5th Generation connected and automated mobility cross-border EU trials

D5.9 Report on standardisation activities and spectrum allocation recommendations v1.0

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Glossary of terms and abbreviations used

Abbreviation / Term	Description
3GPP	3rd Generation Partnership Project
5G-AA	5G Automotive Association
5GPPP	5G Infrastructure Public Private Partnership
CAM	Connected and Automated Mobility
CCAM	Cooperative CAM
CAV	Connected and Automated Vehicles
CEN	The European Committee for Standardization
C-ITS	Cooperative Intelligent Transport Systems
CSP	CAM Standardisation Plan
ETSI	The European Telecommunications Standards Institute
EU	European Union
GSM-R	Global System for Mobile communications - Railways
IEEE SA	The Institute of Electrical and Electronics Engineers Standards Association
IETF	Internet Engineering Task Force
IRS	International Railways Solution
ISO	The International Organization for Standardization
ITS	Intelligent Transport System
ITU-T	International Telegraph Union Telecommunication Standardization Sector
MEC	Multi-Access Edge computing
NFV	Network Functions Virtualisation
NGMN	The Next Generation Mobile Networks Alliance
OEM	Original Equipment Manufacturers
ONF	The Open Networking Foundation
RSPG	Radio Spectrum Policy Group
SDO	Standards Developing Organisations
UIC	International Union of Railways (French: Union Internationale des Chemins de Fer)
V2X	Vehicle-to-everything
VRU	Vulnerable Road Users
WRC	World Radiocommunication Conference
WRC	World Radiocommunication Conference

Executive Summary

This report provides 5G-ROUTES initial analysis of Connected and Automated Mobility (CAM) standards and 5G-ROUTES plan for standardisation activities for CAM services and associated technical enablers. The recommendations for spectrum allocation are also provided based on current discussions at the European level.

The connected and automated mobility represents an ecosystem of technology to address the connectivity on mobile platform for higher value service, including connected and automated driving, passenger connectivity, vehicles controls, and many other applications and use cases.

CAM services analysis drives to the identification of requirements such as interoperability, flexibility, interconnection, high system capacity, wide service area coverage, higher throughput, and reduced latency among others. These requirements are covered by CAM technical enablers mainly based on communication networks assets: edge computing, session/service continuity, integrated network management and orchestration, QoS prediction, vehicles message routing, etc.

Several standards development organisations (SDOs) are identified as appropriate fora to discuss applicable standards for CAM services and associated technical enablers. These include the International Telecommunication Union for the spectrum allocation aspects, the European Telecommunications Standards Institute (ETSI) for the standard applicable to CAM technical enablers (e.g. MEC, V2X), 3GPP for the support of CAM by the 5G network, C-ROADS for a common European platform for Cooperative Intelligent Transport Systems (C-ITS) and many others.

The preliminary gap analysis shows that work is already performed in ETSI on CAM messages and service specifications. However, key aspects necessary for the support CAM services on 5G networks are still to be defined. Hence, the integration of Multi-access Edge Computing (MEC) into CAM standards and the standardisation of information protocols (e.g. for communication between vehicles and network) are identified as the next steps in 5G-CAM standardisation.

5G-ROUTES will work with the relevant standardisation organisations to align 5G-ROUTES ambitions and developments to the existing standards and contribute to their evolution. 5G-ROUTES standardisation approach will consist on 4 following phases:

- Phase1 – Standardisation needs: to collect all the standardisation requirements with respect to the project ambitions
- Phase 2 – Standardisation roadmap: to establish 5G-ROUTES roadmap of standardisation activities
- Phase 3 – Standardisation activities: to execute the standardisation activities as planned in phase 2
- Phase 4 – Report on standardisation activities: to report 5G-ROUTES achievement in standards at the end of the project.

Finally, spectrum allocation is another challenge for CAM services, in particular in the cross-board context where the neighbouring countries can have different spectrum regulations. It is necessary in this particular context to agree on the same spectrum allocation.

The current discussions on this area focus on 5.9 GHz band for V2X. Some frequency allocations are therefore already proposed for roads ITS and rails ITS.

5G-ROUTES will analyse the available options and provide spectrum allocation recommendations for CAM service.

This report provides the initial roadmap for the project standardisation activities. A second publicly available deliverable will be produced 31st May 2023 and will provide 5G-ROUTES standardisation activities report.

1 Introduction

The vision of 5G-ROUTES is to support the EU in achieving its goal of becoming a world leader in Connected and Automated Mobility (CAM), by accelerating the acceptance of fully autonomous, safer, cleaner, more traffic efficient, more user friendly and reliable mobility, as well as for seamless and uninterrupted delivery of interoperable cross-border CAM services along main transport paths throughout Europe.

One of the identified key aspects necessary to efficiently fulfil such achievement is the contribution to the specification and the adoption of common standards. Given the substantial infrastructure investments for the transition to 5G, the existence of a clear and consolidated standards ecosystem represents a solid foundation for fostering the provision of long-term 5G adopted services by the market.

5G-ROUTES aims to support and contribute to the EU vision through the alignment of 5G-ROUTES development with existing standards, the identification of standardisation gaps and the contribution to further development of relevant standards.

Specifically, 5G-ROUTES aims to identify and validate applicable standards as well as provide rationalised contribution to key standardisation bodies so as to sustain standardisation in the telecom and automotive sectors within the CAM context. 5G-ROUTES aims to promote a proactive and joint approach through consortium partners, members of pre-standardisation bodies and fora (e.g. 5GPPP, 5G-AA, IETF, NGMN, UIC) and Standards Developing Organisations (SDOs), such as 3GPP, ITU-T, IEEE SA, ETSI, CEN, ISO, ONF suggesting specific planning actions and contributions for the 2nd and subsequent phases of 5G standardisation, so that they can be taken into consideration in future releases to maximise impact on standardisation.

