Tomorrow's Elastic Adaptive Mobility

Report on standard compliance of the TEAM

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Executive summary

The present document outlines the referenced standards in TEAM & TEAM's contribution to different standardization development organizations (SDO). For EMPOWER application in the TEAM project the most relevant standards are stemming from CEN TC 278 WG 16/ISO TC 204 WG 16, ETSI TC ITS, and 3GPP for LTE communication. For the application development in FLEX and DIALOGUE standards from SAE for communication between vehicles and infrastructure are most relevant. The standardization contributions have been in terms of input to on-going standardization and initiative to new standardizations. Further, flaws in already approved standards have been noted and they are provided herein.

1 Introduction

1.1 Scope

This report presents the analysis of standardization activities of cooperative technology on different levels in Europe collecting the documents relevant to the TEAM project and used in the EMPOWER, FLEX and DIALOGUE applications. The first part of the report provides an overview about the core standards relevant to TEAM. The document classifies the existing standards for their usability and usage in the TEAM applications and components. Further, the required standards extensions for TEAM and the activities of TEAM partners in the standardization groups and their standardization contributions out of the TEAM project form part of the deliverable.

This document presents TEAM's contribution to on-going standardization, initiative to new work items based on outcome within TEAM, and revision of already approved standards spotted during the project.

1.2 Structure of the document

In chapter 2, standards development organizations are detailed and in chapter 3 areas that are subject to standardization are outlined. Readers familiar with standardization can jump directly to chapter 4, which contain the referenced standards in TEAM under different applications EMPOWER, FLEX and DIALOGUE. Chapter 5 outlines TEAM members direct input to standardization. Chapter 6 provides suggestion to revision of already approved standards based on all research, development and implementation work that have been performed so far in TEAM. The document is finalized with conclusions in chapter 7.

2 Standards Development Organizations

2.1 Introduction

Developing standards are important for data communication without standards defining how communication should take place no interoperability between different devices can be achieved. When it comes to cooperative ITS several standards development organizations (SDO) have been involved. The SDOs ETSI, CEN and SAE have played a major role for direct communication between vehicles (vehicle-to-vehicle communication, V2V) and for communication between vehicles and roadside units (vehicle-to-infrastructure, V2I). But also the US-based SDO IEEE did early on standardize the two lowest layers in the protocol stack, which is outlined in IEEE 802.11p [1]. IEEE 802.11p has been selected as the wireless technology for V2V and V2I worldwide. Further, IEEE 802.11p is the mandated wireless technology in the European standard EN 302 663 [2]. IEEE 802.11p is an amendment to IEEE 802.11; however, it is now superseded and enrolled into the legacy IEEE 802.11-2012 [3].

Certain cooperative ITS applications are better suited for cellular technology (e.g., 3G/4G/5G). The main platform for developing standards for cellular technology is 3GPP, which will be described subsequently.

This Chapter gives an insight to the different SDOs and other major stakeholders that are important for the European C-ITS deployment plans.

2.2 ETSI

European Telecommunication Standards Institute (ETSI) [4] is a recognized SDO by the European Commission together with CEN (described in Clause 2.4). ETSI is for example responsible for developing harmonized standards to cover essential requirements stemming from Article 3.2 of Directive 2014/53/EU (a.k.a. Radio Equipment Directive). A harmonized standard developed for a specific frequency band is a necessity to fulfil for putting radio equipment on the European market. ETSI is a member-driven organization consisting of companies, universities, and research institutes. Members pay an annual fee to ETSI and can then be part of standards development. In 2007, ETSI established a new technical committee on intelligent transport systems (TC ITS) to address standardization on C-ITS. ETSI TC ITS is divided into five working groups focusing on different aspects of the protocols stack. It should be noted that ETSI TC ITS has developed the whole protocol stack for C-ITS and focus has been on C-ITS installation in the vehicle. CEN is also working on C-ITS standardization with focus on C-ITS applications running on the roadside, using the same lower layer technologies for communication developed in ETSI TC ITS. In Table 2-1, an outline of the different working groups in ETSI TC ITS is provided. All standards developed and released by ETSI are free for download at ETSI's homepage.

Table 2-1: Overview of working groups in ETSI TC ITS

Working Group Number	Working Group Name
1	Application requirements and services
2	Architecture and Cross-layer
3	Transport and Network
4	Media and Medium Related
5	Security

2.3 ISO

International Organization for Standardization (ISO) [5] is a world-wide SDO with 162 member countries. Every member country has a national standards body, which appoints a delegate representing the country during standardization meetings. The national standards body collects companies and other interested parties of the ISO standardization. ISO hosts nearly 300 technical committees (TC) treating a plethora of different subjects. Each TC is usually divided into several working groups (WG). The TC interesting from a cooperative ITS perspective is TC 204 Intelligent Transport Systems. TC204 is further divided into several WG, which two are dealing with communication – WG 16 Communications and WG 18 Cooperative systems. See Table 2-2, for a full overview of the different WG within TC 204.

Table 2-2: Overview of working groups within TC 204 Intelligent Transport Systems

Working Group Number	Working Group Name
1	Architecture
3	ITS database technology
4	Automatic vehicle and equipment identification
5	Fee and toll collection
7	General fleet management and commercial/freight
8	Public transport/emergency
9	Integrated transport information, management and control
10	Traveller information systems
14	Vehicle/roadway warning and control systems
16	**Communications**
17	Nomadic devices in ITS Systems
18	**Cooperative systems**

2.4 CEN

European Committee for Standardization (CEN) [6] collects the national standards body of 33 European countries, i.e., it is European based. CEN like ETSI, is a recognized SDO by the European Commission. It has a similar structure as ISO with around 400 technical committees divided into subcommittees and some 1600 working groups. TC 278 [7] is dealing with Intelligent Transport Systems and it is divided into 11 active working groups, where WG 16 Cooperative ITS is working on TEAM related applications. TC278 WG16 is dealing with the applications and message sets for cooperative ITS running on infrastructure (e.g., roadside units attached to signs and red lights). ETSI TC ITS is dealing with the vehicle side of cooperative ITS as well as the protocols of the lower layers of the communication stack. CEN TC278 WG16 and ISO TC204 WG18 have a close collaboration when it comes to developing standards for cooperative ITS. In Table 2-3, an overview of the active working groups in TC278 is outlined.

Table 2-3: Overview of working groups within TC278 Intelligent Transport Systems

Working Group Number	Working Group Name
1	Electronic fee collection and access control (EFC)
2	Freight, Logistics and Commercial Vehicle Operations
3	Public transport (PT)
4	Traffic and traveller information (TTI)
5	Traffic control (TC)
7	ITS spatial data
8	Road traffic data (RTD)
9	Dedicated Short Range Communication (DSRC)
10	Man-machine interfaces (MMI)
12	Automatic Vehicle Identification and Automatic Equipment Identification (AVI/AEI)
13	Architecture and terminology
14	After theft systems for the recovery of stolen vehicles
15	eSafety
16	**Cooperative ITS**
17	Ad hoc group U-ITS

2.5 SAE

Society of Automotive Engineer (SAE) [8] is a US-based SDO collecting 138 000 members worldwide. In SAE, membership is granted to individuals and not through companies. SAE is developing standards based on best practices within three main areas: automotive, aerospace, and commercial vehicles. SAE is divided into committees and task forces. Dedicated Short-Range Communication technical committee (DSRC TC) within SAE is dealing with message sets for cooperative ITS.

2.6 3GPP

The 3rd Generation Partnership Project (3GPP) [9] unites seven telecommunications SDOs (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC), known as "Organizational Partners" and provides their members with an environment to produce the reports and specifications that define 3GPP technologies.

The project covers cellular telecommunications network technologies, including radio access, the core transport network, and service capabilities including work on codecs, security, and quality of service. Thus, complete system specifications are provided. The specifications also provide hooks for non-radio access to the core network, and for interworking with Wi-Fi networks.

3GPP specifications and studies are contribution-driven, by member companies, in WGs and at the Technical Specification Group (TSG) level. There exist 4 TSGs in 3GPP:

- Radio Access Networks (RAN),
- Service & Systems Aspects (SA),
- Core Network & Terminals (CT), and
- GSM EDGE Radio Access Networks (GERAN).

The WGs within TSGs, meet regularly and come together for their quarterly TSG plenary meeting, where their work is presented for information, discussion and approval. Each TSG has a particular area of responsibility for the Reports and Specifications with its own Terms of Reference (ToR). TSG SA is responsible for the overall coordination of work and for monitoring of its progress.

The 3GPP technologies from the TSGs are constantly evolving through the notion of generations of commercial cellular/mobile systems. Since the completion of the first long-term evolution (LTE) and the evolved packet core specifications, 3GPP has become the focal point for mobile systems beyond 3G.

Although these generations have become an adequate descriptor for the type of network under discussion, real progress on 3GPP standards is measured by the milestones achieved in particular releases. New features are 'functionality frozen' and are ready for implementation when a release is completed. 3GPP works on a number of releases in parallel, starting future work well in advance of the completion of the current release. Although this adds some complexity to the work of the groups, such a way of working ensures that progress is continuous and stable.

TSG RAN, like other TSGs, ensures that systems based on 3GPP specifications are capable of rapid development and deployment with the provision of global roaming of equipment. In Figure 2-1, past, present and future releases are depicted.

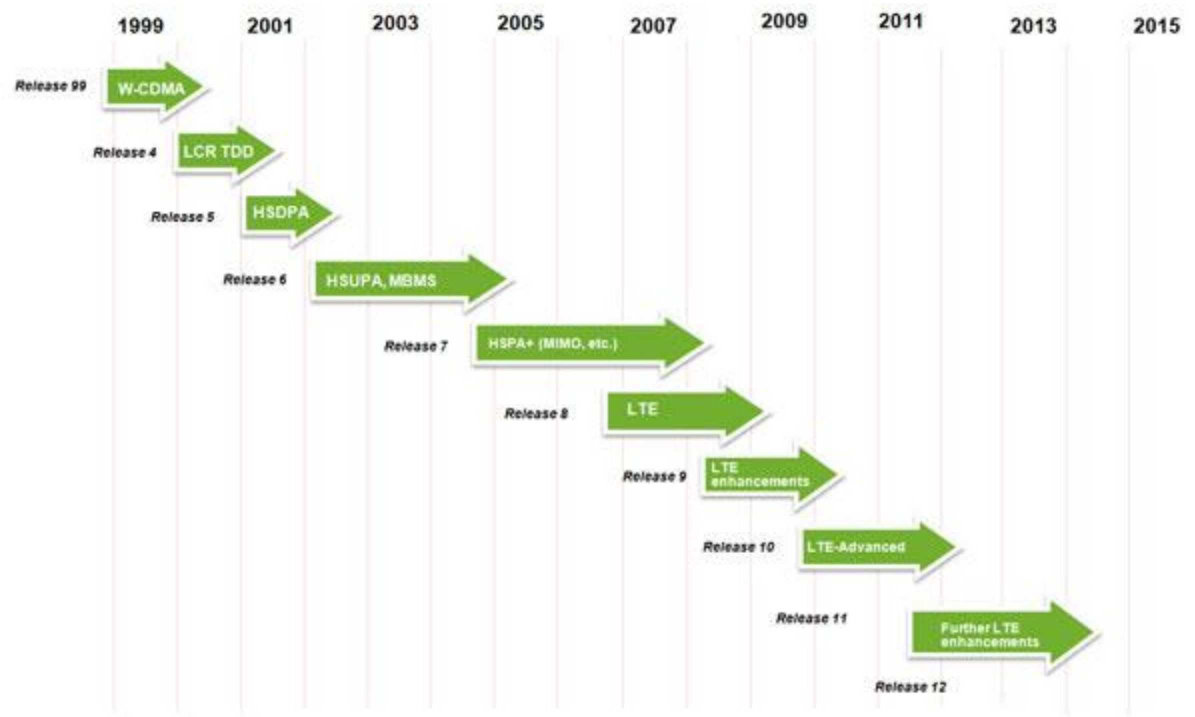

Figure 2-1: Past and present releases of cellular networks

All of these releases have provided a high degree of continuity in the evolving systems, allowing existing equipment to be prepared for future features and functionality such as delivering higher data rates, quality of service, and cost efficiencies. Each progressive 3GPP radio access technology aims to reduce complexity and avoid fragmentation of technologies on offer.

