European Automobile Manufacturers Association

CLEPA European Association of Automotive Suppliers

ACEA-CLEPA paper

Perspectives of the European automotive industry on future C-ITS spectrum needs for Cooperative, Connected and Automated Mobility

The automotive industry strongly supports ambitious policy goals towards achieving a European environment for Cooperative, Connected and Automated Mobility (CCAM), which can contribute to a safer, more convenient and sustainable mobility ecosystem. Cooperative Intelligent Transport Systems (C-ITS) have been proven to reduce traffic fatalities and increase traffic efficiency. Automated driving functions will initially be supported by C-ITS. However, for automated driving level 5 C-ITS will be a pre-condition.

For this to become a reality and for the new functionalities currently being researched and developed to fully achieve the potential of reducing road fatalities and making road transport more efficient and environmentally-friendly overall, additional spectrum will be needed in addition to the currently harmonised ITS spectrum in Europe.

1. Context

The European Automobile Manufactures' Association (ACEA), the European Association of Automotive Suppliers (CLEPA) and their members are currently engaged in various studies and technical work items in various organisations, which are developing future C-ITS use cases. As these solutions are being developed, we would like to engage in a dialogue with spectrum regulators and policy makers in order to determine a timeline for the rollout of innovative C-ITS services. At the same time, we would like to make sure that adequate radio spectrum resources are identified and made available, ideally on a cross-regional, harmonised and protected basis.

Regarding C-ITS, we believe in the necessity for interoperable solutions to guarantee safety today and in the future. We recognise the need to be able to use the full potential of the 5.9GHz ITS band and are fully committed to work with the European Telecommunications Standards Institute (ETSI) to achieve technology coexistence in the ITS spectrum. This is also true for future technologies that are being developed.

Work in standardisation organisations is currently well underway with respect to the evolution of existing C-ITS solutions, ie IEEE 802.11bd and 3GPP Release 16/17. It is our aim to combine developments in standards and technology with the spectrum needs related to new use cases, and in turn provide this information to standardisation and spectrum policy experts.

According to automotive studies under finalisation[1], it is becoming increasingly clear that the

[1] See: Car2Car Communications Consortium, White Paper on Road Safety and Spectrum Needs in the 5.9GHz for C-ITS and Automation Applications, 20 February 2017 and ongoing work in 5GAA

current available ITS spectrum (ie 5.9GHz) is not sufficient to achieve higher levels of safety and serve advanced levels of automated driving and advanced ITS use cases.

To deploy day-1 safety C-ITS use cases, the safety-related C-ITS spectrum currently available in Europe in the 5.9GHz band (5875- 5905 MHz) will be used. We appreciate that further needs have been recognised in the CEPT 71 report proposing a change of the spectrum regulation from 5875-5905 MHz (30 MHz) to 5875-5915 (40 MHz) and sharing possibilities between 5915-5925 MHz (10 MHz) with urban rail. However, studies carried out within the Car2Car Communication Consortium and currently underway in the 5GAA show that the 50 MHz designation for safety related ITS and road user automation will not be sufficient.

While a series of day-1.5 and initial day-2 advanced use cases will use parts of the existing 5.9GHz band, along with the safety use cases being rolled out today, it is expected that some of the cooperative driving use cases and scenarios will require additional dedicated ITS spectrum, especially for V2V and V2I scenarios. Finally, the studies that are currently available do not cover in detail the needs in terms of infrastructure, and therefore we expect that further consultation with road infrastructure providers will be necessary.

ACEA and CLEPA are also studying technical aspects of advanced use cases further and we will gladly present their conclusions to all relevant stakeholders and decision makers. In this context it should also be noted that the industry is also considering the other ITS spectrum in Europe, at 60GHz (63.72-65.88GHz specific for ITS). However, due to the characteristics of these high bands, further technical work needs to be undertaken, as is the case for example with the 802.11bd. Ultimately, this spectrum is not yet within the scope of the 3GPP frequency bands.

The automotive industry is working to identify potential spectrum bands for advanced C-ITS services. These will need to be discussed with the European Commission, national administrations in the CEPT framework and in the context of ITU-R proceedings and, if relevant, at the upcoming World Radio Conference. In addition, we would like the support the Commission in finding solutions for the uptake of Cooperative, Connected and Automated Mobility in Europe.

2. Technical aspects – advanced use cases on the road to automated driving

Different C-ITS scenarios require the transport of C-ITS messages with different performance requirements. In addition, different levels of automated driving will also require specific messages to be exchanged between vehicles, vehicles and the infrastructure and vehicles and vulnerable road users with higher message transmission rates, message sizes and message behaviour characteristics. Initial safety and efficiency use cases, so-called day-1 and day-1.5 services, such as cooperative awareness, decentralised notification and basic infrastructure support, can be achieved within the existing EU C-ITS spectrum.

As mentioned above, new services, extended safety and higher automation levels, will require additional ITS dedicated spectrum. This is especially the case when it comes to services such as collective perception (including vulnerable road users), coordinated driving (like cooperative merging, lane change, overtaking). Beyond advanced safety use cases, a whole new range of other use cases are being elaborated that mirror automation levels.

Many standardisation and industry organisations, together with national authorities are engaged in mapping these use cases and their technology requirements in 3GPP, IEEE, ETSI, SAE, SAE-C, Car2Car communications consortium, 5GAA and other organisations.