The present document, D5.9 is the first output of 5G-ROUTES activities and plans for standardisation aspects, carried out in WP5 Commercialisation, innovation management and standardisation, Task T5.4 Standardisation contribution and spectrum allocation recommendations. This document aims to deliver:

- Initial identification of relevant standardisation and regulatory bodies
- Identification and evaluation of existing roadmaps at international level
- Initial plans for the development of a dedicated CAM standardisation plan
- Proposition of the standardisation activity roadmap including relevant standardisation and regulatory bodies and topics for 5G
- Identification of 5G CAM (e.g. ICT-18 and ICT-53-2020) projects in order to promote shared standardisation contributions.

1.1 Mapping 5G-ROUTES Outputs

Purpose of this section is to map 5G-ROUTES's Grant Agreement commitments, both within the formal Deliverable and Task description, against the project's respective outputs and work performed. The following table provides the link of this deliverable with the 5G-ROUTES project commitment.

Table 1: Adherence to 5G-ROUTES's GA Deliverable & Tasks Descriptions

5G-ROUTES GA Component Title	5G-ROUTES GA Component Outline	Respective Document Chapter(s)	Justification
DELIVERABLE			
D5.9 Report on standardisation & spectrum allocation recommendations v1	*Report on standardisation activities and spectrum allocation recommendations v1* *Initial report*	*All chapters*	*Chapters 3, 4 and 5 define the standardisation objectives of the project and associated methodology.*
TASKS			
T5.4 Standardisation contribution and spectrum allocation recommendations	*5GROUTES will use standardisation as a means to exploit the impacts of the project result and to most efficiently invest the public funding of this project. It will go about this in two ways: Firstly, it will ensure that the R&I results produced by the project will be aligned with existing and emerging standards from the relevant standardisation bodies (e.g. 3GPP, ETSI, ITU, IEEE, IETF, etc.). Secondly, through 5G-PPP pre-standardisation WG and contributing to the 2nd phase of 5G standardisation efforts, 5G-ROUTES will analyse the standardisation gaps with respect to the 5G-PPP vision so that such gaps can be adequately addressed.*	*Chapters 3, 4 and 5.*	*Chapter 3 identifies some relevant standardisation bodies. Chapter 4 provides a state of the art of standard and preliminary gap analysis. Chapter 5 provides the spectrum allocation recommendations.*

1.2 Deliverable Overview and Report Structure

This document addresses the standardisation activities of the 5G-ROUTES project. The chapters of this report are described as follows:

- Chapter 1 provides an introduction to the report and maps the chapters of the report with the requirements of the Grant Agreement.
- Chapter 2 identifies CAM technical enablers and revises the role of 5G for CAM services.
- Chapter 3 reviews the list of relevant SDOs and standardisation interest group and provides the state of the art of CAM and associated technical enablers. This chapter also provides a gap analysis between 5G-ROUTES ambitions and actual standards.
- Chapter 4 presents to 5G-ROUTES approach to ensure the alignment of the 5G-ROUTES research with existing standards, and the action plan and standardisation roadmap to track the evolution of the relevant standards and contribute to the specification of these standards if necessary.
- Chapter 5 investigates the spectrum allocation specificities and provides an action plan to address such challenges.

2 CAM and 5G

This chapter provides an overview of Connected and automated mobility (CAM) technical enablers and revises the role of 5G for CAM services.

2.1 CAM Overview

Connected and automated mobility represents an ecosystem of technology to address the connectivity on a mobile platform for a higher value service, including connected and automated driving, passenger connectivity, vehicles controls, and many other applications and use cases. The use case considered in the frame of the 5G-ROUTES project are provided in D1.1 “Use Cases, scenarios, specs & target KPIs for 5G for CAM” [1].

The CAM implies collaboration between various stakeholders such as telecommunications manufacturers, network operators, service providers, etc. Such collaboration needs to be based on common standards for efficient service deployment and operation.

2.2 CAM requirements and technical enablers

2.2.1 CAM requirements

CAM is by nature based on technical enablers at various levels. One of the principal technical enablers is the network infrastructure which is based on several technologies and standards.

The choice of the communication system for CAM is driven by the following factors:

- **Service area:** The service area should be global as offered today by cellular or satellite networks, while a choice of unicast, groupcast and broadcast communications should also be possible for different CAM services
- **Capacity:** The system should be able to support a large number of heterogeneous devices (vehicles, pedestrians, roadside units)
- **Throughput:** The system should be able to offer high throughput for demanding applications, simultaneously for multiple users
- **Latency:** The system should be able to support ultra-low latency end-to-end services, in the order of < 10 ms
- **Reliability:** The system should be able to provide ultra-high reliability for CAM service in the order of 99.999%.
- **Flexibility:** The system should be able to simultaneously support different vehicular applications and services with heterogeneous stringent requirements
- **Interoperability:** The system should support interworking between different networks, while roaming for border conditions is also necessary.

Legacy vehicles are standalone assets, which do not require communication. Systems such as short range radar, lidar or cameras are used to interact with the environment and improve situation awareness. Because these systems are standalone systems, the need for standardisation is limited and these systems only have to comply with current automotive regulations. This includes spectrum usage, safety constraints which are well known by the automotive industry.

One of the main objectives of CAM is to improve the safety and efficiency of persons and goods transportation. This includes road, rail, boat transport, but also multimodal aspects linked to the change of transport mode. To achieve this, CAM assets need to have higher situational awareness than legacy vehicles. Interconnection, interoperability and the regulatory framework are key drivers for the standardisation of CAMs.

