2014) has been prepared by Technical Committee CEN/TC 278 “Intelligent transport systems”, the secretariat of which is held by NEN.

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A CEN Technical Report is a document adopted by CEN/CENELEC containing informative material not suitable for publication as a European Standard or a Technical Specification.

This document has been prepared by CEN/TC 278/WG 1, Project Team 136. The work done by the project team has been governed by the Technical Committee CEN/TC 278 “Intelligent transport systems”, the secretariat of which is held by NEN, and by CEN/TC 278/WG 1, Electronic fee collection and access control (EFC).

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Introduction

Increasingly, tolling systems are becoming automated and electronic fee collection (EFC) is becoming a pervasive service in Europe. The widespread deployment of EFC systems requires provisions to allow users to employ a single contract and a single OBE to circulate through many different toll domains. In Europe, for example, this need has been officially recognized and legislation on interoperability has already been adopted in the form of the Interoperability Directive 2004/52/EC and the EETS Decision 2009/750/EC.

Standardization in the context of Electronic Fee Collection has been active since the early '90s with the aim of providing the architecture and the definition of interoperable interfaces for interoperable tolling systems. Interoperable interfaces allow tolling systems to exchange information and make mutual use of it. Specifications of such interfaces have been provided in the form of Application Interface Definitions, which are to be considered as toolboxes for defining application protocols and application data exchanged. In many cases, interoperable application profiles have been defined to narrow down the options and provide a sound basis for interoperability.

The standardization results have major relevance for the future of the EETS. Some standards are directly referenced by the EETS Decision and are hence of mandatory application. Other standards provide open and interoperable definitions which are likely to be employed to fulfil the requirement that: "EETS equipment shall be designed in such a manner that its interoperability constituents utilise open standards".

EFC is one of the intelligent transport systems (ITS) applications with the widest deployment. Currently EFC equipment is mostly dedicated to one or a few applications only. On the one hand, EFC equipment is also becoming more capable and EFC OBE may provide platforms for delivering selected Value Added Services as analysed in CEN/TR 16219. On the other hand, future ITS Stations may in principle deliver the EFC Service to users, if certain requirements are fulfilled.

This Technical Report mainly provides a view on how "both worlds", the established and wide-spread EFC services and the emerging ITS services and platforms, could be combined to future solutions in which EFC services are considered as one service amongst others offered by ITS. The Report provides information to designers of ITS about the nature and specialities in the EFC services to be taken into account. It also provides EFC stakeholders with guidance how an integration of EFC into the set of services provided in the ITS environment may be achieved.

In order to identify the guidelines how EFC applications can be provided on ITS in-vehicle stations, the following approach is chosen:

- provide a view and understanding of both EFC and cooperative ITS in terms of available architectures, definitions, specifications, stakeholders and operational experiences (commercially available projects as well as research and trial activities);
- identify major EFC requirements that will have an impact to the ITS Station;
- provide a view as to how EFC roles and functionalities (according to ISO 17573) shall be enabled and supported in the cooperative ITS context (in different phases of the entire life cycle of an EFC service);
- identify a base technical architecture that enables EFC services in an ITS context;
- analyse stakeholders in a business architecture and provide an example of a business architecture for EFC services in an ITS environment; and
- emphasize on particular key areas like conformance and certification, potential synergies in the context of the ITS Station, areas of major concern, governance, critical elements.

This approach could be chosen as the EFC environment is seen very mature in terms of architectural, technical and operational requirements and processes. EFC as a service is already in use in various

commercial projects in many countries throughout the world. Operational experiences have already been taken into account in refining the landscape of existing specifications in EFC. This can be seen as an extraordinary condition compared to other (future) ITS services for which such mature environmental and context is not yet available

ETSI TC ITS has defined a Basic Set of Applications in ETSI/TR 102 638 which is expected to be deployed relatively swiftly after completion of standardization of C-ITS. EFC is directly addressed in this Basic Set of Applications and considered as a primary application. Standardization of the EFC application requirements is, however, within the scope of CEN/TC 278/WG 1, which is in charge of defining the requirements for the EFC use cases in accordance with the set of standards developed by this Working Group.

1 Scope

This Technical Report (TR) contains an analysis of the technical and operational feasibility of using a generic ITS Station as specified in ETSI EN 302 665, *Intelligent Transport Systems (ITS); Communications Architecture*, for EFC applications compliant to the requirements specified in ISO 17573, EN ISO 12855, CEN ISO/TS 17575 (all parts), EN ISO 14906, EN 15509, CEN ISO/TS 12813, CEN ISO/TS 13141 and CEN/TS 16439.

The scope of this Technical Report includes:

- description of the context of Cooperative ITS and the ITS Stations;
- providing details of the context of EFC applications;
- outlining the basic architectural concepts and role model of both EFC and Cooperative ITS;
- identification of core requirement areas for operation of an EFC application on an ITS Station;
- specification of a set of recommendations for functional, operational and security requirements to the ITS Station supporting the EFC application(s);
- description of a possible role model in which the roles known in EFC applications make use of the roles in the C-ITS system in order to provide EFC services in an C-ITS context;
- provision of considerations in particular areas of EFC like certification and governances;
- guideless and recommendations for further standardization work in this area;
- emphasizing on security related elements of EFC that need to be considered in a C-ITS environment.

The scope of this Technical Report is limited to in-vehicle ITS Stations. However, an EFC service always requires the involvement of in-vehicle and central functionalities. Furthermore, for enforcement purposes as well as in DSRC based toll domains for toll charging purposes also, it is essential that road-side based functions are provided and operated. In order to facilitate EFC services a set of functionalities, tasks and responsibilities are defined and specified in an EFC role model (ISO 17573). These functionalities, tasks and responsibilities are shared between the roles Toll Charger, Toll Service Provider, Road User and Interoperability Management. All these roles interact with each other. As a consequence this Technical Report provides in various areas explanations that are beyond the in-vehicle environment. This is required in order to present the full environment and context. It keeps the readability of this document at a sound level and provides valuable information to those readers which are not yet familiar with EFC in detail.

Outside the scope of this Technical Report is:

- detailed technical specifications for EFC services and applications on C-ITS systems;
- implementation specific elements.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 15509, *Road transport and traffic telematics - Electronic fee collection - Interoperability application profile for DSRC*

CEN ISO/TS 12813, *Electronic fee collection - Compliance check communication for autonomous systems (ISO/TS 12813)*

EN ISO 12855:2012, *Electronic fee collection - Information exchange between service provision and toll charging (ISO 12855:2012)*

CEN ISO/TS 13141, *Electronic fee collection - Localisation augmentation communication for autonomous systems (ISO/TS 13141)*

EN ISO 14906, *Electronic fee collection - Application interface definition for dedicated short-range communication (ISO 14906)*

CEN ISO/TS 17575-1:2010, *Electronic fee collection - Application interface definition for autonomous systems - Part 1: Charging (ISO/TS 17575-1:2010)*

CEN ISO/TS 17575-2, *Electronic fee collection - Application interface definition for autonomous systems - Part 2: Communication and connection to the lower layers (ISO/TS 17575-2)*

CEN ISO/TS 17575-3:2011, *Electronic fee collection - Application interface definition for autonomous systems - Part 3: Context data (ISO/TS 17575-3:2011)*

CEN ISO/TS 17575-4:2011, *Electronic fee collection - Application interface definition for autonomous systems - Part 4: Roaming (ISO/TS 17575-4:2011)*

ISO 17573:2010, *Electronic fee collection — Systems architecture for vehicle-related tolling*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

back end

computing and communication facilities of an actor (e.g. a Toll Charger or a Toll Service Provider) exchanging data with a Front or Back End

3.2

back office

generic name for the centrally located computing and communication facilities (of a role involved in EFC)

3.3

charge report

information containing road usage and related information originated at the Front End

3.4

cooperative ITS

subset of the overall ITS that communicates and shares information between ITS Stations to give advice or facilitate actions with the objective of improving safety, sustainability, efficiency and comfort beyond the scope of stand-alone systems

[SOURCE: ISO/DTR 17465]

3.5

electronic fee collection

fee collection by electronic means

3.6

front end

part(s) of the toll system where road usage data for an individual road user are collected, processed and delivered to the Back End

Note 1 to entry: The Front End comprises the on-board equipment and an optional proxy.