2.7 CAR 2 CAR Communication Consortium

The CAR 2 CAR Communication Consortium (C2C-CC) [10] is a non-profit, industry-driven organization initiated by European vehicle manufacturers and supported by equipment suppliers, research organizations and other partners. C2C-CC can be regarded as a pre-standardization organization.

The C2C-CC is dedicated to the objective of further increasing road traffic safety and efficiency by means of cooperative ITS. Major vehicles manufacturers within C2C-CC have signed a memorandum of understanding (MoU) with the intention to start deployment of cooperative ITS during 2015. This date was shifted to 2019 at the C2C Forum in Nov. 2015

2.8 Amsterdam Group

The Amsterdam Group [11] is a strategic alliance of committed key stakeholders with the objective to facilitate joint deployment of C-ITS in Europe. In the Amsterdam group representatives from the following organizations are found: Polis, CEDR, ASECAP, and C2C-CC. In Table 2-4, a description of the different organizations found.

Table 2-4: Description of organizations member of the Amsterdam group

Organization	Description
Polis	Polis is a network of European cities and regions working together to develop innovative technologies and policies for local transport. Cities from 15 European countries are part of Polis [12].
CEDR	Conference of European Directors of Roads (CEDR) [13] is the road directors' platform for cooperation and promotion of improvements to the road system and its infrastructure. 29 European countries are members of CEDR.
ASECAP	Association Européenne des Concessionnaires d'Autoroutes et d'Ouvrages à Péage (ASECAP) has 21 members. ASECAP's mission is to defend and develop the system of motorways and road infrastructures in Europe applying tolls as means to ensure financing of their construction, maintenance and operation [14].
C2C-CC	CAR 2 CAR Communication Consortium collects major vehicle manufacturers together with suppliers, universities, and research institutes.

The Amsterdam Group is active to facilitate information exchange, discussion and creation of solutions between the involved stakeholders in the context of cooperative ITS. The role of the Amsterdam Group is:

- Facilitate dialogue between actors, e.g. on corridors results and needs
- Integrated communication interface towards the individual members of the Amsterdam group

- Exchange of experience between corridors, front runners, etcetera.
- Communicates with EC and other bodies (e.g. ETSI/CEN)
- Functional specifications for C-ITS services as input for standardization
- Taking away barriers for deployment

3 Areas Subject to Standardization

3.1 Introduction

Standards are a necessity to achieve interoperability between communicating parties especially when products from different vendors shall be able to communicate with each other. Standards should not give details on implementation issues since there must be some freedom for products to differ in design and performance. TEAM is mainly using two communication technologies – short-range wireless communication using a dedicated frequency band at 5.9 GHz and long-range cellular networking using frequency bands provided by cellular operators in each country.

In 2008, a frequency band was allocated in Europe dedicated to increase road traffic safety and road traffic efficiency using short-range wireless communication technology. The frequency band is between 5.855-5.925 GHz and it is covered by different ECC decisions and recommendations and an EC decision, see Figure 3-1. To put radio equipment using 5.9 GHz onto the European market the harmonized standard EN 302 571 [15] needs to be fulfilled.

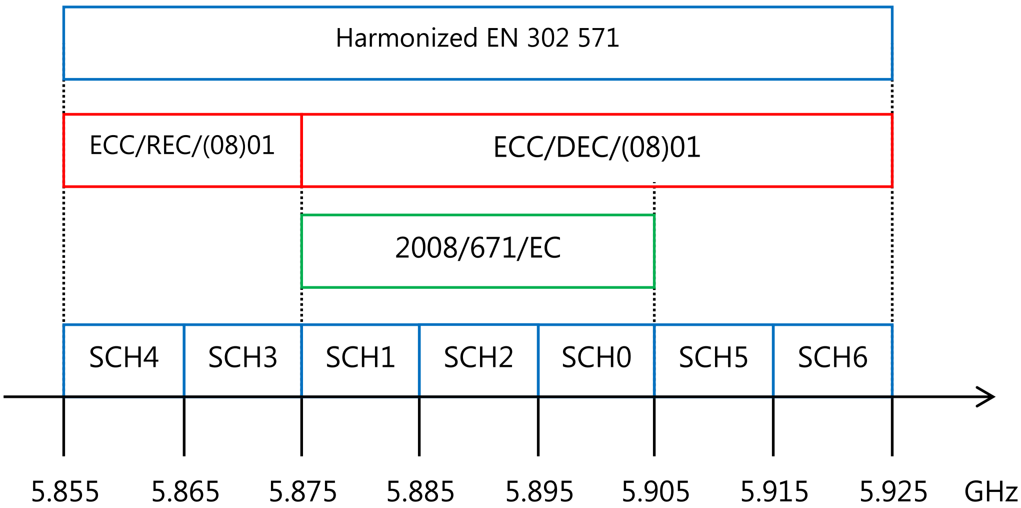

Figure 3-1: Overview of the frequency bands at 5.9 GHz together with relevant ECC, EC, and ETSI documents

This frequency band is intended for V2V and V2I communications, collectively known as V2X communication. The communication range is up to 1000 meters in benign conditions depending on output power. The standards developed for V2X is not relying on any infrastructure to function such as a base station (BS) or an access point (AP). In other words, the network is decentralized and *ad hoc* (if there is someone to communicate with – communication can take place). Roadside units

(RSU) can of course be part of the network but from a network perspective they are peers with vehicles. The frequency band at 5.9 GHz is license-free implying that no subscriptions are needed to use it and there is only an upfront cost.

Discussions about spectrum allocation are also going on within 3GPP. A number of options are being considered (not necessarily mutual exclusive nor exhaustive) such as:

- Use of commercial LTE spectrum:
  - Any band used for commercial LTE service is also used for LTE-based V2X
  - Depending on the regulation, for each region, one or more than one operators are allowed for LTE-based V2X
- Use of dedicated V2X spectrum (e.g., around 5.9 GHz unlicensed band)
  - A spectrum designated for V2X service is used for LTE-based V2X. This spectrum is used only for V2X service.
    - ✓ Option A: For each region, one spectrum dedicated to LTE-based V2X is allocated.
    - ✓ Option B: For each region, multiple spectrums dedicated to LTE-based V2X are allocated.
    - ✓ Option C: For each region, dedicated spectrum is allocated for V2X. It can be used for either DSRC/WAVE or LTE
- Use of band for public safety
  - V2X can be considered as a service for everybody's benefit, so sharing of spectrum assigned to public safety can be considered.

Short-range wireless communication is a complement to the long-range cellular networking offering services from back office systems and the Internet at large to vehicles and infrastructure. Cellular networking is depending on base stations to function providing connectivity to cloud services etc. However, lately, there are ongoing discussions for using future cellular technologies also in *ad hoc* mode on for example license-free frequency bands. Further, cellular networking is depending on subscriptions and therefore, it is not free to use. V2X together with cellular networking enables a plethora of new services and applications aiming for increased road traffic safety and road traffic efficiency.

In this Chapter, the reader will get acquainted with the efforts that have been undertaken so far within standardization on communication technologies used in the vehicular environment. But this Chapter will also give some insights to applications and the human machine interface, being an important part as the vehicles gets more and more connected.

3.2 Short-range communication

3.2.1 Introduction

ETSI TC ITS has developed standards for the whole V2X protocol stack running from access layer to facilities layer to be used at the allocated 5.9 GHz frequency band. The communication architecture was early on detailed in EN 302 665 [16], see Figure 3-2. CEN TC278 WG16 is developing facilities layer protocols that will be used by smart infrastructure such as traffic lights. As pointed out earlier, vehicles and smart infrastructure are perceived as peers in the network. Protocols developed for the transport & network and facilities layers as well as the security will be detailed subsequently.

In the access layer in the bottom of the protocol stack, the wireless technology IEEE 802.11p is used. A reference to IEEE 802.11p [1] with some additional requirements are detailed in the European standard EN 302 663 [2], which has been given the name ITS-G5.

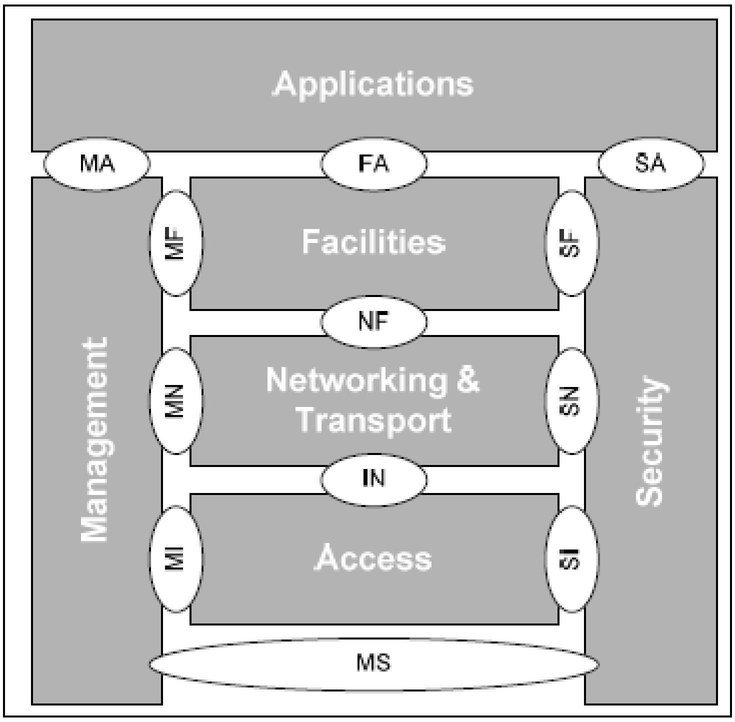

Figure 3-2: Station reference architecture [16]

3.2.2 Facilities layer

Cooperative awareness message (CAM) is the artery of V2X. CAM will be broadcasted with 1-10 Hz depending on vehicle dynamics. As long as the vehicle is turned on, CAMs will be transmitted. CAM contains information about heading, speed, position etc. of the vehicle, and it is outlined in EN

302 637-2 [17] (released in September 2014). CAM is a standalone facility in the facilities layer and does not rely on any applications on top for triggering instead in-vehicle sensors are one input to the triggering of CAMs in the facilities layer.

The other important message specifically developed for the vehicle is the decentralized environmental notification message (DENM). DENM is only triggered on behalf of an application on top of the facilities layer. The application triggering DENMs decides upon repetition rate, which can be 1-20 Hz, dissemination area, and longevity. DENMs contain specific information about the event triggering the DENM such as the event's eventual speed/heading, position, etc. DENM does not contain position information of the vehicle triggering the DENM. DENM is outlined in EN 302 637-3 [18] (released in September 2014). As DENM is event position and not vehicle position based, it can also be used by RSU and applications such as road works warning or dangerous hot spots.