Interconnection means that the different Connected and Automated Vehicles (CAVs) must be able to exchange information between them. This puts constraints on the communication system which must provide uninterrupted service between any communication entities. This communication service is offered by a

wireless network (e.g. cellular, ad-hoc or satellite network). Several networks can be interconnected to provide a global service to CAMs.

Interoperability means that the different CAVs must agree on the protocols to be used depending on the application or the targeted vertical market. CAM use cases involve different verticals and requiring interoperability between protocols of different verticals.

Taking into account the vast number of automotive (OEMs), telecommunication vendors, operators and device manufacturers, the critical role of standardisation for CAM can be understood.

Finally, similar to legacy vehicles, CAVs must comply with the **regulatory framework**. This regulatory framework must continue to evolve to take into account the advanced capabilities and possibilities offered by new technologies and ensure the coexistence of the systems. Safety aspects and spectrum allocation are part of the regulatory framework.

2.2.2 CAM technical enablers

CAM development and success is based on key technical enablers allowing to respond to the identified requirements. The following CAM technical enablers are identified in 5GPPP whitepaper: 5G Trials for Cooperative, Connected and Automated Mobility along European 5G Cross-Border Corridors [2]:

- Edge computing
- Session/service continuity
- Connecting MEC to 3GPP
- MEC-5G-NFV management and orchestration
- QoS prediction
- V2X message routing
- MNO collaboration framework
- Etc.

Further CAM technical enablers will be identified during the project and the related standards with be deeply analysed to ensure that a direct adaption is possible and when it is not possible, adequate standardisation contribution will be considered to update the standards accordingly.

2.3 Role of standardisation for CAM

In the frame of 5G-ROUTES, the CAM is envisioned in the context of EU cross-borders. Appropriate roads and networks infrastructures and technologies are required to support such ambitions with common performance ambitions, interoperability and seamless integration. The roaming of vehicles with service continuity and without additional costs is a key aspect for the achievement of CAM in the cross-borders situations.

The road and traffic regulations can be different in neighbouring countries and without the application of common standards and adequate interfaces, there is no guaranty that CAM across borders will work.

The role of standardisation for CAM is therefore to define common rules and appropriate mapping to ensure that the CAM ambitions will be met in all the situations.

The standardisation will therefore concern various aspects necessary for CAM services such as the vertical constraints, the technical constraints including specific V2X protocol, 5G networks requirements, spectrum harmonisation, etc.

2.3.1 5G standardisation

Even though the Vehicular Ad-hoc Network (VANET) IEEE 802.11p [3] was the first communication protocol to be proposed and tested for vehicular communications, it fell short of the above expectations. Even the improved follow up version of 802.11bd [4] is not expected to be fully compliant with the above requirements.

On the contrary, the 3GPP standardized 5G cellular networks [5] are capable of meeting several network requirements thanks to the special provisions that have been taken for the support of Vehicle to Everything (V2X) communications in the standardisation of 5G, which makes it even more suitable for the support of advanced CAM cross-border use cases. 5G systems will provide a global coverage using, when necessary, roaming to other cellular of satellite networks. 5G systems have the capability to simultaneously offer massive Machine Type Communications (mMTC), Ultra-Reliable Low Latency Communications (URLCC) and extreme Mobile Broadband (eMBB) services for the same or different users, hence meeting the above requirements. The support for V2X services will be further enhanced in the latest release of the 3GPP standard, i.e., Rel.17, which will be able to support advanced CAM use cases, besides the already supported critical safety applications.

2.3.2 Vertical standardisation

Thanks to the network slicing capability, public cellular networks will be able to address different vertical markets, enabling the same user to be allocated differentiated network resources simultaneously accommodating services of heterogeneous requirements (e.g. one slice for UHD video streaming with extreme BW and one slice for remote driving with ultra-low latency and reliability). Some relevant vertical sectors that can be accommodated through 5G slices are:

- Personal communications
- Emergency communications
- Automotive
- Railways
- Smart cities
- Person and good transport
- Police
- Medical
- Broadcasting.

In practice, each slice corresponds to a set of resources in the Radio network part and in the core that are reserved for a particular usage.

- From the radio perspective, the mapping between use cases and verticals is pretty straightforward and enables a flexible allocation of chunks of spectrum to slices by the regulator. A regulator could for example, allocate 4 to 6 chunks of spectrum for personal communications, one for emergency communications, one for police etc. Furthermore, a 5G operator has the capability of utilising the regulator assigned spectrum to allocate multiple slices of differentiated service to the owner of the spectrum band
- A certain vertical sector may utilise several slices; For example TV broadcasting standardised at the DVB Forum is offered on satellite and terrestrial networks
- A single user may also utilise several slices in order to access different services, e.g. video streaming and sensor monitoring.

Standardisation for the various verticals historically takes place in different standardisation groups, which are driven by their own constraints and provide their inputs to the communication system. For example railways systems requirements defined by UIC have led to the definition of the GSM-R standard at ETSI and 3GPP. At the same time, the various components and protocols that make up the end-to-end chain of a service also originate from different standardisation bodies or Standards Developing Organizations (SDOs). In the case of CAM, an end-to-end service contains components and protocols for the vehicles, communication devices, network components, Multi-Access Edge Computing (MEC), Internet protocols and more. That means that standards from various SDOs such as 3GPP, IEEE, ETSI, GSM, IETF etc., have to be designed with interoperability principles in mind and/or with the proper interconnection interfaces.

For road traffic applications, a distinction has to be made between C-ITS services (Cooperative Intelligent Transport Systems), which allow road users and traffic managers to exchange messages to improve safety and efficiency, and infotainment services. Regarding C-ITS services, a lot of standardisation work has been performed during the previous decade by ISO/CEN and ETSI, mainly concentrating originally on ITS-G5 (IEEE 802.11p variant) communications, however during the last years also on "hybrid" communications, including communications over cellular networks. The C-ITS architecture (ETSI EN 302 665) defines the following subsystems: Vehicle ITS subsystem, Personal ITS subsystem, Roadside ITS subsystem and Central ITS subsystem. Each of these subsystems contains an ITS station, based on a common architecture defined by ETSI EN 302 665 [6].