[SOURCE: CEN ISO/TS 17575-1:2010, 3.13]

3.7

interoperability management

role that manages the toll charging environment, i.e. defining and maintaining a set of rules that, taken together, defines the policy of a given toll regime or of the overall toll charging environment

3.8

ITS application

association of two or more complementary ITS-S applications

[SOURCE: ETSI EN 302 665 V1.1.1 (2010-09)]

3.9

ITS service

service provided by an ITS application to the user of ITS

[SOURCE: ETSI EN 302 665 V1.1.1 (2010-09)]

3.10

ITS station

entity in a communication network that executes ITS-S applications within a bounded, secured, managed domain comprised of an ITS-S facilities layer, ITS-S networking & transport layer, ITS-S access layer, ITS-S management entity and ITS-S security entity

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. The appropriate interpretation is clear from the context. The physical instantiation of an ITS-S is named ITS station unit (ITS-SU).

[SOURCE: ISO 21217:2010]

3.11

ITS station service provider

role that is responsible for procuring an ITS Station (ITS-S), arranging the installation of such ITS-S in vehicles and maintains an ITS-S

Note 1 to entry: This role offers ITS Service providers to host their services on this ITS-S.

3.12

ITS station unit

implementation of an ITS-S

[SOURCE: ISO 21217:2010]

3.13

on-board equipment

equipment located on-board a vehicle including nomadic devices with the function of exchanging information with external systems

3.14

policy framework

role that is responsible for all governing and institutional activities required in the system

[SOURCE: prCEN ISO/TS 17427]

3.15

system management

role that is responsible to fulfil all required management activities within the system, this especially includes activities supporting the role 'System Operation'

[SOURCE: prCEN ISO/TS 17427]

3.16

system operation

role that is responsible for the proper execution of the applications that provide the end-to-end service(s)

[SOURCE: prCEN ISO/TS 17427]

3.17

toll charger

entity which levies toll for the use of vehicles in a toll domain

Note 1 to entry: In other documents the terms operator or toll operator may be used.

3.18

toll context data

information defined by the responsible toll charger necessary to establish the toll due for using a vehicle on a particular toll context and to conclude the toll transaction

3.19

toll declaration

statement to declare the usage of a given EFC service to a toll charger

3.20

toll domain

area or a part of a road network where a certain toll regime is applied

3.21

toll service provider

entity providing toll services in one or more toll domains

Note 1 to entry: In other documents the terms issuer or contract issuer may be used.

Note 2 to entry: The Toll Service Provider may provide the OBE or may provide only a magnetic card or a smart card to be used with OBE provided by a third party (like a mobile telephone and a SIM card can be obtained from different parties).

Note 3 to entry: The Toll Service Provider is responsible for the operation (functioning) of the OBE with respect to tolling.

3.22

trusted recorder

logical entity capable of cryptographic functions, used to provide the OBE with security services, including data confidentiality, data integrity, authentication and non-repudiation

4 Symbols and abbreviations

For the purpose of this document, the following abbreviations apply throughout the document unless otherwise specified.

ANPR	Automatic Number Plate Recognition
BSDM	Bounded Secure Management Domain
C2C-CC	Car-to-Car Communication Consortium
CALM	Communication Architecture for Land Mobiles
CALM FAST	CALM network protocol stack
C-ITS	Cooperative ITS
CMC	Configuration Management Centre
CVIS	Cooperative Vehicle Infrastructure Systems
CN	Cellular Network
DSRC	Dedicated Short Range Communication
EAL	Evaluation Assurance Level
EC	European Commission
ECU	Electronic Control Unit
EETS	European Electronic Toll Service
EFC	Electronic Fee Collection
EGNOS	European Geostationary Navigation Overlay Service
ESO	European Standardization Organization(s)
ETSI ITS-G5	Access layer specification for ITS operating in the 5 GHz frequency band (Draft ETSI EN 302 663)
ETSI TC ITS	ETSI Technical Committee on ITS
EU7FP	7th framework program (2007 – 2013) of the European Commission
FNTP	Fast Networking and Transport layer Protocol
GLONASS	Globalnaya Navigatsionnaya Sputnikovaya Sistema (or Global Navigation Satellite System)
GNSS	Global Navigation Satellite System
GST	Global System for Telematics
HGV	Heavy Good Vehicle
HMC	Host Management Centre
HMI	Human Machine Interfaces
I2I	Infrastructure-to-Infrastructure
ITS	Intelligent Transport Systems
ITS-S	ITS Station
ITS-S SP	ITS Station Service Provider
ITS-SU	ITS Station Unit
KPI	Key Performance Indicator
LAC	Localization Augmentation Communication

LDM	Local Dynamic Map
OBE	On Board Equipment
OEM	Original Equipment Manufacturer
OSGi	Open Services Gateway Initiative
PC	Personal Computer
PKI	Public Key Infrastructure
RSE	Road Side Equipment
R&TTE	Radio and Telecommunications Terminal Equipment
SAM	Secure Application Module
SDO	Standardization Developing Organization(s)
SLA	Service Level Agreement
TC	Toll Charger
TD	Toll Domain
TEN-T	Trans-European Transport Network
TR	Technical Report
TS	Technical Specification
TSP	Toll Service Provider
VAS	Value Added Services
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
WLAN	Wireless local area network

5 Context of C-ITS

5.1 Definition of C-ITS

5.1.1 Introduction

Cooperative System(s) or Cooperative ITS (C-ITS) is being proposed as a new paradigm in ITS, but its exact definition sometimes remains unclear and is not agreed upon by all stakeholders. The most common understanding is that C-ITS involves vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication to enhance safety and efficiency of the road transport system. C-ITS is also considered as a mean to get away from the multitude of proprietary stand-alone devices invading the driver environment. The feeling was that it is not sustainable to put a new box with antennas, display, keyboard, etc. for each new application that was going into the car. This is too costly, too unsafe, does not give interoperability, and is just not safe or sustainable from a windshield real estate point of view.

As a consequence ITS has to evolve from “silos” or vertical integration of all functions for each new application, into a new world of sharing common resources where useful and possible.

The definition of what a cooperative system is has proven to be difficult. There are several reasons for this. A major reason is the existence of a plethora of organizations and projects within the field, each deriving their own definition. This can mostly be attributed to historical reasons, but it has also been influenced by turf wars and commercial pressures from actors in existing markets feeling threatened by this new world. The result is that currently several definitions of C-ITS exist.

5.1.2 The European Commission basic definition

The most prevalent understanding of C-ITS is the European Commission (EC) definition (as defined in Mandate M/453): “Co-operative systems are ITS systems based on vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I, I2V) and infrastructure-to-infrastructure (I2I) communications for the exchange of information. Co-operative systems have the potential to further increase the benefits of ITS services and applications”.

The objective of the mandate from EC is primarily to create benefits in terms of transport efficiency, sustainability, safety and security. To realize these benefits it is necessary to ensure interoperability through standardization. It is also expected that a realization of C-ITS will contribute to the competitiveness objectives of the EU Internal Market.

5.1.3 The vehicle active safety viewpoint

A more restricted understanding of C-ITS is the use of 5,9 GHz 802.11p WLAN communications for V2V and V2I links, where the main application is active road traffic safety. The basic idea is that all vehicles broadcast information that will be received by other vehicles at a distance of up to 1 000 m. The typical applications are warnings or active collision avoidance. This is the understanding from many OEMs and authorities involved in the active safety world, such as the Car-to-Car Communications Consortium (C2C-CC, <http://www.car-to-car.org/>). In addition to V2V communication some safety related use cases employ V2I/I2V communication, e.g. warning of construction sites or maintenance work.

5.1.4 The CEN/ETSI/ISO definition

Whereas the EC definition is seen as too generic, the C2C-CC view is often seen as too restrictive both in terms of technology and services. Therefore CEN/ISO and ETSI agreed on another definition in their response to Mandate M/453:

- a co-operative ITS is a subset of the overall ITS that communicates; and
- shares information;

between ITS Stations¹⁾ (ITS-S) to:

- give advice; or
- facilitate actions;

with the objective of improving:

- safety, sustainability, efficiency and comfort;

beyond the scope of stand-alone systems.

This definition seems to attract the most support at the moment, and it is important to see that it also defines the boundary towards existing, non-cooperative ITS.

ISO/DTR 17465 (all parts) states the following features of C-ITS:

- the sharing of information between any ITS-SU;
- the sharing of information between different applications;

1) ITS Station defined in ETSI EN 302 665/ISO 21217, e.g. units installed in vehicles, at the road side, in traffic control/management centres, in service centres, or hand-held units.

- the sharing of resources (communication, positioning, security...) in an ITS-SU;
- the authorized use of information for purposes other than the original intent;
- the support of multiple ITS applications on an ITS-SU.