CAM and DENM have been developed within WG1 in ETSI TC ITS.

In urban scenarios with controlled intersections, the SPAT/MAP messages are the most relevant. SPAT contains the Signal Phase and Timing of the traffic lights signalling, MAP contains the topological information of the intersection. The SPAT message needs the MAP message to enable the receiver to identify the relevant signal for its own position.

The SPAT/MAP applications use the communication of the signalling information from the traffic light controller to all individuals and vehicles using an intersection (e.g. vehicles, bicycles, and pedestrians). The color oriented representation of signal states (e.g. red, amber, and green) is replaced in the data dictionary developed under SAE as SAE J2735 by abstract permissions (e.g. stop-And-Remain, protected-Movement-Allowed, permissive-Movement-Allowed,…). This was done to get rid of ambiguous meanings of colors, combination of colors (e.g. full red and green arrow) and incomplete signals (e.g. single green arrow to the right) in different regions. This enables a new set of use cases for increasing the safety of intersection traffic. Combined with the CAM message, SPAT/MAP can be used to prioritize special vehicles (e.g., buses) crossing an intersection. The SPAT can include information for prioritization response and green wave speed information.

The use cases of the SPAT/MAP application are typical examples of day one Infrastructure-to-Vehicle (I2V) use cases, since equipped vehicles have immediate benefit from day 1 on, independent of the rate of cooperative ITS equipped vehicles, as long as the infrastructure is equipped at the intersections. The use cases are defined as an extension to existing traffic light controlled intersections focusing on optimization of traffic flow for increased safety and decreased environmental pollution. SPAT and MAP are outlined in a joint work item between ISO TC204

WG18 and CEN TC278 WG16 in collaboration with SAE DSRC TC. The joint work item will result in a technical specification (TS) but it is currently under development under the name "TS 19091 – Intelligent transport systems – Cooperative ITS – Using V2I and I2V communications for applications related to signalized intersections".

In later deployment phases also active safety functions and drive automation may be enabled by this information. For heavy vehicles there might be additional signs, which are requested such as size and weight limitations or road gradients.

3.2.3 Networking & Transport layer

ETSI EN 302 636 family of standards covers the networking & transport layer. Specifically, EN 302 636-1 [19] covers requirements, EN 302 636-2 [20] covers scenarios EN 302 636-3 [21] deals with networking architecture and EN 302 636-4-1 [22] specifies the networking protocol. Finally, the transport layer standards for basic transport protocol (BTP) and GN6 are specified in parts EN 302 636-5-1 [23] and EN 302 636-6-1 [24], respectively.

On the network layer, the GeoNetworking protocol provides packet routing in an *ad hoc* network. It makes use of geographical positions for packet transport. GeoNetworking supports the communication among individual ITS stations as well as the distribution of packets in geographical areas. GeoNetworking can be executed over different ITS access technologies for short-range wireless technologies, such as ITS-G5 and infrared. The ITS access technologies for short-range wireless technologies have many technical commonalities, but also differences.

On the transport layer, BTP multiplexes/demultiplexes facilities layer messages and provides a connectionless, unreliable end-to-end packet transport similar to user datagram protocol (UDP). It adopts the concept of ports from the internet protocol (IP) suite and assigns well-known ports for the relevant facilities layer message types. Alternatively to BTP, GN6 enables sub-IP multihop delivery of IPv6 packets without modifications of IPv6. It adapts the stateless address auto-configuration known from IPv6 and extends the concept of an IPv6 link to geographical areas that are associated with an IPv6 point of attachment.

3.2.4 Channel Modelling

Channel models play a crucial importance for evaluating a wireless technology but could also be used for certification of wireless equipment. Channel models try to capture the most essential properties of a wireless channel, which contributes to the signal when travelling through the air. The environment affects the signal and this can be both in a positive or negative respect. The cellular industry (e.g., 2G/3G/4G) usually establishes several channel models early on when developing a new wireless technology in order to optimize it for the environmental circumstances.

Several channel measurement campaigns have been performed for V2V communication at 5.9 GHz and the results have shown that correctly modeling the vehicular channel is imperative for realistic evaluation of VANET applications. This is particularly important for safety applications, where the correct reception of a single message can help avoiding an accident. Specific considerations for vehicular channel modeling include diverse environments where the communication takes place and the objects that impact channel modeling. The models can be classified based on the propagation mechanism scale, modeling approach, and suitability for a particular environment, among other. However, no standardized channel models for V2V exist yet similar to what is available for cellular communication.

3.2.5 Decentralized Congestion Control

The aim with Decentralized Congestion Control (DCC) is to adapt the transmit parameters of the ITS-S to the present radio channel conditions, to maximize the probability of a successful reception at intended receivers. The DCC attempts to provide equal access to the channel resources among neighboring ITS-S. The channel resources allotted by the DCC to the ITS-S should be distributed between the ITS-S' applications according to their needs. The ITS-S determines priorities between different messages and discards messages if application requirements exceed allotted resources (with the ITS-S applications' consent). In case of a situation of road traffic emergency, even during a high network utilization period, where every ITS-S has very few resources, the ITS-S may still transmit a burst of messages during a short period of time to maintain a safe road traffic environment.

DCC is outlined in TS 102 687 [25] and it is mandatory feature needed for certification of C-ITS equipment towards harmonized EN 302 571 [15]. Both TS 102 687 and EN 302 571 are currently being revised within ETSI TC ITS.

3.2.6 Security

Security of V2X communication is essential for reliable operation and user acceptance of ITS. Versatile security measures prevent misuse of V2X applications, protect its users, and establish trust into ITS technologies.

The security layer of the station reference architecture provides the necessary functionalities that include cryptographic primitives for signing, verifying, encrypting, and decrypting V2X messages, codecs for processing security headers and certificates, secure storage of credentials, as well as management of certificates and identities for pseudonymous operations. These are standardized within WG5 of ETSI TC ITS. Formats and headers are found in TS 103 097 [26].

Outside the ITS stations, security requires additional backend services; the public key infrastructure (PKI) consisting of root authorities, enrolment authorities, and authorization authorities issues and revocation of certificates. Currently, C2C-CC is working on formats and protocols for interaction between ITS stations and the PKI and tests these mechanisms in the field with the C2C-CC Pilot PKI.

3.3 Long-range communication

Historically, cellular technologies have adhered to an approximate 20-year cycle from launch to peak penetration, with around ten years between the launch of each new technology. In Figure 3-3, a timeline of the launch of different generations of cellular technologies are depicted [27].

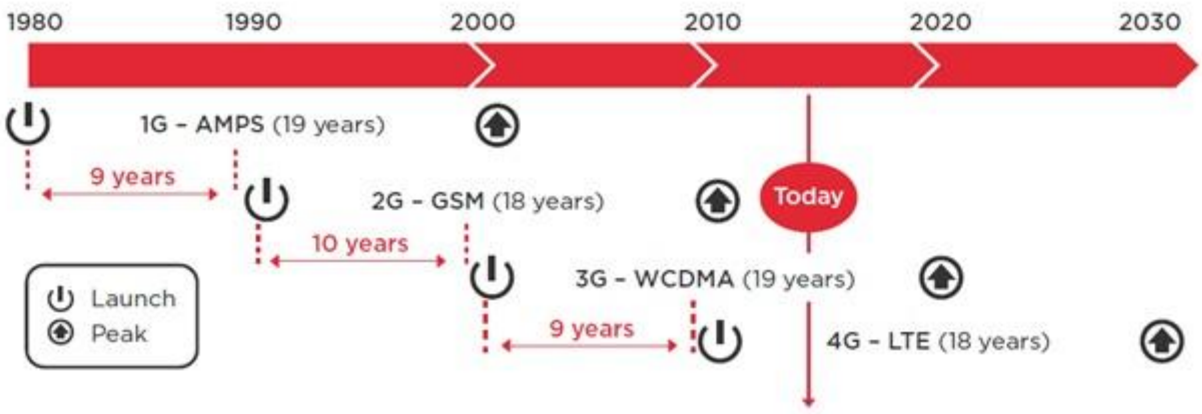

Figure 3-3: Evolution of mobile cellular communications

The first commercial LTE networks went live in 2009 and based on historical precedent we would not expect the technology to reach a peak level of connections until around 2030.

In reality, the adoption of LTE is proceeding at a faster rate than its predecessors, yet LTE expects to peak during the next decade, see Figure 3-4.

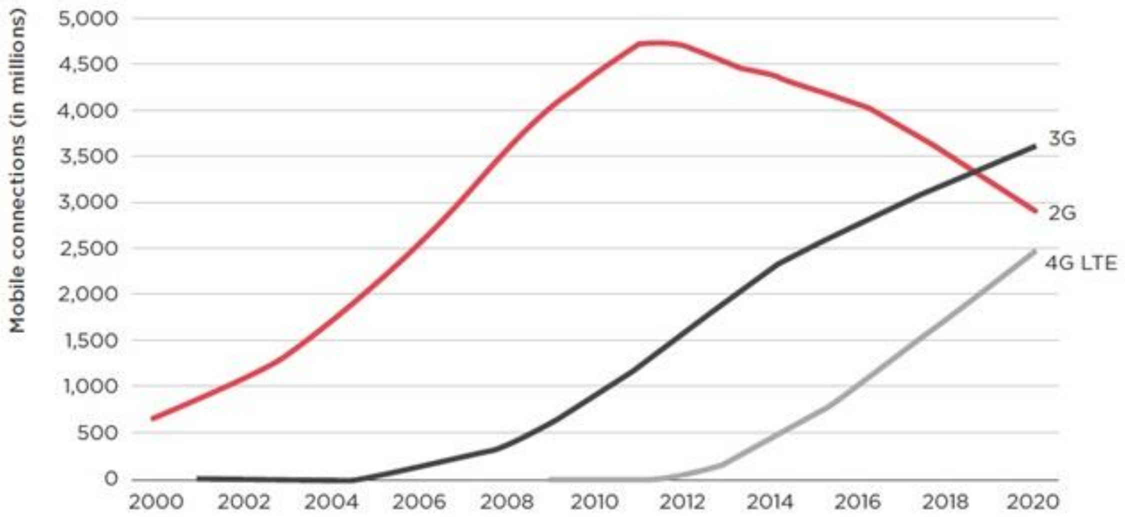

Figure 3-4: Total cellular connections, globally by technology generation

In the context of cellular networking, Device2Device technology [28] (D2D) has drawn widespread attention in the industry for its potential to improve system performance, enhance user experience and expand cellular applications through offering short-range communication feature.

D2D is a peer-to-peer (P2P) service model for information exchange between devices for services such as advertising, affinity, social, dating etc. In such a vision, D2D is a possible candidate technology for V2X communication.

Each D2D-enabled terminal can communicate directly with other D2D-enabled terminals identified in a surrounding area without routing via any cellular networks nodes. The main functionalities of D2D are:

- Announcement: the peer node communicates its own identity and the list of its capabilities to surrounding peers
- Discovery: the peer discovers the presence of other peers in a surrounding area (e.g., up to 500 meters outdoor)
- Peering: the peer establishes a relation with another peer (point-to-point or multi party)
- Communication: the peer exchanges information directly with other peers

As mobile services and technologies develop, short distance data sharing between nearby users, small scale social and commercial activities and location based services for local users will become a significant source of business growth on the wireless platform.

D2D communication makes it possible for cellular communication terminals to set up an *ad hoc* network. If the wireless infrastructure is damaged or terminals are not covered by a wireless network, multi-hop D2D can be used for P2P communication or even access to cellular network.