In the case of 5G-ROUTES, new use cases have been identified, which can be directly mapped on their respective network slices as depicted Table 2. It can be seen that certain use cases have a Main (M) and Secondary (S) provided service, which is supported by the corresponding slice. By examining the various functionalities that the different 5G-ROUTES use cases are offering, the need for interworking and interoperability among the various utilized components becomes evident, while the multi-purpose use of nodes, equipment and protocols is another characteristic of CAM use cases, as they can be employed for services of different vertical as well. For instance:

- A pedestrian User Equipment (UE)/ smartphone can be simultaneously used to provide the pedestrians information (location, bearing, speed, etc.) to CAM safety services, while also receiving a video stream or pictures from a navigation application or video game
- The CAVs are capable of receiving and transmitting information to a multitude of other equipment and/or services, such as other CAVs, internet servers over cellular networks, road-side equipment and sensors, pedestrian's UEs, etc.

Table 2: Overview & relevant information of CAM use cases addressed in 5G-ROUTES

5G Routes Category		Automated Driving			Awareness Driving	Sensing Driving		Awareness Driving	Uninterrupted infotainment passenger services on the go		Awareness Driving	Multimodal services		
5G verticals		Automotive					VRU		Personal communications		Logistics			Railways
5G Routes Use Cases	Responsible	EDI	EDI	VTT	EDI	VTT	VED	SWM	BRA	BRA	TTU	VEDIA	WINGS	EVR
	UC ID	1.1	1.2	1.3	2.2	3.1	3.3	2.1	4.1	4.2	3.2	5.1	5.2	5.3
	UC description	Dynamic vehicles platooning	Cooperative lane change	See through view for safe automated overtake	Traffic jam chauffeur	Sensor info sharing for cooperative situation awareness	Vulnerable Road User (VRU) Collision Avoidance	Real-time traffic info and cooperative intersection collision control	360 immersive multiuser gaming on the go	3D real-time virtual collaboration on the go	Connected Maintenance	Goods tracking visibility in multimodal cross border logistics	5G-based Proactive and multimodal Management of Passengers and Freight	FRMCS telemetry operation
5G services	mMTC										M	M	M	M
	URLCC	M	M	S	M	M	M	M	M	S				
	eMBB			M						M			S	
Test facilities	VTT test site (4G)			X	X	X								
	Vedecom test site						X							
	TTU 5G Lab							X			X	X		
	CTTC 5G Lab	X	X						X	X			X	
Field trials	Riga Race Track	X	X		X									
	Baltic sea											X	X	
	Valga train													X

2.3.3 Regulation

The regulatory framework is composed of all activities not directly related to the developments of CAMs but necessary for the development of commercial solutions. It includes Safety norms and market regulations.

Safety norms

The purpose of the safety norms is to ensure that CAMs will provide a minimum guaranty of safety for persons and goods, as well as respecting other users of resources such as roads, air or spectrum. The compliance to safety norms is not new and is already done by a vehicle manufacturer for legacy systems. However, in the case of CAM additional effort is needed to guaranty that autonomous vehicles are at least as safe as human driven vehicles. The objective of standardisation activities in the safety domain is to update the current standards to authorize autonomous vehicle on public roads. This includes the definition of the norms and testing procedures.

Market regulation

All verticals need an authorisation from a regulator to develop a service. The regulator evaluates the price to pay, which can be expensive for commercial services, free or even financed in case of services of general interest (for example emergency services), the interest and may put some additional constraints (e.g. white zones coverage) before delivering an exploitation licence.

The question of licencing is particularly important for verticals which use a shared resource, like spectrum, air or roads. In that case, the vertical must in general justify its needs for the resource and guaranty that it will respect other users of the resource. The objective of the standardisation activities in the market regulation domain is to harmonize and facilitate the development of the verticals.

2.3.4 Lobbying

Although not directly linked to the standardisation, lobbying activities are necessary and carried out either directly in the pre-standardisation groups or special groups of interest for each vertical. The objective of this lobbying activity is to gather the requirements of stakeholders in order to develop new products adapted to the needs and constraints of the verticals. Typical interest group to be considered for CAM standardisation is the 5GPPP Standardisation group which aims at harmonizing the standardisation view a European level.

3 State of the art of CAM and associated technical enablers in standards

This chapter reviews the list of relevant SDOs and standardisation interest group and provides the state of the art of CAM and associated technical enablers. This chapter also provides a gap analysis between 5G-ROUTES ambitions and actual standards.