Note that an ITS-SU is not restricted to execute cooperative applications. It might also be used as a platform to implement non-cooperative applications. Therefore an ITS-SU can also communicate with sub-systems in the non-cooperative ITS domain, provided that it can trust these sub-systems to provide credible and accurate data within the appropriate security and privacy constraints.

5.2 C-ITS role model and business architecture

5.2.1 Role model

5.2.1.1 Introduction

The roles and responsibilities in the context of C-ITS are defined in prCEN ISO/TS 17427. In addition the EU7FP project CVIS has defined a role model with associated responsibilities. In both of these definitions the role models also define responsibilities and liabilities in regard to privacy and data protection issues.

5.2.1.2 Role model introduced by ISO

In prCEN ISO/TS 17427 the definition of roles and responsibilities are based on an organizational or enterprise viewpoint as defined in ISO/IEC 10746 (all parts), *Information technology — Open distributed processing*. The roles are separated into external and internal roles, where the internal roles only exists for the purpose of C-ITS, while the external roles are also involved in other activities (non-C-ITS services and applications). The four major roles from prCEN ISO/TS 17427 are shown in Figure 1.

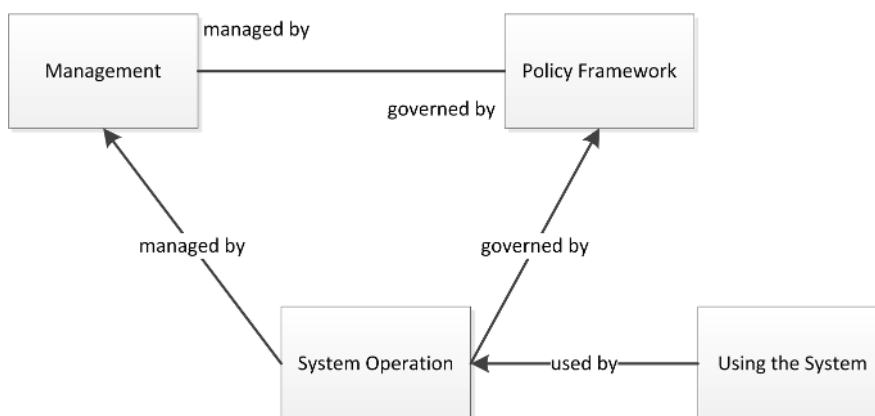


Figure 1 — Organizational architecture with the four major roles

The roles System Operation, Management and Policy Framework are further subdivided into sub-roles.

The role System Operation is responsible for the proper execution of the applications that provide the end-to-end service(s). The role System Operation is composed of the sub-roles Content Provision, Service Provision and Presentation Provision. Their general responsibilities are reflected in the process chain shown in Figure 2.

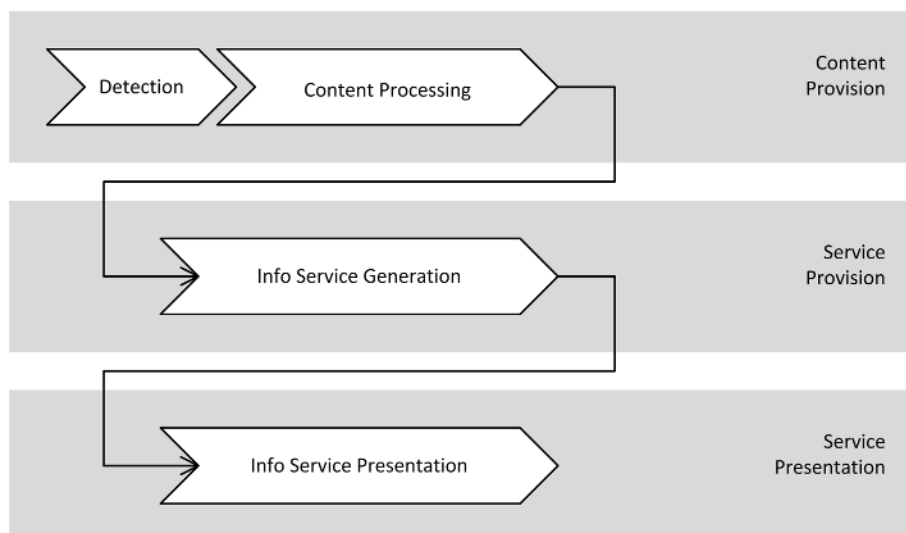


Figure 2 — Sub-roles of System Operation – process chain

The role System Management is responsible for all management activities in the system. Sub-roles of System Management are: Service Catalogue Manager, Communication Manager, Service Owner, C-ITS Architect, Project Manager, Test Manager, Service Level Manager, Risk Manager, Capacity Manager, Availability Manager, Information Security Manager, Access Manager, Technical Analyst, Change Manager, Configuration Manager, Homologation Manager, System Monitoring, and optionally Financial Manager.

The role Policy Framework is responsible for all governing and institutional activities in the system and governs the management and system operational activities. Sub-roles of Policy Framework are: Compliance Manager, Policy Institution, Standardization Organization, Security Certificate Body, Legislation/Jurisdiction.

As stated in prCEN ISO/TS 17427 a service might be implemented in multiple ways, each implementation being a possible scenario. A scenario is understood as a transposition of roles to actor groups for the system operation. In addition every implementation scenario additionally deals with System Management and Policy Framework as eminent supporting roles.

Prior to the use of the system each actor needs registration and authorization to request of access permissions. Each role and therefore each actor is responsible to respect both ISO/TR 12859 as well as national regulations and laws on privacy and data protection when participating in C-ITS.

5.2.1.3 Role model developed in the CVIS project

CVIS D.DEPN.3.1, *Design principles for a privacy protective, secure, safe and fault tolerant CVIS design*, describes a role model for C-ITS services. This role model is based on the architecture developed in the GST (Global System for Telematics) project. CVIS has adopted the Reference Model for Open Distributed Processing (RM-ODP) as a structure for its architecture. The role model in CVIS is shown in Figure 3. This role model is based on requirements for privacy, security, safety and fault tolerance.

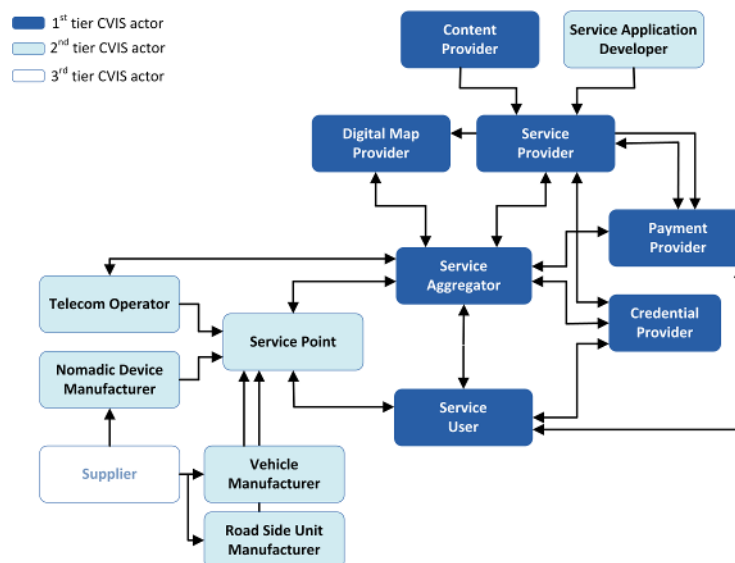


Figure 3 — CVIS roles [source and courtesy of CVIS]

5.2.2 Business architecture

C-ITS can be considered as a distributed system where there is hardware deployed in vehicles, at the road side, in traffic control/management centres, in service centres, or even as hand-held units. This distributed hardware platform is required to execute services. The hardware platform in itself does not provide value. The software running on the hardware platform provides services, which can generate value. There exists a potential unlimited number of services deployable.

To derive a business architecture all roles and sub-roles as described in previous subclauses need to be assigned to corresponding actors. Where one role can be assigned to multiple actors and one actor can occupy multiple roles. Actors are generally grouped to “vehicle (system)” and “infrastructure (system)”.

In CVIS a conceptual business model template was developed, see Figure 4. This template shows the different actors (grouped in business areas), and enables services to be described as value networks using arrows.