D2D communication was introduced within 3GPP standard in Release 12 where Proximity-based Services (ProSe) allows a User Equipment (UE) to discover another UE within an authorized range either directly or with network assistance. The discovery process is under network control, and provides additional service related information to the discoverer UE. In addition, for public safety use, the UEs within the allowed range are able to directly communicate with each other using group based communication. 3GPP Release 12 was frozen in March 2015.

Regarding long range communication on cellular networking, LTE is already a well-established technology with its features improving performances within LTE Advanced framework already defined in 3GPP. Therefore, the evolution in the next years will focus on the 5G mobile technology. As stated by Next Generation Mobile Network (NGMN) Alliance [29]: "5G is an end-to-end ecosystem to enable a fully mobile and connected society. It empowers value creation towards customers and partners, through existing and emerging use cases, delivered with consistent experience, and enabled by sustainable business models."

In addition to supporting the evolution of the established prominent mobile broadband use cases, 5G will support countless emerging use cases with a high variety of applications and variability of their performance attributes: from delay-sensitive video applications to ultra-low latency, from high speed entertainment applications in a vehicle to mobility on demand for connected objects, and from best effort applications to reliable and ultra-reliable ones such as health and safety. Furthermore, use cases will be delivered across a wide range of devices (e.g., smartphone, wearable, machine-type communication) and across a fully heterogeneous environment. NGMN has developed 25 use cases for 5G, as representative examples, that are grouped into 8 categories. The use cases and categories serve as an input for stipulating requirements and defining the building blocks of the 5G architecture. The use cases are not meant to be exhaustive, but rather as a tool to ensure that the level of flexibility required in 5G is well captured. The following diagram shows the 8 categories with one example use case given for each family, and description of these categories and examples of use cases are given in Figure 3-5.

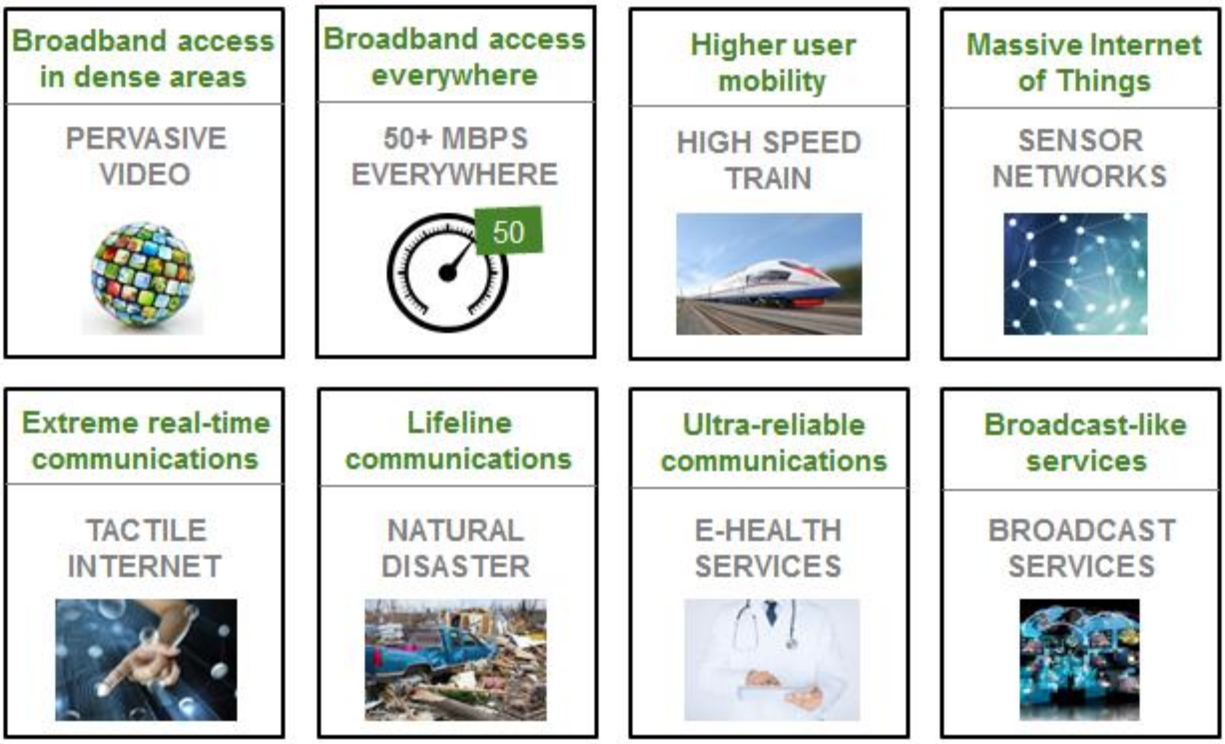

Figure 3-5 : 5G use case categories together with related examples

Focusing on the transport and mobility sector, use cases of interest are mainly grouped into:

- *Higher User Mobility*. Beyond 2020, there will be a growing demand for mobile services in vehicles, trains and even aircrafts. While some services are the natural evolution of the existing ones (navigation, entertainment, etc.), some others represent completely new scenarios such as broadband communication services on commercial aircrafts (e.g., by a hub on board). Vehicles will demand enhanced connectivity for in-vehicle entertainment, accessing the internet, enhanced navigation through instant and real-time information, autonomous driving, safety and vehicle diagnostics. The degree of mobility required (i.e. speed) will depend upon the specific use case.
- *Massive Internet of Things (IoT)*. The vision of 2020 and beyond also includes a great deal of growing use cases with massive number of devices (e.g., sensors, actuators and cameras) with a wide range of characteristics and demands. This family will include both low-cost/long-range/low-power machine-type communication as well as broadband MTC with some characteristics closer to human-type communication (HTC).
- *Extreme Real-Time Communications*. This family covers use cases which have a strong demand in terms of real-time interaction. These demands are use case specific and, for

instance, may require one or more attributes such as extremely high throughput, mobility, critical reliability, etc. For example, the autonomous driving use case that requires ultra-reliable communication may also require immediate reaction (based on real-time interaction), to prevent road accidents. Others such as remote computing, with stringent latency requirement, may need robust communication links with high availability.

- *Ultra-reliable Communications*. The vision of 2020 and beyond suggests not only significant growth in such areas as automotive, health and assisted living applications, but a new world in which the industries from manufacturing to agriculture rely on reliable MTC. Other applications may involve significant growth in remote operation and control that will require extreme low latency as well (e.g., enterprise services or critical infrastructure services such as smart grids). Many of these will have zero to low mobility.

Considering this reference context, the main requirements of the 5G network have been identified in:

- Data rates of several tens of Mb/s should be supported for tens of thousands of users.
- 1 Gbit/s to be offered, simultaneously to tens of workers on the same office floor.
- Several hundreds of thousands of simultaneous connections to be supported for massive sensor deployments.
- Spectral efficiency should be significantly enhanced compared to 4G.
- Coverage should be improved.
- Signalling efficiency enhanced.
- Latency should be significantly reduced compared to LTE

Based on the design principles, NGMN envisions a 5G architecture that leverages the structural separation of hardware and software, as well as the programmability offered by Software Defined Network (SDN) and Network Function Virtualization (NFV). As such, the 5G architecture is a native SDN/NFV architecture covering aspects ranging from devices, (mobile/ fixed) infrastructure, network functions, value enabling capabilities and all the management functions to orchestrate the 5G system. Application Programming Interfaces (API) are provided on relevant reference points to support multiple use cases, value creation and business models. This architecture is illustrated in Figure 3-6.

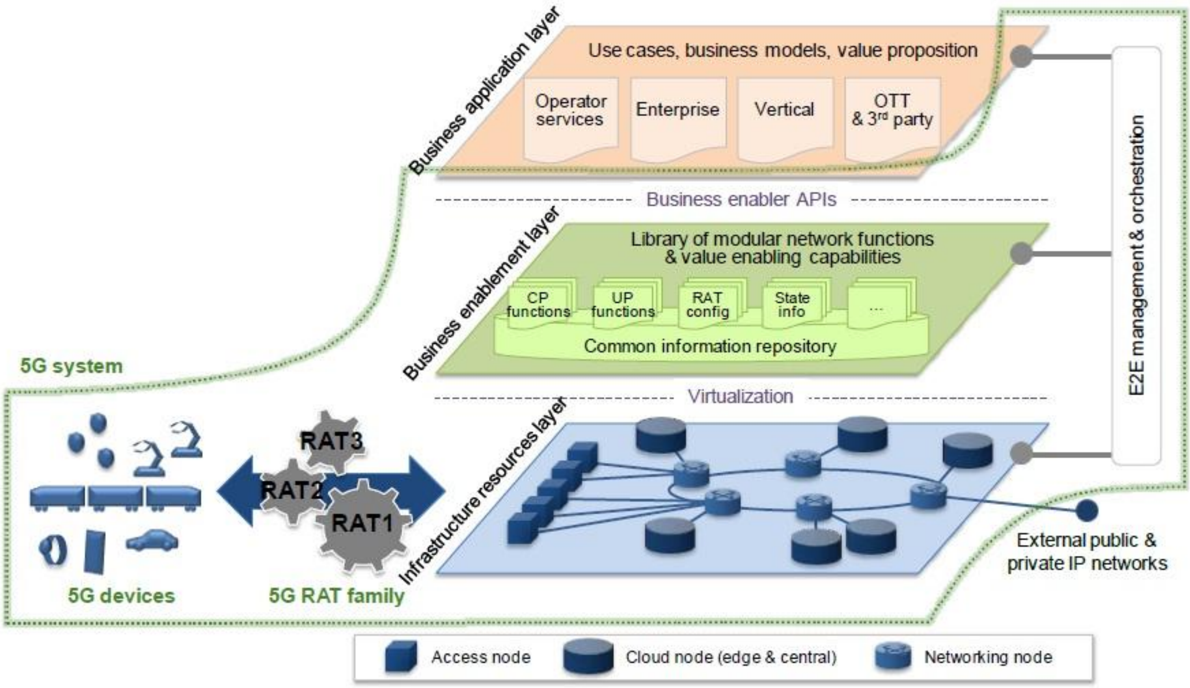

Figure 3-6 : High-level 5G architecture

The architecture comprises of three layers and an End-to-End (E2E) management and orchestration entity. The infrastructure resource layer consists of the physical resources of a fixed-mobile converged network, comprising access nodes, cloud nodes (which can be processing or storage resources), 5G devices (in the form of smartphones, wearables, customer-premises equipment, machine type modules and others), networking nodes and associated links. 5G devices may have multiple configurable capabilities and may act as a relay/hub or a computing/storage resource, depending on the context. Hence, 5G devices are also considered as part of the configurable infrastructure resource. The resources are exposed to higher layers and to the E2E management and orchestration entity through relevant APIs. Performance and status monitoring as well as configurations are intrinsic part of such an API.

The business enablement layer is a library of all functions required within a converged network in the form of modular architecture building blocks, including functions realized by software modules that can be retrieved from the repository to the desired location, and a set of configuration parameters for certain parts of the network, e.g., radio access. The functions and capabilities are called upon request by the orchestration entity, through relevant APIs. For certain functions, multiple variants might exist, e.g., different implementations of the same functionality which have different performance or characteristics. The different levels of performance and capabilities offered could be utilized to differentiate the network functionality much more than in today's networks (e.g., to offer as mobility function nomadic mobility, vehicular mobility, or aviation mobility, depending on specific needs).