3.1 Identification of SDOs

Table 3: 5G-ROUTES joint standardisation actions

Standards body, forum	Specific group targeted	Main contributors	5G-ROUTES contribution	WP to impact
Pre-Standardisation				
5G-PPP	Pre-standardisation	CTTC ADSF, EEE	• Monitor current activities on behalf of the consortium, align project's outcomes into work for next releases (e.g. R.18)	WP1-WP4
5G-AA	WG2, WG4	ADSF, EEE, LMT, VED	• WG2: Define interoperable solutions for CAM architecture • WG4: Spectrum requirements for V2X in ITS	WP2
IETF	ANIMA SFC ACTN	EEE	• ANIMA: common Autonomic Network control plane elements related to specific requirements of E2E 5G networks • SFC, ACTN: model transformations and test applicability of developed solutions/standards	WP2-WP3
NGNM	Management, Orchestration, Sat integration	EEE ADSF	• Requirements for unified operation and management of cross border 5G networks (e.g. resource reservation & distribution) • Integration of satellite solutions in 5G terrestrial ecosystem	WP2-WP3
UIC, EIM	FRMCS	EVR PV	• Leverage findings from UC5.3 trials to progress work in FRMCS including the support of multiple access technologies	WP4
Standards Developing Organisations				
3GPP	SA1&2, SA4&5, CT1, CT3, CT4, RAN1, RAN3	CTTC EEE, ADSF, TELIA	• Overall system requirements and dynamic network slicing. • Different functional splits for fronthaul in the RAN WG. • 5G management and 5G edge cloud services w.r.t MEC • Satellite integration with the 5G core network and satellite / terrestrial handovers	WP1 WP3 WP4
ITU-T	ITU-T 2020 FG, FG NET-2030	EEE, ADSF, TELIA	• Vision, novel use cases and architecture for Net 2030 • Conformance of ML functionalities in 5G networks	WP2
IEEE SA	SDN/NFV, SLAs	CTTC	• Analyse and present potential contributions to IEE P1917.1 for improving reliability, analytics and requirements for SDN/NFV	WP2
	Green ICT	TTU	• Reporting activities/innovations related to the 5G base-stations energy efficiency (waveforms vs	WP3

			power amplifier)	
ETSI	ZSM ISG	CTTC, IQU	• End-to-end network slicing • Dynamic on the fly network slicing	WP2
	ITS	VTT	• Report findings from 5G-ROUTES trials to the automotive Intelligent Transport Systems WG for different V2X scenarios.	WP4
	ENI	WINGS	• Monitor and report on project's outcomes related to network intelligence functionalities	WP2
	NFV	WINGS	• Monitoring and reporting on project's NFV-related aspects	WP2
		CTTC, TELIA	• NFV and service orchestration for cross domain CAM services, fusing project outcomes into work for next releases	WP2
		ATOS	• Thanks to its role in the OSM Technical Steering Committee, Atos will facilitate any relevant contribution to OSM	
	MEC ISG	CTTC	• Content caching techniques leveraging ML algorithms	WP2
	RRS	WINGS	• Monitoring and reporting on project's innovative radio usage	WP2
	TC RT	EVR, PV	• Interoperability requirements for ITS and urban rail apps	WP3
CEN	TC 278	VTT VED	• Use findings from 5G-ROUTES field trials for progression on the work in urban intelligent transport systems (ITS), mobility, vehicle/roadway warning and control systems.	WP4
ISO	TC 204			
ONF	T&I WG	CTTC	• Continuously reporting the activities/innovations of the project to the Testing & Interoperability Working Group	WP1 WP4

3.1.1 ITU

The International Telecommunication Union (ITU is a specialized agency of the United Nations responsible for all matters related to information and communication technologies. Established in 1865 as the International Telegraph Union (French: Union Télégraphique Internationale), it is one of the oldest international organizations in operation. It is composed of 3 sectors:

- ITU-T

The Study Groups of ITU's Telecommunication Standardisation Sector (ITU-T) assemble experts from around the world to develop international standards known as ITU-T Recommendations which act as defining elements in the global infrastructure of information and communication technologies (ICTs). Standards are critical to the interoperability of ICTs and whether we exchange voice, video or data messages, standards enable global communications by ensuring that countries' ICT networks and devices are speaking the same language.

- ITU-R

The ITU Radiocommunication Sector (ITU-R) plays a vital role in the global management of the radio-frequency spectrum and satellite orbits - limited natural resources which are increasingly in demand from a large and growing number of services such as fixed, mobile, broadcasting, amateur, space research, emergency

telecommunications, meteorology, global positioning systems, environmental monitoring and communication services - that ensure safety of life on land, at sea and in the skies.

- ITU-D

The Telecommunication Development Sector (ITU-D) fosters international cooperation and solidarity in the delivery of technical assistance and in the creation, development and improvement of telecommunication and ICT equipment and networks in developing countries.

3.1.2 ETSI

ETSI is a European Standards Organization (ESO) dealing with telecommunications, broadcasting and other electronic communications networks and services. ETSI supports European regulations and legislation through the creation of Harmonised European Standards.

Several technical committees are in charge of 5G or CAM related standardisation work.

- SES (Satellite Earth station and Systems)
- ITS (Intelligent Transport System)
- TCCE (Tetra and Critical Communication Evolution)
- ARF (Augmented Reality Framework)
- F5G (Fifth Generation Fixed Networks)
- MEC (Multi-Access Edge computing)
- NFV (Network Functions Virtualisation).

3.1.3 ISO and CEN

ISO (International Organisation for Standardisation) is an independent, non-governmental organisation with a membership of 165 national standard bodies. CEN, the European Committee for Standardisation, brings together the National Standardisation Bodies of 34 European countries. CEN and ISO have an agreement for technical cooperation. Standardisation work is performed in Technical Committees. Committees relevant for the work in 5G-ROUTES include:

- ISO/TC 204/WG 18 (Cooperative Systems) and CEN/TC 278/WG 16 (Cooperative Systems)
- ISO/TC 22 Road Vehicles: SC 31 Data Communication and SC 33 (Vehicle dynamics and chassis components), which also addresses testing of automated driving systems.

3.1.4 3GPP

The 3rd Generation Partnership Project (3GPP) unites [Seven] telecommunications standard development organizations (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC), known as “Organizational Partners” and provides their members with a stable environment to produce the Reports and Specifications that define 3GPP technologies.

3GPP is in charge of 5G standardisation, covering cellular telecommunications technologies, including radio access, core network and service capabilities. It also offers hooks for non-radio access to the core network, and interworking with non-3GPP networks.

3GPP technical specification groups (TSG) are grouped by technology:

- TSG RAN (Radio Access)
- TSG CT (Core Network)
- TSG SA (Service and Architecture).