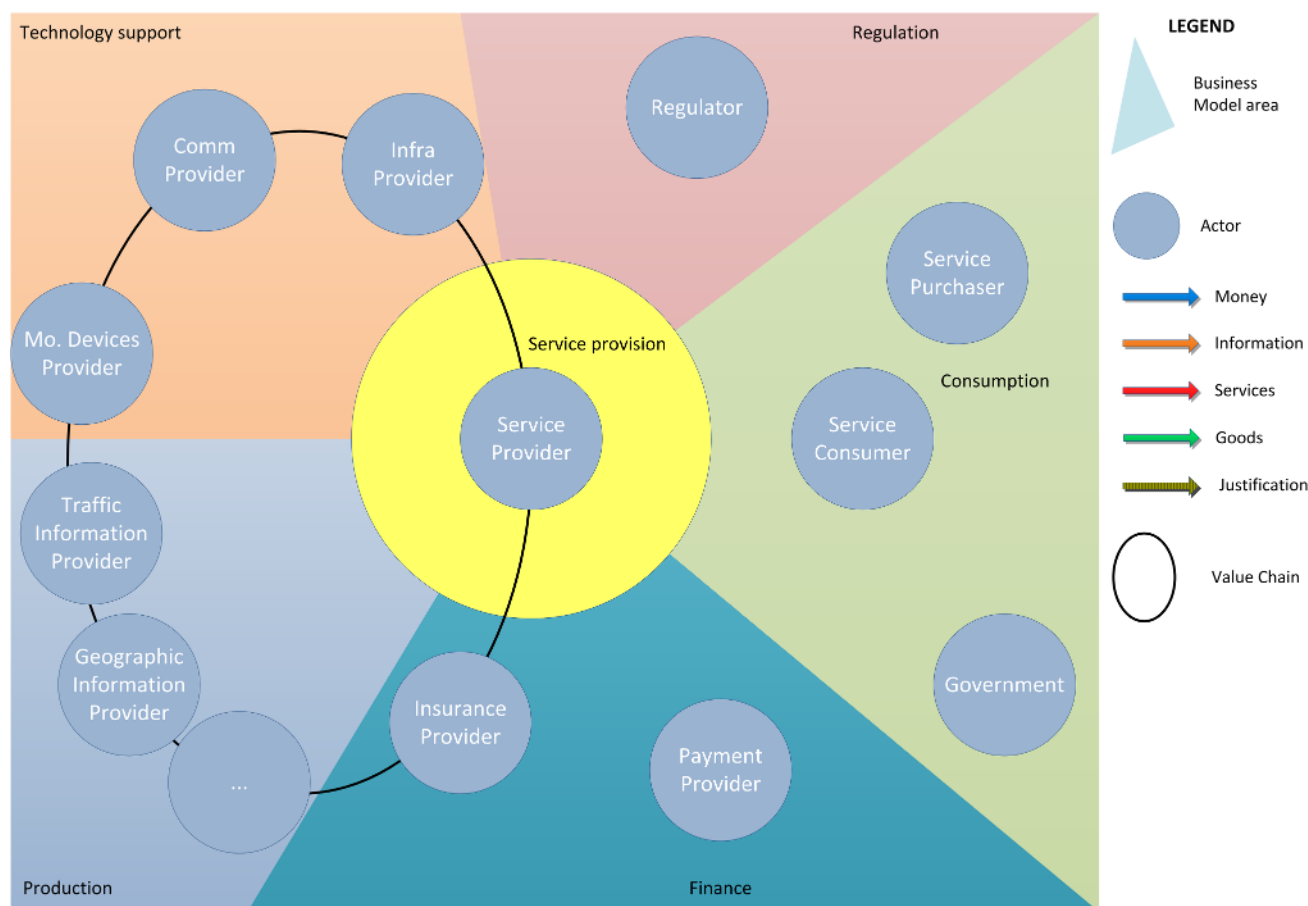


Figure 4 — Conceptual business model template [source and courtesy of CVIS]

The different business areas are:

- **Consumption** - This area represents those actor(s) that are perceived as consumers who are paying the service provider for the service(s) delivered to them.
- **Service Provision** - This area represents those actor(s) that are contractually providing the service(s) directly or indirectly through the producers to the consumer(s).
- **Production** - This area represents those actor(s) that are producing the functionality of the service(s) and delivering this functionality to the service provider or directly to the consumer(s).
- **Technology Support** - This area represents those actor(s) that are supporting the producers of the functionality of the service(s) or the service provider with the necessary technology.
- **Finance** - This area represents those actor(s) that are supporting the financial transactions within the business model and the assurances related to the services.
- **Regulation** - This area represents those actor(s) that are monitoring the compliancy with legislation related to the service.

Figure 5 shows an example of a filled-in template. This uses the service “Dangerous goods / route guidance” as an example.

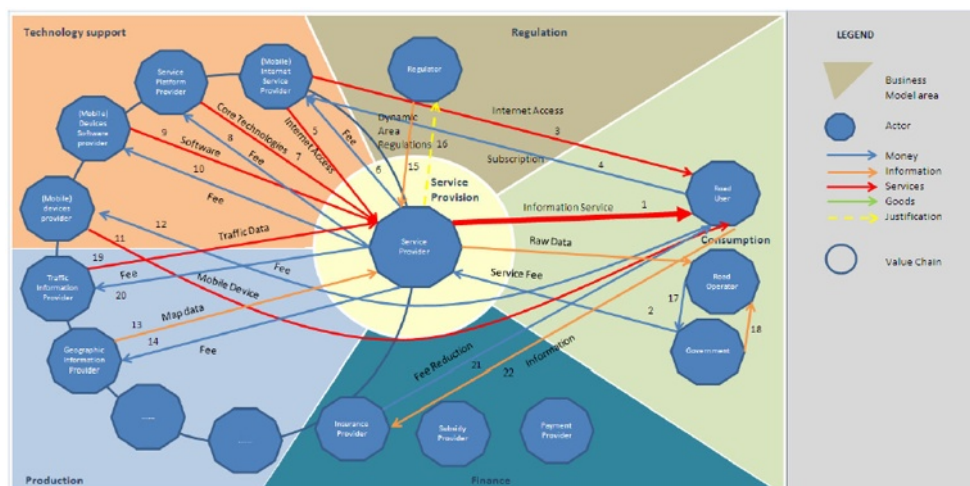


Figure 5 — The service “Dangerous goods / route guidance” modelled with conceptual business modeller [source and courtesy of CVIS]

5.3 Technical architecture

5.3.1 ITS Station architecture

An ITS station (ITS-S) is an important component of the overall ITS communications architecture. The features that most clearly differentiate an ITS-S unit from any other node in the ITS communication network is the station management and security entities that are required. These entities ensure amongst other things the reliability and authenticity that are necessary when deploying safety critical applications and services.

The basic ITS-S reference architecture is shown in Figure 6.

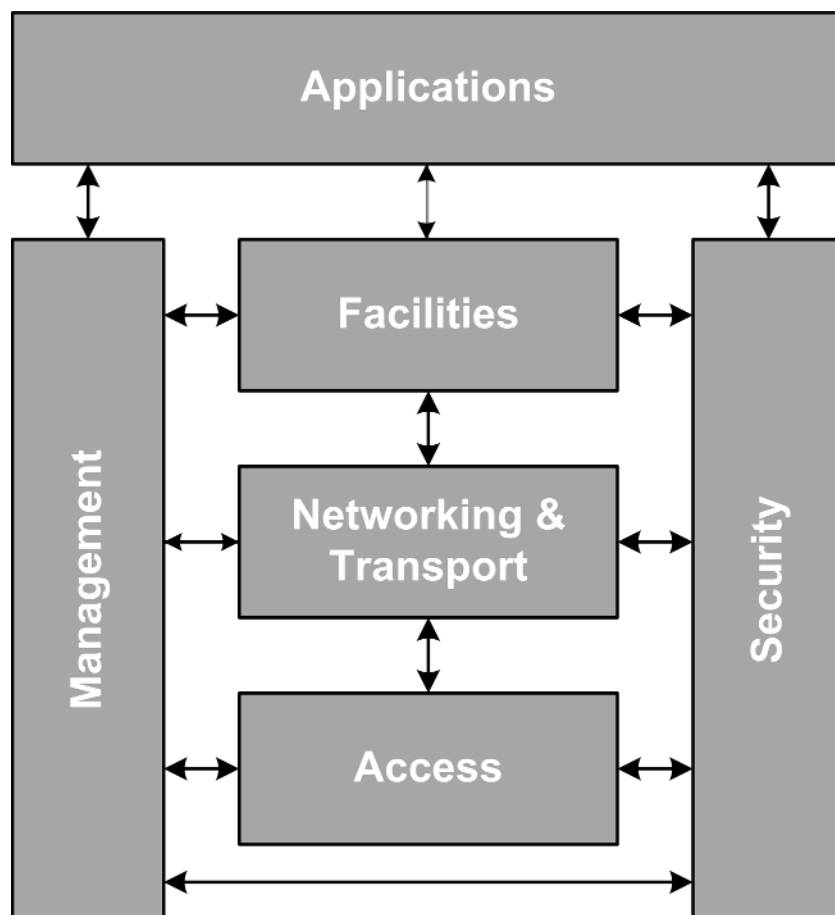


Figure 6 — Simplified ITS station architecture [source: ISO 21217:2010]

When a set of such ITS-S are connected together, they form a distributed system and belong to an ITS network. This is described in ISO 21217.