The business application layer contains specific applications and services of the operator, enterprise, verticals or third parties that utilize the 5G network. The interface to the E2E management and orchestration entity allows, for example, to build dedicated network slices for an application, or to map an application to existing network slices.

The E2E management and orchestration entity is the contact point to translate the use cases and business models into actual network functions and slices. It defines the network slices for a given application scenario, chains the relevant modular network functions, assigns the relevant performance configurations, and finally maps all of this onto the infrastructure resources. It also manages scaling of the capacity of those functions as well as their geographic distribution. In certain business models, it could also possess capabilities to allow for third parties (e.g., MVNOs - Mobile Virtual Network Operators and verticals) to create and manage their own network slices, through APIs and Everything as a Service (XaaS), e.g., software/platform/infrastructure as a service principles. Due to the various tasks of the management and orchestration entity, it will not be a monolithic piece of functionality. Rather it will be realized as a collection of modular functions that integrates advances made in different domains such as NFV, SDN or SON (Self Organizing Networks). Furthermore, it will use data-aided intelligence to optimize all aspects of service composition and delivery.

Regarding D2D communication in 5G [28], potential improvements that could be added at the access side include:

- *D2D discovery*. This involves detecting and identifying nearby D2D terminals. For multi-hop D2D networks, this technique should be considered in combination with routing and to meet the needs of special 5G scenarios such as efficient discovery in ultra-dense networks and ultra-low latency in IoT scenarios.
- *D2D synchronization*. Certain scenarios such as outdoor coverage or multi-hop D2D networks may present a big challenge to system synchronization.
- *Wireless resource management*. 5G D2D communication may include broadcast, multicast, and unicast, and can be used in multihop and relay scenarios. Therefore, radio resource management and scheduling in 5G networks is more different and complex than in traditional cellular networks.

- *Power control and interference coordination*. Cellular-based D2D has the advantage of controllable interference over traditional P2P. However, cellular based D2D creates extra interference in cellular communication. Moreover, considering multihop and unauthorized LTE-U spectrum as well as high-frequency communication in 5G D2D, research into power control and interference coordination will be critical.
- *Communication mode switching*. It includes the switching between D2D and cellular modes, between cellular D2D and other P2P (such as wireless local area network) modes, and between authorized spectrum D2D and LTE D2D modes using unlicensed spectrum (LTE-U). Advanced communication mode switching can maximize the performance of wireless communication systems.

Within the context of TEAM a multi-technology information dissemination system was developed.

3.4 Human Machine Interface

Regardless of communication technology the human machine interface (HMI) plays a very important role in vehicles. Driver distraction is one cause to accidents. Therefore, the HMI must be designed to ease the driving task for the driver without distracting the driver. However, the HMI is more or less what is left for vehicle manufacturers to compete with and therefore, HMI is not as easy to standardize such as a message set.

ETSI TC Human Factors (HF) released TR 102 762 "Human Factors (HF); Intelligent Transport Systems (ITS): ICT in cars" in April 2010 [30]. The TR walks the reader through several subjects such as design guidelines and interaction with displays. ETSI TC HF deals with human factors in general and currently, there is no on-going work in the area of ITS.

CEN TC278 WG10 "Human-machine interfacing" is dealing with HMI. But, currently, there are no active work items in this group.

"The European Statement of Principles on Human Machine Interface for In-Vehicle Information and Communication Systems" [31] was released in 1998. The statement contains guiding principles when designing HMI for in-vehicle information and communication systems. An update of this European Statement was published in 2008 by the European Commission in a so-called commission recommendation[1] "Commission Recommendation of 26 May 2008 on safe and

[1] Recommendations are without legal force but they do have a political weigh. Recommendations are usually a preparation for legislation.

efficient in-vehicle information and communication systems: update of the European Statement of Principles on human-machine interface" [32].

In 2011, ITU established a Focus Group on Driver Distraction (FG Distraction) [33] with the aim of investigating the HMI issue for automotive applications by producing reports as an input to standardization and ITU-T recommendations. FG Distraction concluded its work in March 2013 with the following deliverables:

- Final report [33]
- Report on uses cases [33]
- Report on user interface requirements for automotive applications [33]
- Report on situational awareness management [33]
- Report on vehicle-to-applications communications interface [33]

3.5 Applications

C-ITS applications have not yet been clearly defined in different SDOs. ETSI TC ITS WG1 released a technical report (TR) already in 2009, TR 102 638 [34], which outlines a basic set of applications. A TR has the "lowest" status within ETSI standardization and it does not contain any requirements. TR 102 638 lists several C-ITS uses cases but does not provide any closer details. CAM is self-contained in the facilities layer and the triggering conditions for CAMs are detailed in EN 302 637-2 [17], i.e., CAM does not need a separate application on top of the facilities layer to execute. The CAM specification could be regarded as a C-ITS application for cooperative awareness.

C2C-CC signed a MoU [35] in 2012 containing the following list of applications:

- Emergency vehicle warning
- Emergency brake light
- Stationary vehicle warning
- Traffic jam ahead warning
- In-vehicle signage
- Hazardous location warning
- Contextual speed limit
- Road works warning

- Signal violation warning
- Green light optimal speed advisory

As can be seen the C2C-CC list of use cases contain both V2V and I2V applications. Not in the list is the general cooperative awareness provided by CAM dissemination. C2C-CC has developed triggering conditions for the use cases running on the vehicle. However, they have not yet been brought into standardization.

The Amsterdam Group (AG) has defined a roadmap between automotive industry and infrastructure organizations on initial deployment of cooperative ITS in Europe. The AG derived the following criteria for the right choice of applications to start with [36]:

- Simple and non-complex services that provide end user benefit and supported by a solid business model
- A balanced mix of services that support all environments of cooperative ITS (urban, rural, inter-urban) which can be regarded as minimum set of services for day one
- Services feasible with low/minimum risk to avoid a first day bad image hampering further user acceptance
- Services that provide credibility to cooperative ITS
- Services that support a fast penetration and offer a platform for further deployment of other services

With the criteria as a starting point several use cases have been identified as important by AG. The following V2V applications are listed:

- Hazardous location warning
- Slow vehicle warning
- Traffic Jam ahead warning
- Stationary vehicle warning
- Emergency brake light
- Emergency vehicle warning
- Motorcycle approaching indication

Identified I2V applications by AG are:

- Road works warning
- In-vehicle signage
- Signal phase and time
- Probe vehicle Data

The message sets for support and developing the use cases defined as important by both C2C-CC and AG are already standardized (i.e., SPAT/MAP, CAM, and DENM). However, triggering conditions and definition of applications have not yet been brought into standardization.

4 Referenced standards in TEAM

The specification documents of EMPOWER (D2.4.1), FLEX (D3.4.1), and DIALOGUE (D4.4.1), have been analysed to find which standards are referenced.

In the following tables the standards found in EMPOWER (D2.4.1), FLEX (D3.4.1) and DIALOGUE (D4.4.1) are listed.

Relevant for an approval in TEAM especially the parts of Cooperative Systems, LTE communication and HMI where chosen.

4.1 Results of analysing specification documents

Table 4-1: Standards analysed from TEAM SP 2 components

Layer	Component	Standard	Explanation	Applies: fully/partially/no
Network & Transport	GNBTP	EN 302 636-5-1 Ver. 1.2.0		Fully
		EN 302 636-4-1 Ver. 1.2.0		Fully
		EN 302 636-6-1 Ver. 1.2.0	IPv6 over GeoNetworking is not used in the project	No
		TS 102 636-4-2 Ver. 0.0.28	Still in drafting stage	No
Facility	CA	N/A		
	CAM	EN 302 637-2 Ver. 1.3.0	CAMs are implementing the standard verbatim. Tested and validated in ETSI plug-tests	Fully
	CM	N/A		
	CPOS	IS-GPS-200		
		ETSI DTR/SES-00290		
	DENM	EN 302 637-3 Ver. 1.2.0	DENMs are implementing the standard verbatim. Tested and validated in ETSI plug-tests	Fully
	LDM++	current LDM proposed standard		
	POTI	Draft ETSI TS 102 890-3		
	SCB	CAN, Bluetooth Serial Port Profile		

	TMP	TMP specific (proprietary), however applications are free to define message fields and extend of content		
	TPEG	CEN ISO TS 24530		
	VDP	CAN, OSGI		
Security	**SEC-CRED**	C2C-CC Security Management Message Formats		
		TS 103 097 Ver. 1.1.1		
	SEC-CRYPTO	SHA256, ECDSA NIST-P 256, AES128 (optional)		
	SEC-IDM			
	SEC-PKICA	C2C-CC Security Management Message Formats		
		TS 103 097 Ver. 1.1.1		
	SEC-PKIRA	N/A		
	SEC-SMP	TS 103 097 Ver. 1.1.1		
		TS 102 723-8 Ver. 1.0.0 DRAFT		
Management	**MGT**	IEEE 802.3 / TCP + UDP, DRIVE-C2X IF.MGMT.2 MGMT-to-GEONET		
	TU	N/A		
Application Enablers	**SPATFOR**	EN 302 637-2 Ver. 1.3.0		
		BALLOT_J2735_Amendment_May12_2014	SPAT/MAP-message data dictionary is specified in SAE J2735 pre-released version with European profile. Usage of data elements is specified in ISO TS 19091. Detailed Parameters are also specified in SPaT/MAP whitepaper of C2C-CC.	Fully
	TLPM	TEAM protocol messages (Traveller position, profile data, preferences, trip data)		
	Com Monitoring			
	GeoToolbox			

Table 4-2: Standards analysed from TEAM SP 3 components

Layer	Component	Standard	Explanation	Applies: fully/partially/no
Actors	SP3-TRAVELLER	HMI specification or implementation		
	SP3-SOCIALMEDIA	N/A		
	SP3-DRV	N/A		
	SP3-VHCL	N/A		
	SP3-TMC	Datex2		
		TPEG		
		MAP		
		SPAT		
		DENM		
	SP3-PTO	HMI specification or implementation		
	SP3-BUS	CAM		partially
	SP3-Transport-Authority	N/A		
	SP3-Traffic-Light-Controller	ACTROS		
		SPOT-UTOPIA		
	SP3-VMS	N/A		
	SP3-MAP	MAP	MAP-message data dictionary is specified in SAE J2735 pre-released version with European profile. Usage of data elements is specified in ISO TS 19091. Detailed Parameters are also specified in SPaT/MAP whitepaper of C2C-CC.	partially
		SPAT		fully
	SP3-Weather	N/A		
Application	SP3-CMC-CTTC	Datex2		
		TPEG		
		MAP		partially
		SPAT		fully
		DENM		
	SP3-COPLAN-DATACO	N/A		
	SP3-COPLAN-STATCO	N/A		
	SP3-COPLAN-MAPAN	N/A		
	SP3-COPLAN-PRETRA	N/A		
	SP3-COPLAN-MODPLAN	N/A		
	SP3-COPLAN-MULTINAV	N/A		
	SP3-CCA-ODID	N/A		