3.1.5 C-ROADS Platform

The C-ROADS Platform is a joint initiative of European Member States and road operators for testing and implementing Cooperative Intelligent Transport Systems (C-ITS) in the light of cross-border harmonisation and interoperability. Objectives include a common understanding of the functionality of Day 1 C-ITS services, the architectures and the responsibilities of the stakeholders. The C-ROADS platform has provided specifications for C-ITS Day 1 services (Hazardous Location Notification, Road Work Warning, Signalised Intersections, etc.). The message specifications are also being discussed with the Car2Car organisation.

C-ROADS is concentrated on mature communication methods for C-ITS, and addressed both ITS-G5 and IP-based communication, for messages transmitted between back-ends of different organisations. The IP-based protocol is based on publish-subscribe mechanisms using AMQP Specifications.

3.1.6 UIC

International Union of Railways (UIC, French: Union Internationale des Chemins de Fer) is an international rail transport organisation which provides standards for trains in order to provide common understanding and reduce potential confusion. UIC is therefore in charge of design, construction, operation and maintenance of the services that the railways provide worldwide. It is known as International Railway Solution (IRS). UIC works in collaboration with several other SDOs including ETSI for the telecommunication topics [7]. UIC has been deeply involved in ETSI for the specification of GSM-R standards.

3.2 Gap analysis

The European Commission has invited SDOs to develop and perform in-depth scrutiny of CCAM services from the standardisation standpoint, taking into account existing architectures, current standards and technical specifications [8]. ETSI is working at several levels on “Release 2” services, which includes, among others, platooning and Vulnerable Road Users (VRU) protection. Work is performed both on service specification, message and service specifications, such as Collective Perception Service and Maneuver Coordination Service.

ETSI is currently working on ETSI TR 102 962 “Framework for Public Mobile Networks in Cooperative ITS (C-ITS)” [9], for deploying C-ITS applications (ETSI Release 1 and release 2) using the 3GPP Uu interface. The work is currently (January 2021) under work, and is expected to be published in July 2021. The document describes the information architecture for the delivery of Day 1 and Day 2 services. The standard is still in a preliminary stage. For the dissemination of the C-ITS messages to the network two solutions are proposed, one based on the solution in CONCORDA project [10], and the other on the solution of the CONVERGE project [11].

Regarding C-ITS, recent standards include ISO TR 21186-2 Guidelines of the usage of C-ITS standards - Part2: Hybrid communications [12]. The ETSI TR 103 630 “Pre-standardisation study on ITS facility layer security for C-ITS communication using Cellular Uu interface” [13] has studied the standardisation gaps related to enabling ITS security at facilities layer.

The standards in ETSI ITS do not use 5G specific elements, such as Multi-Access Edge Computing and slicing. Regarding MEC, ETSI GS MEC 030 V2.1.1 “Multi-access Edge Computing (MEC); V2X Information Service API” [14] specifies how V2X messages can be routed over MECs to reduce latency. The information carried is out of scope of the standard. There is no link between the MEC standard and the C-ITS standards mentioned above.

Hence, regarding CCAM standardisation, the following issues still need to be addressed:

- Specification of ETSI release 2 messages, including CPM and MCM
- Standardisation of the information architecture (ETSI TR 102 962 [9]). MEC should be incorporated in the standard. Standardisation of the information protocols, e.g. for communication between vehicle and network (e.g. MQTT) and the protocols for communication between MECs or service backend
- Security related standardisation
- Other aspects:

- 5G cross-border roaming: Simple inter-MNO and multi-MNO roaming is still under discussion in 3GPP
- Network slicing: Network slicing is a key feature of 5G technology in V2X scenarios (3GPP TS 22.186 [15], 3GPP TS 23.501 [5], 3GPP TS 23.287 [16]) and 5GROUTES must make sure we have the necessary support for the selected use-cases
- Network based positioning. Positioning services description and requirements are specified in TS 22.261 [17] and TS 22.186 [15]. There are several methods for positioning with different accuracy levels. 5G-ROUTES must make sure we have the necessary support for the selected use-cases.

4 5G-ROUTES standardisation approach

This chapter presents the 5G-ROUTES approach to ensure the alignment of the 5G-ROUTES research with existing standards, the action plan and standardisation roadmap to track the evolution of the relevant standards and the 5G-ROUTES plants to contribute to the specifications if necessary.

4.1 Overview

5G-ROUTES will ensure that the research activities conducted within the project align where possible with existing relevant standards and where possible 5G-ROUTES will aim to contribute to the evolution of the standards relevant to the CAM and identified key technical enablers. The identified standardisation organisations and working groups will be tracked in their evolution for the alignment of 5G-ROUTES development with relevant standards and to contribute to the specification of their next versions.

5G-ROUTES will have a wide area to consider for such approach, including the CAM's specialized organisations (C-ROADS, ETSI ITS), the 5G standards organisations (3GPP) and the wider communication standardisation vision uniformed at European level (5GPP).

Figure 1: 5G-ROUTES relation

During the project, 5G-ROUTES standardisation activities will be conducted in four major phases as shown in the Figure 2.