From an abstract point of view, the term “ITS station” refers to a set of functionalities. The physical instantiation of an ITS-S is named ITS station unit (ITS-SU). An ITS-SU may be implemented as one box or as several boxes connected with an ITS station-internal network. A personal ITS-SU might be implemented as a software module inside a smartphone, PDAs or other hand-held device. In larger installations such as in a vehicle, the ITS-SU will often consist of a communications device (Mobile Router) and one or more computers (Mobile Hosts and Gateways to ECUs). For a roadside installation (Roadside ITS-S), there may be several communication devices in an internal network (Access Routers), and several computers running the actual services. In general the following types of ITS-Ss can be identified:

- personal ITS-S (in hand-held devices);
- central ITS-S (part of an central ITS subsystem);
- vehicle ITS-S (in cars, trucks, etc., in motion or parked);
- roadside ITS-S (on gantries, poles, etc.).

5.3.2 ITS communication access technologies

The V2I and V2V communication facilities required by C-ITS can be realized using ad hoc short range communication based on wireless local area network (WLAN) technologies. The prevalent standard for this is

IEEE 802.11p. Alternatively, or as a supplement, commercial cellular networks such as 2G/3G and 4G (LTE) can be utilized.

The idea of using WLAN technologies for V2V and V2I has been widely accepted around the world, and in many regions and countries frequency bands around 5,9 GHz has been reserved for this purpose. In Europe the EC has adopted a decision “on the harmonised use of radio spectrum in the 5875-5905 MHz frequency band for safety related applications of Intelligent Transport Systems (ITS)” [2008/671/EC].

The use of ad hoc short range communication enables low latency communication, which is important for safety. It also enables easy and low cost dissemination of localized information to nearby ITS-SUs.

Many use cases for C-ITS require ubiquitous Internet connectivity. This can be realized using commercial cellular networks, but also suitable positioned roadside access points can be utilized.

Several different protocols have been specified to be used in C-ITS. Different protocol exists at each layer (see Figure 6). Some examples are:

a) ITS-S access layer:

- 1) IEEE 802.11;
- 2) IEEE 1609.4;
- 3) ETSI ITS-G5;
- 4) M5;
- 5) IR (ISO 21214)
- 6) GSM;
- 7) UMTS;
- 8) LTE;

b) ITS networking and transport layer:

- 1) IPv4 TCP/UDP;
- 2) IPv6 TCP/UDP as specified in ISO 21210;
- 3) Fast Networking and Transport Layer Protocol (FNTP - ISO 29281-1);
- 4) GeoNetworking Basic Transport Protocol (BTP);
- 5) WAVE Short Message Protocol (WSMP);

NOTE EU/US harmonization task groups HTG1/3 recommended merging the WAVE protocols WSMP/WSA with the ISO protocols FNTP/FSAP.

c) ITS-S facilities layer:

- 1) Cooperative Awareness Message (CAM);
- 2) Decentralized Environmental Notification Messages (DENM);
- 3) Signal Phase and Timing Message (SPaT);

d) ITS-S management entity:

- 1) FAST Service Advertisement Protocol (FSAP - ISO 24102-5);
- 2) ITS station internal management communication protocol (IICP - ISO 24102-4).

5.3.3 Application provisioning and life cycle management

C-ITS is all about the sharing of information between ITS-S application processes within and amongst ITS stations. In addition C-ITS is also seen by several stakeholders as a mean to get away from the multitude of proprietary stand-alone boxes invading the driver environment. Here the goal is the ITS-SU that will serve as a platform for ITS applications, where the applications share common resources where possible (using the facilities layer shown in Figure 6). It is expected that the set of applications installed on any ITS-SU will change during its lifetime, both due to existing services being improved and new services being invented. As the set of applications is unknown during manufacturing, facilities for service provisioning and life cycle management is most likely needed. Several means to achieve this already exist, but a prevailing view is that each ITS-SU needs to be managed by a configuration management centre (CMC). Such a mechanism was implemented and tested in the CVIS project. The responsibilities of the CMC is both provisioning and remote monitoring. One CMC can serve multiple ITS-SUs. A single ITS-SU may be connected to different CMCs. This is illustrated in Figure 7 and shows the three steps to install new applications:

- 1) service creation;
- 2) service deployment; and
- 3) service provisioning.

The provisioning procedure is responsible, using remote management mechanisms, for life cycle management of the applications. This includes installing, starting, stopping and updating the applications. Note that the service execution step (not shown in the figure), utilizes information exchange between ITS-Ss and/or one or more service centres (central ITS-S).

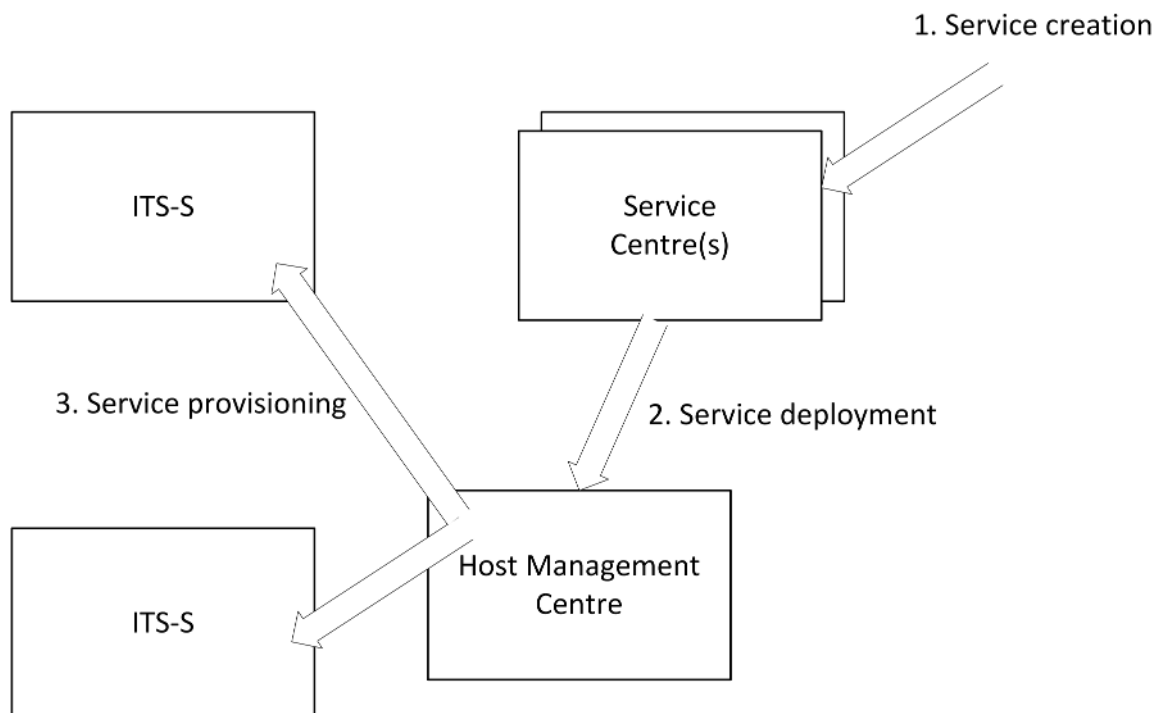


Figure 7 — Service deployment and provisioning (adapted from CVIS)

The provisioning of ITS-S applications, ITS-S facilities and ITS-S protocols to an ITS-SU is typically triggered by a subscription request from the user. But it is also possible to deem some applications mandatory. This can for example be applications that are mandatory for an area. Examples of such applications can be of regulatory kind such as electronic fee collection, electronic registration identification and low emission zones.