	SP3-CCA-TRAVELCOACH	N/A		
	SP3-CCA-SOCIAL	Proprietary protocols		
	SP3-CCA-OPTCONF	N/A		
	CSI-INTERBROAD	UDP, J-SDK to NEC LinkBird MX		
	CSI-OPTIM	SPOT-UTOPIA controllers native protocol		
		OCIT-O		
		traffic lights controller ACTROS native protocol		
	SP3-CPTO-DBS	Possible use of TEAM protocol messages		
	SP3-CPTO-PRTI	Possible use of TEAM protocol messages		
	SP3_DCC_TMDR	N/A		
	SP3_DCC_CAR	N/A		
	SP3_DCC_TRLDM	N/A		
	SP3_DCC_RRL	N/A		
	SP3_DCC_DRVMS	N/A		
	SP3_DCC_RARV	N/A		
	SP3_DCC_CCV	N/A		
Application Enablers	EN_FLEX_INT_DATA_2.0	Possible use of TEAM protocol messages		
	EN_FLEX_INT_DATA_3.0	N/A		
	EN_FLEX_INT_DATA_4.0	N/A		
	EN_FLEX_INT_DATA_5.1	LDM	EN 302 895 Ver. 0.0.12	
		CAM	EN 302 637-2 Ver. 1.3.0	fully
		DENM	EN 302 637-3 Ver. 1.2.0	fully
		SPAT_MAP	SAE J2735 (pre-release May 2014);	fully
		SPAT_MAP Profiles	ISO TS 19091 (expected Sep 2014)	partially
		OCIT-C	DIN V VDE 0832-601/-602	no
		OCIT-O	OCIT Outstations multiple documents	no
		Public Transport	CEN TS 15531; CSN EN 12896	no
			ETSI-Documents about security have to be checked of relevance	
	EN_FLEX_DIA_DATA_2.0	See details	Upgrade existing services, e.g. by HERE	
	EN_FLEX_INT_ALG_1.1	N/A		

	EN_FLEX_INT_ALG_2.1	N/A	DATEX2 and TPEG implementation to be evaluated at pilot sites, proprietary protocols as base solutions	
	EN_FLEX_INT_ALG_4.1	See details	To be determined by CMC application	
	EN_FLEX_INT_ALG_5.0	XML file format for O/D and network information		
	EN_FLEX_INT_ALG_6.0	N/A		
	EN_FLEX_DIA_ALG_3.0	N/A		
	EN_FLEX_INT_TOOL_1.1	CAM		
		Possible use of TEAM protocol messages		
	EN_FLEX_INT_TOOL_2.0	N/A		
	EN_FLEX_INT_TOOL_3.0	TMP	TMP (TEAM Messaging Protocol) implemented in SP2-TMP components for IP-based data exchange between TEAM applications.	
	EN_FLEX_INT_TOOL_4.0	See details	An XML-based protocol will be defined in order to allow exchange of information between the SG_CB and all the other applications	
	EN_FLEX_DIA_TOOL_2.0	N/A		

More details to the standards analysed are available in tab Detail of IR6_5_1_Appendix_2_v05.xlsx.

Table 4-3: Standards analysed from TEAM SP 4 components

Layer	Component	Standard	Explantion	Applies: fully/partially/no
N/A	SP4-EN_DIALOGUE_HMI_PROXY	OSGi/TCP socket	HMI_Proxy offers several OSGi services which can be used by the applications to inform the driver or get the driver's feedback.	Fully
N/A	SP4-EN_DIALOGUE_HMI_DP	OSGi/TCP socket	The HMI_Device_Provider will receive presentation	Fully

			jobs formatted as XML via TCP socket connection from the HMI_Proxy. User feedback is sent back as JSON.	
N/A	SP4-EN_DIALOGUE_VAA	N/A	The Vehicle Actuator Arbiter (VAA) alter the speed of the vehicle supporting the CACC functionality.	N/A
N/A	SP4-EN_DIALOGUE_OTP	OSGi	The Object Tracking and Prediction (OTP) component supports the driving and merging by determining the presence of object and predicting the time when the vehicle will meet road restrictions.	Fully
Facilities	SP4-EN_DIALOGUE_GLOSA	SPaT/MAP	The Green Light Optimized Speed Advisor (GLOSA) calculates speed advice based on incoming MAP and SPaT messages. SPaT and MAP have recently been finalized and therefore, old versions of SPaT and MAP are used in TEAM.	Partially
N/A	SP4-EN_DIALOGUE_SA	N/A	This component provides speed advice based on several input sources.	N/A
N/A	SP4-EN_DIALOGUE_GLSSA	N/A	The Green Light Start/Stop Assistant determines when to shut	N/A

			down the engine while waiting for green light at an signalized intersection.	
N/A	SP4-EN_DIALOGUE_AM	N/A	The Lane Access Management provides an interface for requesting access to dedicated lanes.	N/A
N/A	SP4-EN_DIALOGUE_DA	N/A	Drivetrain adaptation enables a bus/truck to adapt to local regulation regarding noise, emission, and speed.	N/A
N/A	SP4-EN_DIALOGUE_DRSP	N/A	The Driving Safety Performance Assessment ranks the driving behaviours of the user regard safe driving.	N/A
N/A	SP4-EN_DIALOGUE_UREG	HTTP	The User Registration assists the user in providing information regarding the user's digital identity.	Fully
N/A	SP4-EN_DIALOGUE_UDM	HTTP	The User Data Management assists the user when modifying some information defining the user's digital identity.	Fully
N/A	SP4-EN_DIALOGUE_UAUT	OpenID2.0, RFC6616	The User Authentication component verifies claims about specific identities.	Fully
N/A	SP4-EN_DIALOGUE_DING	REST/API	The Data Ingestion components implement all methods managing	Fully

			the data generated by the community.	
N/A	SP4-EN_DIALOGUE_SN	N/A	The Social Networking component is responsible for proving all the basic functionalities needed to support social networking.	N/A

4.2 Referenced standards in Cooperative Systems communication

ETSI TC ITS is the main SDO for communication standards related to cooperative systems. ETSI TC ITS defines the whole protocol stack and focuses on applications for the vehicle. CEN TC278 WG16 focuses on applications for the infrastructure side of cooperative systems (using the lower layer protocols developed by ETSI TC ITS). CEN TC278 WG16/ISO TC204 WG18 works in close collaboration with SAE DSCR in developing specific protocols for infrastructure such as the SPaT and MAP for signalized intersections.

Most important standards for security issues used in TEAM are:

- ETSI TS 103 097 v1.1.1 (including bug fixes from ETSI Plug-test 2013)
- C2C-CC internal specification of Security Management Messages for PKI
- Draft ETSI TS 102 723-8 v1.0.4 (2014-07)

4.3 Referenced standards in HMI

For HMI the first step of this activity has been focusing the relevance of standards for HMI design. The survey identified as documents/WGs of potential interest:

1. ETSI TR 102 762 V1.1.1 (2010-04): Human Factors (HF); Intelligent Transport Systems (ITS); ICT in cars: (http://www.etsi.org/deliver/etsi_tr/102700_102799/102762/01.01.01_60/tr_102762v010101p.pdf).
2. ITU's Telecommunication Standardization Sector (ITU-T) Focus Group on Driver Distraction "Report on User Interface Requirements for Automotive Applications" available at: http://www.itu.int/en/ITU-T/focusgroups/distraction/Documents/deliverables/FG%20Distraction%20-

%20Report%20on%20User%20Interface%20Requirements%20for%20Automotive%20Applications.pdf

3. ISO TC 22/SC 13/ WG 8 this group is made up of subject matter experts on automotive HMI and well represented by academia and automakers. More information can be found at: http://www.iso.org/iso/iso_technical_committee.html?commid=46880

4.4 Not approved standards

Not explicitly mentioned and not in the focus of TEAM standards approval are all the standards commonly used to fulfil the CE-marking and other legal requirements. These have to be fulfilled in the responsibility of the providers of equipment.

4.5 Support design and development tasks

To support the design and development tasks to achieve compliance to selected standards is supported by:

- Architecture is developed by partners with lots of experience and participation in the relevant SDO's, as NEC for the ETSI TC ITS standards, STS for the ISO and SAE V2I standards, VOLVO for HMI standards, TI for 3GPP standards.

- Identification and provision of the relevant standards to the partners involved in the development of the core components.

- Usage of components already tested in previous ETSI Plug-Test and approved in research projects.

- Implementations of core components supported by partners experienced in the standards

- Provision of checklist as reminder for the main requirements

4.6 Availability of referenced standards

Released documents are available either for free, or for charge, so every partner is able to get these standards. As an amount of standards are still under development, the access to that is limited and must be managed in several ways.

As most of the partners are active in either C2C-CC or ETSI the access to this documents is broadly given.

Partly partners can be involved in the SDO's to get access to the draft issues of documents this is the case for the SAE International standards.

For ISO TC 204 WG 18 there is an agreement to get the legal access to the developing draft documents organized by participating partners.

5 Contributions to On-Going Standardization Activities

5.1 Introduction

This chapter provides information on what TEAM project members have contributed to on-going standardization activities and in which forums. A contribution could be an initiative to start new work items or input to already existing development of standards that have not yet been approved or that have been approved during the duration of the TEAM project.

5.2 Long-range communication

Regarding D2D communication (please refer to section 3.3), in 3GPP Release 13 (expected to be closed in March 2016) there are plans for further enhancements to ProSe to support restricted discovery and targeted discovery, in which the user is able to control who can discover him/her and to operate in a mode to only announce upon a request. The one-to-one communication and relay support are also considered to be added for direct communication. All these features can find a good application in the V2X use cases. However in Release 12 and Release 13, the ProSe has been designed for use with pedestrian mobility speed. It would therefore not be able to be used directly for V2X. For example the physical channel assumptions may not be suitable for direct discovery and communications in vehicle speed and UE to network signalling delays would limit its usefulness for V2X. Enhancements are necessary to adapt the ProSe system to support V2X [37].

For these reasons 3GPP standardization is focusing Release 14 to consider V2X as a specific work item to adapt ProSe to V2X communication requirements and use cases. A specific study [38] is under preparation with the goal to identify use cases and potential requirements for LTE support of V2X services taking into account what have already been defined in other SDOs (e.g. GSMA Connected Living, ETSI TC ITS…) or related governmental agencies. The essential use cases for LTE V2X to be studied and requirements identified are as follows:

- V2V: covering LTE-based communication between vehicles;
- V2P: covering LTE-based communication between a vehicle and a device carried by an individual (e.g., handheld terminal carried by a pedestrian, cyclist, driver or passenger…),
- V2I: covering LTE-based communication between a vehicle and a roadside unit.

The study includes safety and non-safety related applications.

Moving towards the 5G technology, the roadmap, milestones and steps to be taken towards the final deployment are essential prerequisites for its overall success. NGMN has defined a 5G roadmap that shows an ambitious time-line with a launch of first commercial systems in 2020. At the same time it defines a reasonable period for all the industry players to carry out the required activities (such as standardization, testing, trials) ensuring availability of mature technology solutions for the operators and attractive services for the customers at launch date. The key milestones are as follows:

- Commercial system ready in 2020
- Standards ready end of 2018
- Trials start in 2018
- Initial system design in 2017
- Detailed requirements ready end of 2015

3GPP has provided a tentative timeline [39] for standardization of 5G shown in Figure 5-1.