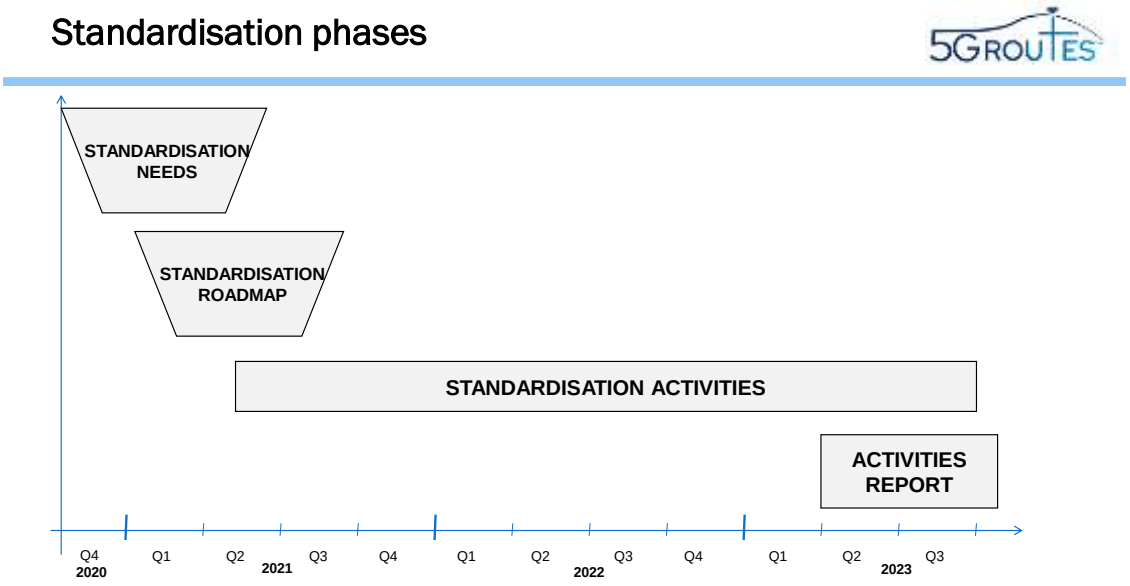

Figure 2: 5G-ROUTES proposed standardisation phases

The proposed phases are further detailed in the following sections.

4.2 Standardisation needs

The objective of this phase is to identify the standardisation opportunities in the project. This task will take inputs from WP1 and WP5 for business development aspects.

5G-ROUTES has identified several use cases that could benefit from 5G networks. In WP1, these uses cases will be mapped on vertical markets and network slices and associated technical requirements will be collected. In WP5, business cases will be done to assess the potential of the verticals and use cases. Use cases will be tested in labs and demonstrated during the field trials. Many of the demonstrated features will be the new features, which must be standardised in order to foster the market acceptance of these products. Some of these features may also be patented prior to their standardisation.

This phase is planned to begin in M2 (October 2020) and to be completed in M7 (March 2021).

4.3 Standardisation Roadmap

The objective of this phase is to define the standardisation plan, based on the identified standardisation needs and in line with the project ambition and the roadmap of different standardisation organisations and pre-standardisation groups (e.g. 5GPPP).

A gap analysis between the state of the standardisation and 5G-ROUTES ambitions will be updated and major issues will be highlighted in order to drive the standardisation activities.

Following this phase, a clear 5G-ROUTES a standardisation roadmap will be defined.

The plan to participate to specific working groups, work items, study items and any other sub-entities of SDOs will be established.

This phase is planned to begin in M6 (February 2021) and to be completed in M10 (May 2021).

4.4 Standardisation activities

The standardisation activities phase will consist of effective work with the SDOs following the plan defined the standardisation roadmap phase.

Most of the standardisation organizations are organised in groups or technical committees in charge of writing guidelines, technical reports or specifications. Standardisation activities in the frame of the different considered groups or technical committees may take several forms:

- Technical survey of a group or technical committee of interest, including the analysis of their specific standardisation roadmaps and the review of relevant specifications
- Contribution to a technical report or specification (e.g. simulation, test results addressing particular topics)
- Presentation of general topics (e.g. liaison from other groups, project presentation, etc.)
- Edition of technical reports and specifications
- Coordination of a technical committee
- Joint actions with other 5G CAM (e.g. ICT-18 and ICT-53-2020 projects) to promote opportunities for shared standardisation contributions and transfer of knowledge across the 5G-PPP pre-standardisation WG.

The exact standardisation activities will be defined during the elaboration of the standardisation roadmap and plan and will be updated as the standardisation activities are running the specifications evolving as well as the project achievements.

Standardisation activities carried during the project will be traced as follows using an excel sheet:

- List of upcoming relevant standardisation meetings
- List of planned participants from the project
- List potential contributions from the project/the project partners
- List of effective participations and contributions to the meetings.

In addition, contribution submitted by the project/project partners will be recorded.

4.5 Report on standardisation activities

This phase will provide 5G-ROUTES achievements in SDOs. The actual record of all the standardisation activities of the project will be reported in D9.10. This will include the final list of attendance of the meetings and working groups or technical committees, the effective contribution to the technical report and specifications, and the join actions with other 5G CAM projects in the frame of the 5G-PPP standardisation group.

A final gap analysis between the state of the standardisation and 5G-ROUTES achievements will be performed and 5G-ROUTES impacts in standard will be evaluated.

Finally, a proposal of the plan to continue the efforts in standards beyond the scope of the project will be provided.

5 Spectrum allocation recommendations

This chapter of the report investigates the spectrum allocation specificities and provides an action plan to address such challenges.

5.1 The 5G-NR bands and coverage

The frequencies considered by the ITU during the latest World Radiocommunication Conference (WRC-19) for the 5G systems are 24.25-27.5 GHz, 37-43.5 GHz, 45.5-47 GHz, 47.2-48.2 and 66-71 GHz in addition of current 2G-4G bands. In total, 17.25 GHz of spectrum has been identified for IMT by the Conference, in comparison with 1.9 GHz of bandwidth available before WRC-19. Out of this number, 14.75 GHz of spectrum has been harmonized worldwide, reaching 85% of global harmonisation [18]. The harmonisation needs to read near 100% to ensure service continuity and efficient CAM services in the cross-border context.

The coverage has been specified during years in percentage of population. But for CAM service, the coverage needs to be evaluated in terms of area or roads and rails infrastructure.