To enable provisioning and life cycle management a harmonized software run-time platform is needed. Several of the projects described in 5.6 have chosen to use the OSGi framework. The OSGi framework is a module system and service platform for the Java programming language. It implements a dynamic component model and allows applications to be remotely installed, started, stopped, updated, and uninstalled without interfering with the running of other concurrent applications.

5.3.4 Security

In ISO 21217 the ITS-S (as shown in Figure 6) is defined to be within a bounded secured management domain (BSMD). This is a requirement to be able to meet the stringent security requirements of ITS applications related to safety and enables secure peer-to-peer communication between ITS-SUs. The BSMD enables the ITS-SU to be trusted to operate according to the policies and procedures assigned to it by a trusted authority. To establish and maintain this trust there is a need for a public key infrastructure (PKI) for both trust assertion and certificate management.

The ETSI security framework for ITS is a guideline for the secure implementation of ITS applications based on the communication and ITS station architecture defined in ISO 21217 extended by a common security architecture.

ETSI's Specialist Task Force 423²⁾ has elaborated a set of ITS security standards. All standards are part of the package *Intelligent Transport Systems (ITS); Security* and deal with a certain aspect:

- ETSI/TS 102 940, *ITS communications security architecture and security management*;
- ETSI/TS 102 941, *Trust and Privacy Management*;
- ETSI/TS 102 942, *Access Control*;
- ETSI/TS 102 943, *Confidentiality services*.

The ITS security package above refers and is based on ETSI/TS 102 731, *Intelligent Transport Systems (ITS); Security; Security Services and Architecture*.

More detailed security considerations are provided in Annex A.

5.4 Legal aspects and background

5.4.1 European action plan and directive for ITS

In 2008 the EC published an *Action Plan for the Deployment of Intelligent Transport Systems in Europe* [COM(2008) 886 final]. The purpose of this action plan is to accelerate and coordinate the deployment of ITS throughout Europe, with the final goal of creating benefits in terms of transport efficiency, sustainability, safety and security, while contributing to the EU Internal Market and competitiveness. The action plan outlines six action areas. In action area 4, *Integration of the vehicle into the transport infrastructure*, the development and adoption of an open in-vehicle platform supporting C-ITS is specified. This action area is also the basis for M/453.

The action plan was followed by Directive 2010/40/EU in July 2010 (the ITS directive). The purpose of the directive is the same as the action plan, but a directive is a legislative act which requires member states to

2) ETSI Specialist Task Force 423 received funding in the framework of the ICT Standardisation Work Program of the European Commission.

achieve a particular result without dictating the means of achieving that result. The four first action areas from the action plan maps to the directives four priority areas.

5.4.2 User privacy and data protection

The central concept of C-ITS is the communication and sharing of information between actors in the transport system. For several of the new C-ITS applications and services this will involve the communication and processing of personal data. Therefore relevant legislations for user privacy and data protection need to be adhered to when deploying C-ITS.

In the *EC Action Plan for the Deployment of Intelligent Transport Systems in Europe*, action 5.1 is to assess security and data protection aspects related to ITS.

The ITS directive (2010/40/EU) refers to Directive 95/46/EC (on the protection of individuals with regard to the processing of personal data and on the free movement of such data) and Directive 2002/58/EC (concerning the processing of personal data and the protection of privacy in the electronic communications sector) for the processing of personal data.

5.4.3 Liabilities regarding application performance / suitability for use

Liability issues has been identified as a possible barrier to the deployment of C-ITS. These liability issues are related to any technical malfunctions or operational errors that potentially result in injuries and loss of lives due to accidents, loss of money due to inefficiencies, or even loss of privacy due to non-confirming processing of personal data.

In the *EC Action Plan for the Deployment of Intelligent Transport Systems in Europe*, action 5.2 is to address liability issues pertaining to the use of ITS applications and notably in-vehicle safety systems. The ITS directive (2010/40/EU) states that the member states shall ensure that issues related to liabilities relevant for ITS shall be addressed in accordance with European Union law, including in particular Directive 85/374/EEC (on the approximation of the laws, regulations and administrative provisions of the Member States concerning liability for defective products).

5.5 Overview of standardization activities

5.5.1 Introduction

Within ITS standardization there are three Standardization bodies that are of special interest. These are CEN/TC 278, ETSI TC ITS and ISO/TC 204. In addition IEEE also plays an important role in certain aspects of ITS standardization through their 802.11 and 1609 Working Groups. In Europe CEN/TC 278 and ETSI TC ITS are of particular interest since they have special focus on European legislations. To ensure and support a fast work progress and cooperation in standard development the EC has created so called mandates. These shall ensure that standards are developed within certain high focused areas. In 2009, the EC issued mandate M/453 which invited the European Standardization Organisations (ESOs) - CEN, CENELEC and ETSI – to prepare a coherent set of standards, specifications and guidelines to support European Community wide implementation and deployment of Co-operative Intelligent Transport Systems (ITS). CEN and ETSI have formally accepted the Mandate.

CEN and ETSI have agreed to jointly develop the response and work programme under this Mandate with a list of minimum set of standards for interoperability and other identified standards and technical specifications to support Co-operative ITS services. The minimum set of standards is understood as a set of standards which forms the essential basis for the realization of C-ITS and simultaneously is open for extension with regard to applications and as well with regard to other technologies. The work programme also defines an agreed split of responsibility and tasks between CEN and ETSI as well as a detailed description of the on-going cooperation between the two ESOs.

The division of responsibilities is centred on primary capabilities, with the competence of ETSI being in the field of communications and the relation of ETSI to the Car-2-Car Communication Consortium with the

experience of vehicle-to-vehicle applications. CEN has a focus on the overall framework architecture and on the roadside and traffic management applications, which mainly involve vehicle-to-road-infrastructure and infrastructure communications.

The ITS Coordination Group (ITS-CG) between CEN and ETSI has been established to ensure on-going coordination of the standardization activities within these two SDOs.

ISO, IEC and ITU are global SDOs who standardize ITS on a global level. Many of the working groups (WGs) with CEN are joint working groups with ISO. To harmonize and obtain a good and fruitful cooperation CEN/TC 278 and ISO/TC 204 has joint meetings twice a year.

ITS standardization is also going on in US, both within IEEE and SAE. An EU-US joint declaration of Intent on Research Cooperation in Cooperative systems has been established.

Cooperation between global ITS SDOs is important in order to achieve harmonized standards providing global interoperability. Detailed cooperation between the SDOs has been initiated in addition to the already existing cross participation by membership in the relevant organisations.

The scope of the standardization activities is broad to cover the complete architectural hierarchy. It covers amongst others:

- standardization of architectures for ITS services;
- various radio communications systems;
- formats and structure of message systems and transport;
- security and privacy technologies and system aspects;
- interfaces and reference points;
- database technologies and data file structures.

The usage areas of the standards can be grouped into categories such as:

- traveller information systems;
- transport control systems;
- vehicle to driver communication (HMI);
- vehicle to vehicle communication;
- vehicle to roadside communication;
- goods and vehicle information;
- public transport aspect including emergency systems.

5.5.2 Basic set of ITS applications

In CEN/ETSI Task Force on Standardization Mandate M/453 1st report, *Programming report under M453*, framing is defined by both a framework architecture and a communication architecture which supports the implementation of a basic set of applications as described in ETSI/TR 102 638. The selection for the basic set of applications was based on an opinion making process with involvement of representatives from key relevant stakeholders

In detail, the following application classes are considered in the minimum set of standards:

- Cooperative Awareness Driving Assistance (safety): Information from other vehicles as basis for the generation of in-vehicle Warnings: Emergency Vehicle Warning, Intersection Collision Warning, Slow Vehicle Warning, Motorcycle Approaching Indication;
- Floating Car Data Collection for Roadside Applications: Collection of Information from vehicles for infrastructure applications;
- Event Driven Road Hazard Warning V2I, I2I: Based on a certain event a warning message is sent out: Roadwork Warning, Wrong Way Driving Warning, Collision Risk Warning from an ITS-S Roadside, Traffic Condition Safety Warning, Weather condition warning;
- Event Driven Road Hazard Warning V2V: Based on a certain event a warning message is sent out: Emergency Electronic Brake Light, Stationary Vehicle Warning, Roadwork Warning, Wrong Way Driving Warning, Traffic Condition Safety Warning, Weather condition warning;
- Traffic Management V2I, I2I: Optimum traffic throughput via speed limits, centrally determined routing, road network management, no overtaking for trucks monitoring and routing of dangerous goods;
- Traffic Management V2V: Improved traffic throughput based on information from other vehicles e.g. position, speed, acceleration information;
- Cooperative Traveller Assistance: Navigation considering information received about restricted access, etc., parking information/booking;
- Value Added Services: Insurance and Financial Services.