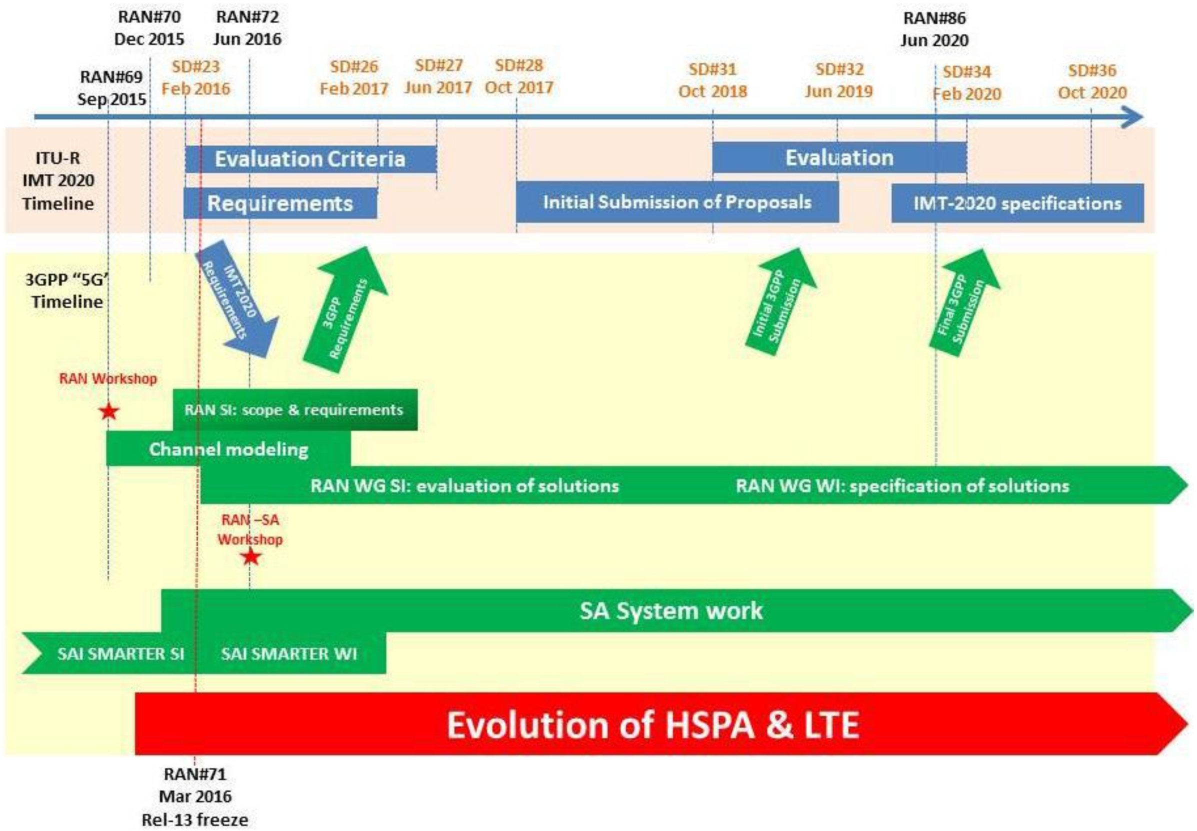

Figure 5-1 : Tentative 3GPP timeline for 5G [39]

Although there is no globally agreed definition of the requirements for 5G, the requirements being defined for International Mobile Telecommunications (IMT)-2020 by ITU-R provides a good benchmark towards 5G. 3GPP is also committed to submitting a candidate technology to IMT-2020 for evaluation.

TEAM members are part of the development of the V2X use cases.

5.3 Short-range communication

5.3.1 Facilities layer

TEAM member was part of the initiation of a new work item in ETSI TC ITS WG1 during 2014. The established work item is dealing with I2V messages including those already under standardization in SAE J2735, ISO TS 19091 and ISO TS 19321. The work will result in TS 103 301 "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for I2V messages".

5.3.2 Transport & Networking layer

TEAM partners have identified shortcomings in EN 302 636-4-1 [22]. The standard is one of the core parts of GeoNetworking and defines the media-independent functionality including packet header format and protocol operation. For the following technical aspects, change requests were proposed by TEAM members, in relation to the experiences obtained in the design of the TEAM system:

- Store-Carry-and-Forward (SCF) functionality
- GeoArea line forwarding
- Location Service
- Gatekeeper issue

TEAM members have contributed to the finalization of the EN 302 636-5-1 [23]. EN 302 636-5-1 is the transport-level counterpart of EN 302 636-4-1, and is implemented in the GNBTP component of the TEAM system. EN 302 636-5-1 defines UDP-like protocol for message multiplexing/de-multiplexing in ITS station in combination with the GeoNetworking protocol EN 302 636-4-1. The standard has been validated by implementing and testing it as part of the GNBTP component within TEAM. Similar to EN 302 636-4-1, the feedback has been provided to the standardization bodies.

5.3.3 Channel Modelling

Since no standardized channel models exist for V2X communication at 5.9 GHz (see Clause 3.3.4), TEAM members have proposed and initiated a new work item in ETSI TC ITS aiming for a technical specification "TS 103 257 Intelligent Transport Systems (ITS); Access Layer; ITS-G5 Channel Models and Performance Analysis Framework".

Members of TEAM project have actively proposed and are leading the work on standardized channel models within ETSI. The goal of ETSI TS 103 257 is to provide standardized models and performance frameworks for modelling vehicular channels on both the link and system level.

Link-level channel modelling deals with signal propagation characteristics for a single instance of V2V communication, encompassing pathloss, delay and Doppler spread, fading statistics, and the channel's non-stationarities. With regards to link-level models, TS 103 257 distinguish between three types of radio channel models: tap delay models, ray based models, and geometry-based stochastic models.

On the other hand, system-level models aim at efficient simulation of channels at large scale, in diverse environments, and with different characteristics of communicating entities. The main goal of system-level models is realistic evaluation of safety and traffic efficiency protocols and applications before their deployment in the real systems. Current state-of-art system-level models are able to distinguish between different line-of-sight conditions and environments, and incorporate small-scale channel models, which are able to provide appropriate delay and Doppler statistics for each representative environment.

5.3.4 Decentralized Congestion Control

Members of TEAM have been actively involved in the work of ETSI STF469, a specialist task force dealing with "Cross Layer Distributed Congestion Control (DCC) management entity standardization for ITS G5 systems". The main tasks of the task force are to produce the following three documents:

- *ETSI TR 101 612: "Intelligent Transport Systems (ITS); Cross Layer DCC Management Entity for operation in the ITS G5A and ITS G5B medium; Report on Cross layer DCC algorithms and performance evaluation"* [40]. This work item provides a technical overview of needed cross-layer DCC algorithms to be implemented into the DCC management entity. It describes the DCC algorithms in detail and includes performance evaluation results based on simulations. The report includes cross-layer power control algorithms in support of the DCC functionality, a rate control algorithm and the needed parameter management functionalities.
- *ETSI TS 103 175: "Intelligent Transport Systems (ITS); Cross Layer DCC Management Entity for operation in the ITS G5A and ITS G5B medium"* [41]. This work item specifies the functionality of the centralized DCC control entity including the required interfaces and parameters for controlling the DCC mechanisms in the facility layer, network and transport layer and the access layer. The centralized DCC entity is responsible for evaluating the

actual DCC state of the active frequency channels based on status information from the access layer, the network layer and the facilities layer. In addition, the DCC status should be predicted for the upcoming transmission intervals.

- *ETSI TR 101 613: "Intelligent Transport Systems (ITS); Cross Layer DCC Management Entity for operation in the ITS G5A and ITS G5B medium; Validation set-up and results"* [42]. This work item covers the overall validation of the cross-layer DCC functionality of the ETSI ITS architecture. It considers inputs from the cross-layer DCC specification developed in TS 103 175, the cross-layer algorithm description in ETSI TR 101 612 and the DCC specifications developed in the other relevant layers. This report is intended to support the test specification to be developed in a planned work item.

TEAM members have been actively involved in producing all three documents. Part of the effort was related to providing the input from the experiences in defining and implementing TEAM communication system.

Further, TS 102 687 which is the DCC standard that is mandatory to fulfil for putting cooperative ITS equipment onto the market in Europe is currently being revised by TEAM members.

5.3.5 Security

As the emphasis of the TEAM project is not on security, the project did not contribute new ideas to the standardization process. Nonetheless, current implementations of security standards (e.g. TS 103 097) were used and thereby proved. TEAM was one of the first projects to use the C2C-CC Pilot PKI and provided substantial feedback to its developers.

5.4 Human Machine Interface

No active standardization is currently taking place with regard to HMI.

5.5 Applications

5.5.1 Cooperative Adaptive Cruise Control

A work item on Cooperative Adaptive Cruise Control (CACC), which is one of the main applications in TEAM, has been initiated both in ETSI and SAE by TEAM members. Collaboration has been established between ETSI TC ITS WG1 and SAE DSRC TC. In ETSI, the outcome from the work item will be "TR 103 299 Intelligent Transport Systems (ITS); Cooperative Adaptive Cruise Control (CACC); Pre-standardization study".

5.5.2 Platooning

Closely related to CACC is platooning. A work item on platooning has been initiated both in ETSI and SAE by TEAM members. Collaboration has been established between ETSI TC ITS WG1 and SAE

DSRC TC. In ETSI, the outcome from the work item will be "TR 103 298 Intelligent Transport Systems (ITS); Platooning; Pre-standardization study".

5.5.3 eCAll

In the application domain, eCall as regulated by European Commission [43], covers a particular importance within safety. It is a public service focusing an emergency call, either automatically triggered by the vehicle or manually by the vehicle occupants, when a serious accident has occurred. It will be mandatory for members of the EU (and mobile telecom operators) from October 2017; for the car makers the compliance to this service will be compulsory from March 2018 on new car models manufactured.

The eCall system creates a voice connection with the closest public safety answering point (PSAP) using the European emergency number 112 and sends a minimum set of data (MSD) using common standards developed at European level, see Figure 5-2. The MSD includes: accident timestamp, accurate localization information (GPS coordinates and direction of travel), vehicle identification number (VIN).

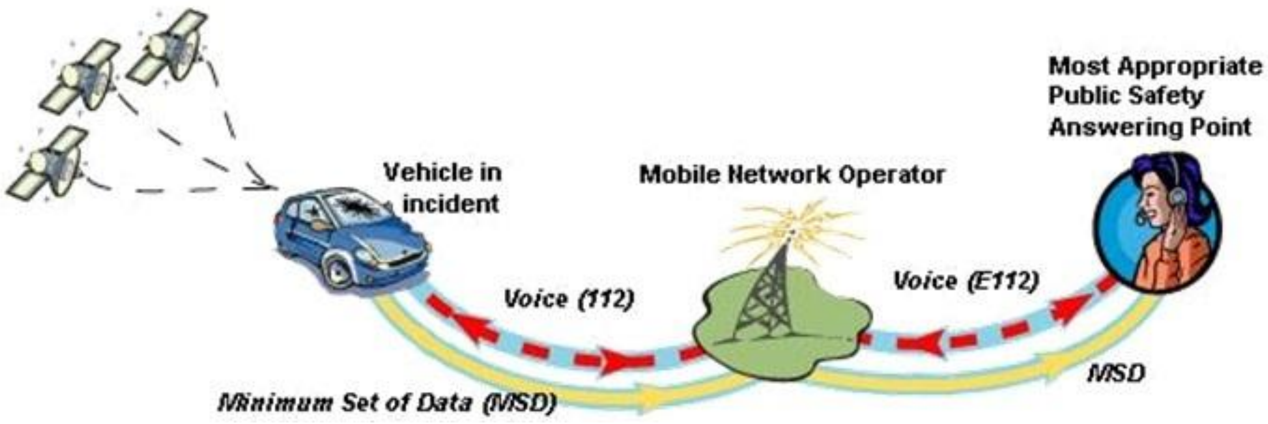

Figure 5-2: High-level architecture of eCall

Currently, there are also several commercial solutions offering emergency services that connect customers with an operations center through a box installed on cars with emergency button.