5.2 Spectrum regulations for V2X

In the European Union the main discussions over the spectrum needs for V2X focus on 5.9GHz band. The latest decision concerning the topic is the European Commission implementing decision on the use of radio spectrum in the 5875-5935MHz frequency band for ITS [19].

The recommended frequency allocation by the document is shown on Figure 3 for Road ITS and on Figure 4 for urban rail ITS.

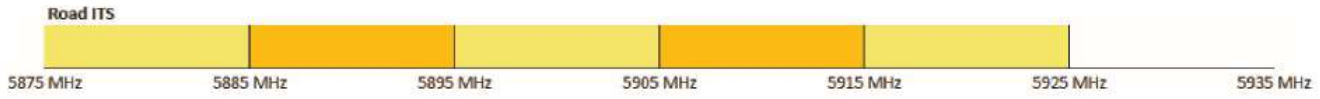

Figure 3: Frequency arrangement for road ITS

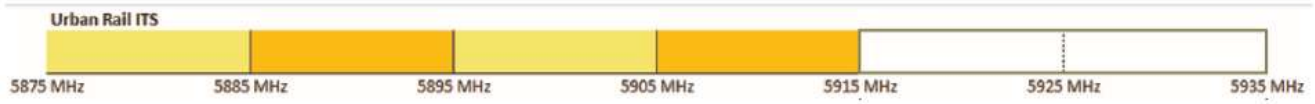

Figure 4: Frequency arrangement for urban rail ITS

For road ITS the applications shall use channels within the boundaries of each 10 MHz block. Channel bandwidth may be less than 10 MHz

For urban rail ITS in 5875-5915MHz the applications shall use channels within the boundaries of each 10 MHz block. Channel bandwidth may be lower than 10 MHz. In 5915-5935MHz the maximum channel bandwidth shall be 10 MHz for urban rail ITS applications. The dotted line shows the preferred harmonised frequency arrangement but, at national level, rollouts may use a channel centred at 5 925 MHz.

The decision also states the deadline for implementation in Article 3 [19]:

Member States shall, no later than 30 June 2021, designate the frequency band 5 875-5 935 MHz for intelligent transport systems and limit it to urban rail ITS in 5 925-5 935 MHz. Following that designation, Member States shall, as soon as reasonably practicable, make that frequency band available on a non-exclusive basis

5.3 The European Union 5G and CAM Initiatives

The different public initiatives in EU regarding 5G are described in 5G-ROUTES deliverable D1.3 in the chapter 5 “Current 5G deployment plans & readiness in Latvia, Estonia & Finland” section 5.2 “CAM legislative

framework". In this section there are described the different public initiatives that have been adopted in EU and the steps towards the deployment of automated driving in the EU.

5.4 The current status of radio spectrum and regulation in 5G-ROUTES trial countries

The current situation in the countries where the 5G-ROUTES project trials take place are thoroughly described in 5G-ROUTES deliverable D1.3 in the chapter 5 "Current 5G deployment plans & readiness in Latvia, Estonia & Finland" section 5.1 "Spectrum regulation and availability". In this section it is described how the spectrum is regulated and what is the availability in those countries, how the coordination between neighbouring countries take place and what are the challenges.

6 Conclusions

The 5G-ROUTES project's goal is to accelerate the acceptance of CAM for fully autonomous, safer, cleaner, more traffic efficient, more user friendly and reliable mobility, as well as for seamless and uninterrupted delivery of interoperable cross-border CAM services along main transport paths throughout Europe. 5G-ROUTES aims to achieve high-scale and long-lasting impact. Therefore, delivering the work results to the standardisation bodies is of paramount importance.

The deliverable presents the importance of standardisation of CAM technologies and highlights the current blockers stopping the technological advancement. The document describes the role of standardisation for CAM including 5G and vertical standardisation, regulation and lobbying. It provides an overview of key standardisation bodies, pre-standardisation organizations and other stakeholders that are initially identified as relevant to the scope of 5G-ROUTES.

Additionally, the deliverable puts up 5G-ROUTES preliminary framework of activities for the promotion of 5G technologies for the CAM in cross-border scenarios within the standardisation bodies. The frame consists of identification of standardisation needs, definition of standardisation plan, effective works with standardisation bodies, and the reporting on the standardisation actions taken.

ROUTES is primarily an innovation activity, therefore 5G-ROUTES will use standardisation mostly to ensure that the R&I results produced by the project will be aligned with existing and emerging standards. During the standardisation activities, the gaps in standardisation that should be considered for the successful realisation of the project use-cases and enablers, will be identified and contributed to relevant standardisation working groups according to proposed project standardisation roadmap. The contributions to standardisation working groups, project and stakeholder meetings will be recorded and documented in the standardisation activity report.

Lastly, the deliverable provides the current status of radio spectrum and regulation in 5G-ROUTES trial countries and presents the spectrum allocation recommendations for connected vehicles, focusing on 5G-ROUTES use cases. The frequency 5915-5935MHz are identified candidates for ITS with a block allocation of 10 MHz for a channel.

This report provides the initial roadmap for the project standardisation activities. A second publicly available report will be produced 31st May 2023 which will update the 5G-ROUTES roadmap and will include the following additional aspects:

- Update of the standardisation activity roadmap based on the project's work progress and in conjunction with the SDOs progress recommending which outcomes should be standardised
- A report on the monitoring of standardisation group activities through targeted engagement with the standardisation community (including drafting and defence of contributions and promotion of technology contributions)
- A report on the promotion of 5G-ROUTES at standardisation-related workshops, panels, and summits
- A report on joint actions with other 5G CAM (e.g. ICT-18 and ICT-53-2020) projects to promote opportunities for shared standardisation contributions and transfer of knowledge across the 5G-PPP pre-standardisation WG.

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