The mandate covers the development of a minimum set of standards that allows the implementation of the basic set of applications. This set is extensible, by principle, in order to facilitate a sustainable deployment of the system.

In ETSI/TR 102 638 Electronic Toll Collection is defined as a co-operative traffic management application. The use case defines use of I2V communication to broadcast electronic toll payment capabilities from RSU. ETSI/TR 102 638 also defines two similar use cases; one for automatic access control/parking management and another for local electronic commerce. These two use cases are classified as applications for comfort and entertainment.

5.5.3 CEN/TC 278/WG 16 on cooperative systems

CEN/TC 278 is an European standardization body with the name “Intelligent Transport Systems”. CEN/TC 278 was the first ITS standardization body, and CEN/TC 278 has laid the ground works for global ITS standards. In general, CEN has a good representation and participation from industry, service providers, public bodies and road operators/authorities, but less from car makers.

Within CEN/TC 278, Working Group (WG) 16 has the responsibility for standards related to Co-operative systems. As defined in the response to M/453 CEN has a focus on the overall framework architecture and on the roadside and traffic management applications, which mainly involve vehicle-to-road-infrastructure and infrastructure communications.

5.5.4 ISO/TC 204/WG 18 on cooperative systems

ISO/TC 204/WG 18 is a joint working group with CEN/TC 278/WG 16.

5.5.5 ISO/TC 204/WG 16 on wide area communications/protocols and interfaces

ISO/TC 204/WG 16 - wide area communications/protocols and interfaces – has defined the CALM (Communication Access for Land Mobiles) set of standards. The goal is to provide ubiquitous continuous communication for ITS services, both between vehicles and between vehicles and the infrastructure. Working Group 16 produced the globally applicable ITS communication architecture (ISO 21217) where different communication protocol stacks are combined, and the actual protocol stack used at any time is dependent on the current availability and capabilities of the protocol stacks and the application requirements and objectives. This “best” choice of available communication protocol stack is transparent to the application (prCEN ISO/TS 17423).

The ITS communication architecture ISO 21217 makes a distinction between *ITS-S specific access technologies*, which have been specifically designed for CALM, and *other access technologies*, which is included in the architecture by an adaption layer. An example of the former is IR (ISO 21214), which specifies the use of infrared light technologies for V2V and V2I communication. Example of the latter are M5 (ISO 21215) and 2G/3G (ISO 21212 and ISO 21213).

In the ITS-S network and transport layer, both standard IPv6 based communication, including NEMO (Network Mobility), and a protocol optimized for low latency V2V and V2I communication called FNTP (Fast Network and Transport Protocol) has been defined (see ISO 21210 and ISO 29281-1).

5.5.6 ETSI Technical Committee on ITS (ETSI TC ITS)

ETSI is the European Telecom Standardization Institute, and is a major contributor to global telecom standards such as GSM and DVB. ETSI does also have a formal and legal role in Europe since it produces Harmonized European Norms, which is an operative part of the R&TTE directive that allows sale and operation of radio equipment without type approval. ETSI is a private institution with paying members.

The stated mission of ETSI Technical Committee ITS is the creation and maintenance of standards and specifications for the use of information and communications technologies in future transport systems. Current focus is mostly on wireless communications for V2V and V2I communications.

The work of ETSI TC ITS is divided in five working groups:

- WG1: User and application requirements;
- WG2: Architecture and cross layer;
- WG3: Transport and network;
- WG4: Medium and medium related;
- WG5: Security.

Together these WGs cover all parts of a protocol stack for V2V and V2I communication. On the application side the focus of ETSI is on road safety. The ITS communication architecture is defined in ETSI EN 302 665, which is based on ISO 21217.

5.6 Overview of R&D projects and other relevant initiatives

5.6.1 CVIS project on cooperative vehicle infrastructure systems

CVIS (Cooperative Vehicle Infrastructure Systems) was an integrated R&D project co-funded by EC – DG INFSO, under the ICT priority of the 6th Framework Programme for Research. The project ran from 2006 to 2010. In CVIS a platform for C-ITS was developed. This C-ITS platform, consisting of hardware and software prototypes for in-vehicle and roadside deployment, allows mobile units, roadside units and centres to interact and communicate seamlessly. The CVIS platform features:

- an implementation of the ISO set of standards, including M5 (ISO 21215), IR (ISO 21214), 2G/3G (ISO 21212 and ISO 21213) media;
- a JAVA/OSGi based software and runtime environment supporting application provisioning and life cycle management.

In addition to the platform development CVIS also implemented selected services for increased road efficiency and safety, running on top of this platform.

The CVIS high-level architecture is shown in Figure 8.

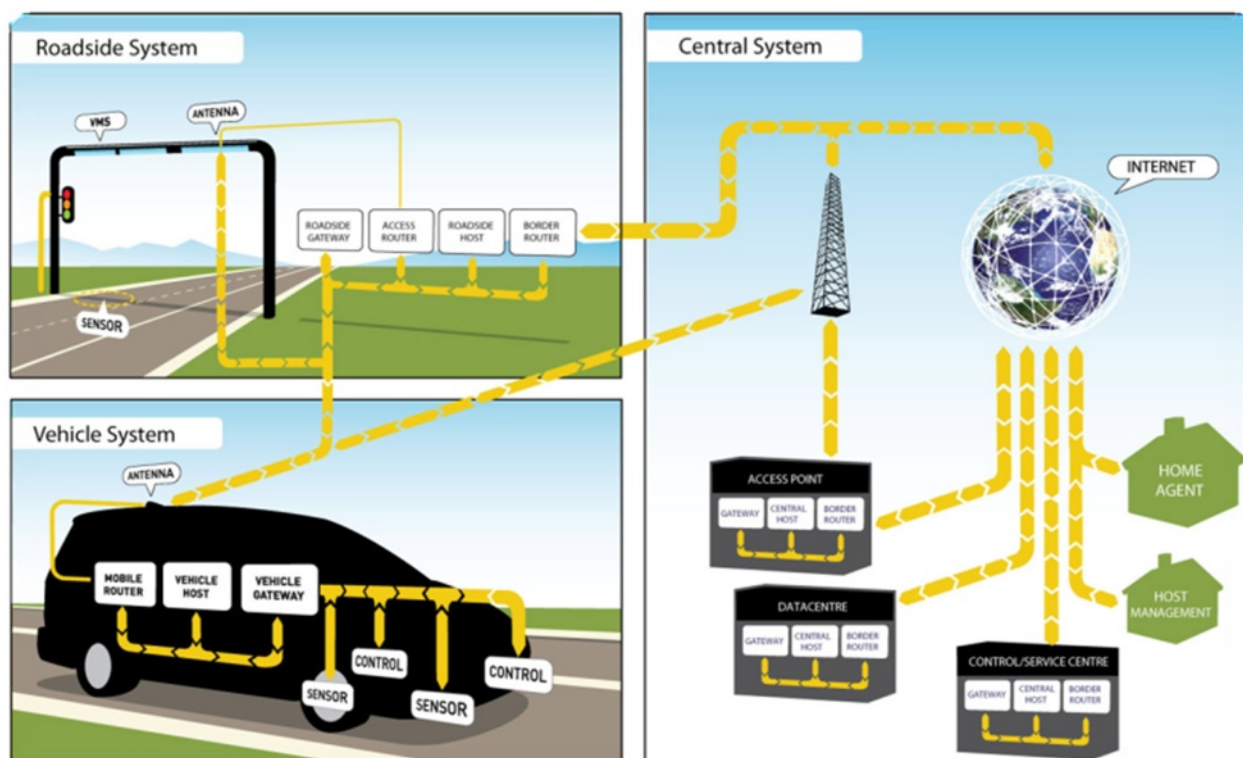


Figure 8 — CVIS high-level architecture [source and courtesy of CVIS]

5.6.2 SAFESPOT project on road safety related applications

SAFESPOT (Cooperative vehicles and road infrastructure for road safety) was an integrated R&D project co-funded by EC – DG INFSO, under the ICT priority of the 6th Framework Programme for Research. The project ran from 2006 to 2010. The goal of SAFESPOT was based on C-ITS techniques to develop a “safety margin assistant” for drivers. To achieve this several C-ITS prototype applications were developed and tested. Due to cooperation with the CVIS project these prototype applications were also portable to the CVIS platform. Due to the safety focus of SAFESPOT only 802.11p/ M5 based communication technology was employed.