The operations center, in consequence of a customer request (also in case of alarm automatically detected by the crash-box), is able to handle the call and, if necessary, it can contact the public emergency service closest to the customer.

The evolution of standardization will focus the interaction between these commercial services and the public eCall system. Particular relevance will be played by the standard EN 16102 [44].

EN 16102 addresses technologies and methods of delivering data and voice, from the vehicle to a third party service provider (TPSP) call center premise. EN 16102 bases its data set on the EN 15722 [45] standard (MSD format), however, it does not describe or suggest the technology to be adopted for data and voice transmission from the vehicles to the TPSP.

Once the TPSP has received an emergency call, and the call has been filtered to determine if it is a real emergency, the most appropriate PSAP has to be contacted. The TPSP will need a method to determine the PSAP that is in charge of handling emergency calls for the location of the incident. It is important to note that the TPSP may not be located in the same geographic area, or even the same country as the PSAP. Architecture of an eCALL is depicted in Figure 5-3.

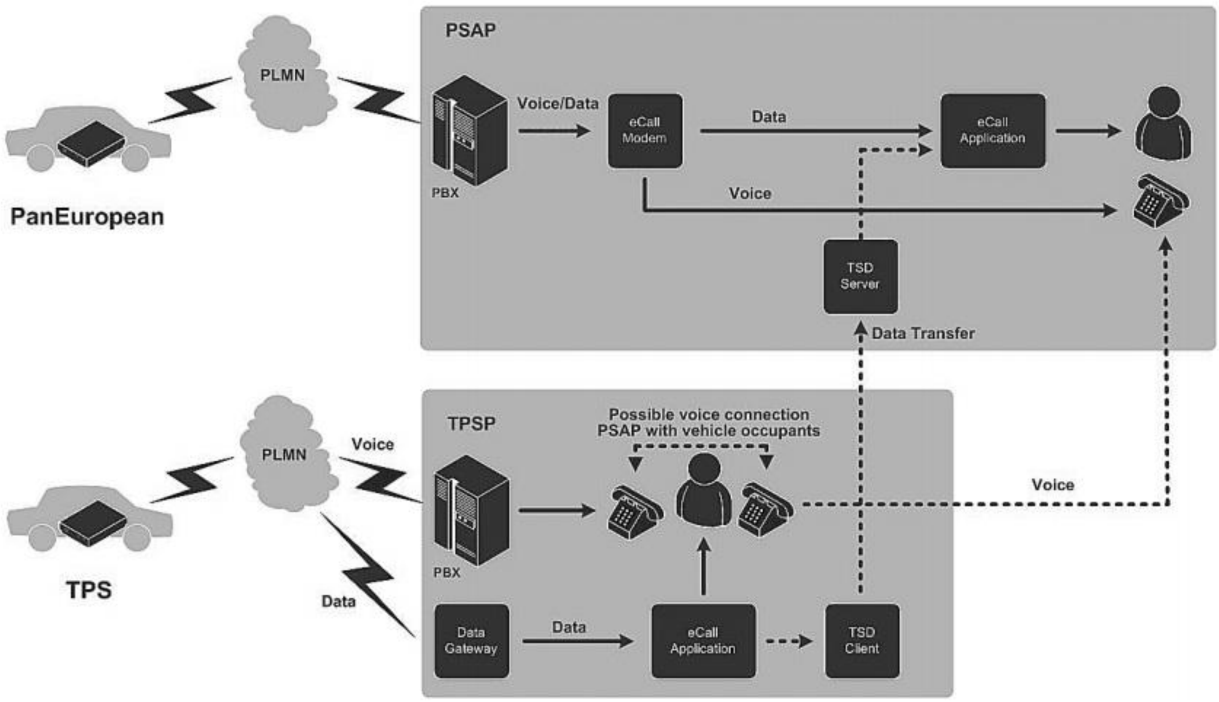

Figure 5-3:The different actors involved in an eCall

An example could be a French car, customer of a French TPSP, having an accident in Spain. The TPS eCall would reach the French TPSP, who would then need to reach the PSAP in Spain responsible for sending emergency services to the scene of the accident. As described in the example, the TPSP would not be able to dial a three digit emergency number (such as 112) to reach the Spanish PSAP because they would instead reach the French PSAP (based on the location of their call center). This is why the E.164 long phone numbers are necessary for the TPSPs to be able to reach the most appropriate PSAPs. To assure the correct distribution of calls the following information is needed:

1) PSAPs have to give TPSPs their territorial competences/geographic boundaries and types of emergency calls they are responsible for.

2) PSAPs must make their E.164 (fixed line) long number available to TPSPs. For data transmission, if any, PSAPs have to give the necessary connection information to TPSPs.

TEAM members have been part of the development of the eCall standards.

6 Revision of Approved Standards

6.1 Introduction

Based on all development and implementation work that have performed in the TEAM project several issues have been noted with already approved standards. This Clause will provide these issues, which needs to be addressed in future revision of standards.

6.2 Suggestion for revision of standards

Table 6-1: List of changes in Standards

Standard	SDO	Suggestion of change
J2735	SAE	MAP needs new attribute for lanes available only for vehicles with granted permission. This attribute shall inform the vehicle about the existence of such a lane and the possibility on how to access it.
		Future enhancements of the MAP may include additional topology-descriptions as road segments (used for describing road deviations due to road works), high speed curves (for speed reduction information) or position of traffic signal lights (for simplified optical detection as second information channel, needed for safe automated driving).
TS 102 894-2 EN 302 637-2	ETSI	The optional element *PtActivation* should be extended to not only be applicable to public transport but to also be used by emergency vehicles, heavy goods vehicles or vehicles with officials on board. Suggestion is to move the *PtActivation* element to another position in the CAM.
		The element *LongitudinalAccelerationValue* needs to have a resolution of 0.01 m/ss. Since TEAM needed a higher resolution on this element a new data type has been introduced in TEAM to avoid to make any changes to EN 302 637-2.
EN 302 637-2	ETSI	Harmonize CAM with upcoming other message types requiring periodic data exchange such as platooning and CACC.
EN 302 637-3	ETSI	It would be beneficial to introduce a new event in DENM signalling a lane change. This is currently not available in DENM and has been introduced in TEAM.

6.3 Standards' Gap Analysis

Gaps between standards and the TEAM system can mainly be identified in areas, where standards do not exist or are still at a preliminary stage

- **Multi-channel operation**: The standards for multi-channel operation (MCO) are at an early stage. For some of the applications in TEAM, especially those with stringent constraints such as platooning, MCO could help enable and adopt them more quickly, since it would allow supporting a higher number of services in the ITS-G5 band. Initial standardization work at ETSI TC ITS and C2C-CC has started and it will take some time before they are finalized.

- **Platooning and CACC:** Work items on platooning and CACC have been initiated both within ETSI TC ITS WG1 and SAE DSRC TC (and a liaison has been established between the two groups). Platooning and CACC put up higher requirements on the communication compared to use cases aiming for increasing the information horizon for the driver (can be regarded as an advanced driver assistance system). In platooning and CACC, received information from other vehicles is supposed to be taken into account directly in the control of the vehicles. This puts up new requirements on data integrity.
- **Applications:** As spotted in Clause 3.5, there has not been much of application standardization in any of the SDOs. C2C-CC has developed triggering conditions for use cases listed in the MoU but apart from that not much has happened from a standardization point of view.
- **HMI:** There is no activity on HMI standardization but certain generic guidelines for HMI are a necessity for building a safe system that does not distract the driver.
- **Management**: Standards for management that are relevant for the TEAM system have not been developed so far, but would be important in the context of configuration management and multi-channel operation.

7 Conclusions

TEAM has contributed to standardization both in terms of initiating new work items but also contributing to on-going activities. This report also contains suggestions to updates of already approved standards and a standards' gap analysis. Standards regarding the lower layers of the protocol stack are stable and will not require any major changes in the near future. However, as we move closer to C-ITS deployment all activities concerning applications and message types will need changes. TEAM has shown this. Some of the changes are small but must be carefully implemented to not break any backward compatibility to already approved standards. New applications have shown up in standardization such as CACC and platooning, which might require so much changes to already existing standards (e.g., CAM and DENM) that they will need new message types.

Further, there are areas of which there are no standards or guidelines are missing. For example, multichannel operation is one such area. In Europe, C-ITS has access to several frequency channels for communication but how to utilize these channels in an efficient manner is still unclear. Standards for HMI are lacking but standardization in this area is crucial because OEMs can differentiate themselves and provide unique selling points.

List of abbreviations and acronyms

Abbreviation	Meaning
3GPP	Third Generation Partnership Program
AG	Amsterdam Group
AP	Access Point
API	Application Programming Interface
ARIB	Association of Radio Industries and Businesses
ASECAP	Association Européenne des Concessionnaires d'Autoroutes et d'Ouvrages à Péage
ATIS	Alliance for Telecommunications Industry Solutions
BS	Base Station
BTP	Basic Transport Protocol
C2C-CC	CAR 2 CAR Communication Consortium
CA	Cooperative Awareness
CACC	Cooperative Adaptive Cruise Control
CAM	Cooperative Awareness Message
CCSA	China Communications Standards Association
CEDR	Conference of European Directors of Roads
CEN	European Committee for Standardization
CT	Core Network & Terminals
D2D	Device-to-Device
DCC	Decentralized Congestion Control
DEN	Decentralized Environmental Notification
DENM	DEN Message
DSRC	Dedicated Short-Range Communication
E2E	End-to-End
EDGE	Enhanced Data Rates for GSM Evolution
EN	European Norm
ETSI	European Telecommunications Standards Institute
FG	Focus Group
GERAN	GSM EDGE Radio Access Network
GPS	Global Positioning System
GSMA	GSM Association
GSM	Global System for Mobile Communications

HMI	Human Machine Interface
HTC	Human-Type Communication
I2V	Infrastructure-to-Vehicle
IEEE	Institute of Electrical and Electronics Engineers
IMT	International Mobile Telecommunications
IoT	Internet of Things
IP	Internet Protocol
ISO	International Organization for Standardization
ITS	Intelligent Transport Systems
ITS-S	ITS Station
ITU-R	International Telecommunications Union – Radiocommunications sector
LTE	Long-Term Evolution
LTE-U	LTE Unlicensed
MAP	Map
MCO	Multi-Channel Operation
MoU	Memorandum of Understanding
MSD	Minimum Set of Data
MTC	Machine-Type Communication
MVNO	Mobile Virtual Network Operators
NFV	Network Function Vrtualization
NGMN	Next Generation Mobile Network
P2P	Peer-to-Peer
PKI	Public Key Infrastructure
ProSe	Proximitybased Service
PSAP	Public Safety Answering Point
RAN	Radio Access Network
RSU	RoadSide Unit
SA	Service & System Aspects
SAE	Society of Automotive Engineers
SDN	Software Defined Network
SDO	Standards Development Organization
SON	Self-Organizing Networks
SPaT	Signal, Phase and Timing
TC	Technical Committee
ToR	Terms of Reference

TPSP	Third Party Service Provider
TR	Technical Report
TS	Technical Specification
TSDSI	Telecommunications Standards Development Society, India
TSG	Technical Specification Group
TTA	Telecommunications Technology Association of Korea
TTC	Telecommunications Technology Committee, Japan
UE	User Equipment
UDP	User Datagram Protocol
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
VANET	Vehicular Adhoc Network
VIN	Vehicle Identification Number
WG	Working Group
XaaS	Everything as a Service

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[9] 3GPP, http://www.3gpp.org

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