5.6.3 eCoMove project on road transport efficiency applications

eCoMove (Cooperative Mobility Systems and Services for Energy Efficiency) is an integrated R&D project co-funded by the European Commission under the 7th Framework Programme for Research and Development. The project period is from April 2010 to March 2013. The project goal was to create an integrated solution for road transport energy efficiency to help drivers, freight and road operators:

- save unnecessary kilometres driven (optimised routing);
- save fuel (eco-driving support);
- manage traffic more efficiently (optimised network management);

The project's core concept is that there is theoretical a minimum energy consumption achievable with the "perfect eco-driver" travelling through the "perfectly eco-managed" road network.

The technical platform to implement the eCoMove services is heavily based on the outcome of the CVIS project, including a JAVA/OSGi based software and runtime environment for applications.

5.6.4 DRIVE C2X project with focus on field trials

DRIVE C2X is an integrated R&D project co-funded by the European Commission under the 7th Framework Programme for Research and Development. The project period is from January 2011 to December 2013. The project objectives are:

- carry out a comprehensive assessment of cooperative systems through extensive European field operational tests;
- create and harmonize a European wide testing environment for cooperative systems;
- coordinate the tests carried out on parallel throughout the DRIVE C2X community;
- evaluate cooperative systems;
- promote cooperative driving.

DRIVE C2X will test and evaluate both safety and efficient related services. The DRIVE C2X reference system implements a JAVA/OSGi runtime environment for applications.

5.6.5 Car-to-car communication consortium (C2C-CC)

C2C-CC (CAR 2 CAR Communication Consortium) is a European based membership organization related to C-ITS. C2C-CC has several membership classes: partner, associate membership and development membership. Only vehicle manufacturers can be partners. Currently there are 12 partners of C2C-CC. The mission and the objectives of the CAR 2 CAR Communication Consortium are:

- the development and release of an open European standard for cooperative Intelligent Transport Systems and associated validation process with focus on Inter-Vehicle Communication Systems;
- to be a key contributor to the development of a European standard and associated validation process for Vehicle-2-Roadside Infrastructure Communication being interoperable with the specified inter-vehicle communication standard;
- to provide its specifications and contributions to the standardization organisations including in particular ETSI TC ITS in order to achieve common European standards for ITS;
- to push the harmonization of Car-2-Car Communication Standards worldwide;

- to promote the allocation of a royalty free European wide exclusive frequency band for Car-2-Car applications;
- to develop realistic deployment strategies and business models to speed-up the market penetration;
- to demonstrate the Car-2-Car System as proof of technical and commercial feasibility.

5.6.6 EasyWay project on applications for the major EU road network

EasyWay is an European project for ITS deployment on main European road corridors. The project is driven by national road authorities and operators with associated partners including the automotive industry, telecom operators and public transport stakeholders. EasyWay is partly funded by the European Commission as part of the Trans-European Transport Network (TEN-T) programme which is administered by the Trans-European Transport Network (TEN-T) programme.

EasyWay has established a Cooperative Systems Task Force. This task force has selected seven priority services for first deployment of C-ITS. These are: Hazardous location notification, Traffic jam ahead warning, Road works warning, Decentralised floating car data, Traffic information and recommended itinerary, In-vehicle signage, and Parking management. The task force is cooperating with the DRIVE C2X project and has also stated its intention to support CEN/TC 278 and ETSI TC ITS for the standardization of cooperative systems.

5.6.7 COMeSafety and COMeSafety2 projects on road safety applications

COMeSafety was a support action co-funded by the European Commission under the FP6. COMeSafety2 is a follow-up project under FP7. One of the main objectives of COMeSafety2 is to support the development of a minimum of standards for C-ITS as European Norms, and to support international harmonization of standards. COMeSafety2 also wants to coordinate field operational tests (FOTs) by the exchange of test tools and methods.

5.6.8 Amsterdam Group

The Amsterdam Group is a cooperation platform with the aim to enable deployment of C-ITS. The members are:

- ASECAP – European professional association of operators of toll road infrastructures;
- CEDR – European organization for the national road administrations;
- POLIS – network of European cities and regions working together to develop innovative technologies and policies for local transport;
- CAR-2-CAR Communication Consortium.

The stakeholders within the Amsterdam Group have agreed on a roadmap for deployment of certain “day one applications” which are to be implemented from the year 2015.

6 Context of EFC

6.1 Definition of EFC

The change from traditional road user charging with manually operated toll booths to electronic free flow tolling systems was the birth of a new term:

- Electronic fee collection (EFC).

In ISO 17573 *Electronic fee collection — Systems architecture for vehicle-related tolling*, the term electronic fee collection is defined as follows:

- Electronic fee collection (EFC) is toll charging supported by electronic equipment on board a vehicle.

NOTE The actual payment (collection of the fee) can take place outside the EFC system.

Including the fact that EFC systems nowadays are free flow systems and do not require a wire based data interface for the tolling process, the definition shall be refined to:

- Electronic fee collection (EFC) is toll charging by electronic means via a wireless interface supported by electronic equipment on board a vehicle.

In the context of EFC according to ISO 17573 toll charging is the electronic collection of tolls for vehicle-related transport services. A transport service is related to the use of, or the presence of a vehicle in a toll domain. The toll domain may encompass a road network, a specific section of road (e.g. a bridge, a tunnel or a ferry connection) or a specific area offering a service (e.g. a parking lot or access to a protected area in a city). It could also be any service related to the use of a vehicle in the transport system, e.g. a petrol station enabling the driver to buy petrol by means of EFC.

Financial authorities may define policies for a toll charging environment and the financial environment it shall operate, e.g. whether the toll is a tax or a fee. They may also define policies for the use of certain types of payment means, e.g. electronic purses, and the split of roles between the toll charging environment and the financial systems.

6.2 EFC role model and business architecture

6.2.1 Role model

The role model for interoperable EFC systems was developed in the CESARE project and is currently standardized in ISO 17573. According to this role model, the Toll Charger is the provider of the tolled infrastructure or transport service and, hence, the recipient of the road usage charges. The Toll Charger is the actor associated with the Toll Charging role (also called “charging of the toll”, see Figure 9).

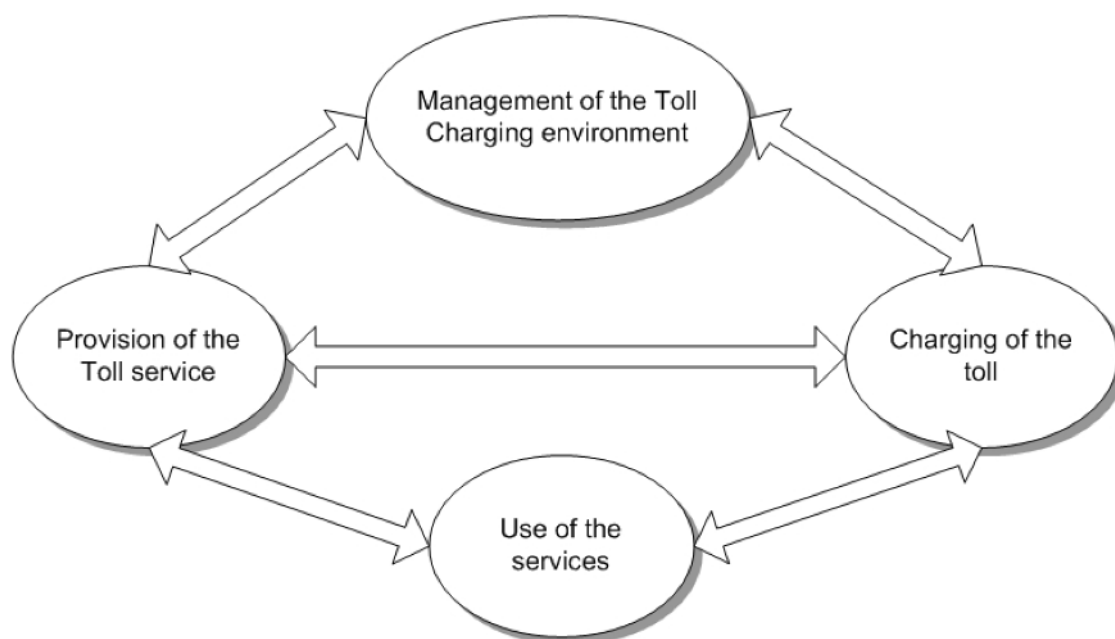


Figure 9 — The EFC role model [source: ISO 17573:2010]