For the purpose of this paper and in line with current discussions, advanced use cases are being regrouped in the following scenarios:

- Advanced safety and efficiency (day 1 and beyond, awareness driving)
- Collective perception
- Cooperative driving
- Sensor driving: sensor sharing
- Remote driving
- Vulnerable road users (VRUs)
- Vehicle automation levels with initially vehicle platooning

2.1. Advanced safety and efficiency

The automotive industry is currently deploying safety and efficiency use cases, both in the 5.9GHz ITS spectrum band, supported via standard wireless connectivity (following the hybrid communication approach as proposed by the European Commission). As a first step, these use cases, such as emergency break assist, manoeuvre information/warnings, traffic information and road-side work warnings, will strongly contribute to increasing road safety in a non-automated driving context. These efforts will also lay the groundwork for additional technologies to be rolled out and will complement functional safety.

2.2. Collective perception

Besides vehicles equipped with an ITS station sending out cooperative awareness messages (CAM) there will be other road users, such as cyclists and pedestrians, who will not be equipped with ITS stations, but who will be recognised as such by available traffic light systems and vehicles. ITS station equipped vehicles may therefore send information about non-equipped road users to others. This collective perception (CP) service may be seen as an extension of the CAM. Research[2] has shown that this will result in a higher data exchange as that required for the current CAM, and therefore may, depending on the circumstances, require additional capacity.

[2] See: Car2Car Communications Consortium, White Paper on Road Safety and Spectrum Needs in the 5.9GHz for C-ITS and Automation Applications, 20 February 2017 and ongoing work in 5GAA

2.3. Cooperative driving

Cooperative driving (such as collective group start in intersection situations or lane merge assist) enables semi-automated or fully-automated driving, ie level 3+. Each vehicle and/or roadside unit (RSU) shares data obtained from its local sensors with vehicles in proximity, thus allowing vehicles to coordinate their trajectories or manoeuvres. In addition, each vehicle shares its driving intention with vehicles in proximity.

The benefits of this use case group are safer travelling, collision avoidance, and improved traffic efficiency.

2.4. Sensing driving: sensor sharing

Extended sensors enable the exchange of raw or processed data gathered through local sensors or live video data among vehicles, RSUs, devices of pedestrians and V2X application servers. The vehicles can enhance the perception of their environment beyond what their own sensors can detect and thus have a more holistic view of the local situation.

Sensor and state map sharing (SSMS) enables the sharing of raw, pre-processed or processed sensor data to build collective situational awareness. The concept is an extension of the local dynamic map embodied in ETSI and ISO technical reports and standards, with the primary difference being higher spatiotemporal fidelity, low latency and the ability to transition from hyperlocal to transportation link to network area of 'state map' awareness.

Sensor and state map sharing would leverage properties of highly reliable transmission and system resiliency. This enables services such as low latency communication for precision positioning and control. Such properties can enable mission critical applications such as cooperative driving (vehicle platooning), intersection safety of all road users to include pedestrians and emergency vehicle communication. For these use cases, highly resolved sensor images do not necessarily need to be transmitted (where smart nodes perform on-board processing and data exchange for a shared or fused situational awareness, whereupon vehicles autonomously perform reasoning or tactical manoeuvre planning operations).

However, due to the plethora of disparate connected sensors, it is anticipated that significant data bandwidth will be needed for SSMS. Identified requirements are as follows:

- High bandwidth
- High reliability for fusion confidence
- High level of trust
- Short latency to allow highly dynamic automated vehicle operation and emergency vehicle response
- High density of transmitting devices
- Large messages
- Integration of network and cloud-based information (eg local dynamic map)

To realise this kind of awareness and support upcoming use cases and services, high precision positioning techniques are also essential. Improvement of the position awareness will also require additional position improvement data exchange, as GPS alone will not be able to provide this in a trustworthy fashion under all conditions, as has been determined by European Projects such as HIGHTS[3].

2.5. Remote driving

Remote driving enables a remote driver or a V2X application to operate a remote vehicle for passengers who cannot drive themselves or a remote vehicle located in dangerous environments. For a case where variation is limited and routes are predictable, such as public transportation, driving based on cloud computing can be used. In addition, access to a cloud-based back-end service platform can be considered for this use case group. Remote driving is a concept in which a vehicle is controlled remotely by either a human operator or cloud computing.

While autonomous driving needs a lot of sensors and sophisticated algorithms like object identification, remote driving with human operators can be realised using less of them. For example, if an on-board camera of the vehicle feeds the live video to a remote human operator, the operator can easily understand the potential hazard in which the vehicle is placed without any assistance from sophisticated computing. Based on these video and other sensors, the remote operator sends commands to the vehicle.

Remote driving implements different use cases than autonomous driving. Buses follow pre-defined static routes and a specific lane and stop at pre-defined bus stops. Thus, requirements to operate these buses are somewhat different from what is required to operate autonomous vehicles. For these buses, live video streams include not only outside bus images but also inside bus images, so remote operators also need to react to more diverse scenarios such as passengers getting on/off the bus.

In the future, cloud computing can replace human operators in some scenarios and improve coordination between vehicles. For example, if all vehicles feed their schedule and destination, the cloud can coordinate which route each vehicle will take. This coordination will reduce traffic congestion and overall travel time and reduce fuel consumption.

In addition, given the stringent requirements expected for advanced use cases related to autonomous and automated driving, it is important to be able to cope with enhanced quality of service (QoS) support. Vehicle QoS support enables the timely notification of expected or estimated change of quality of service to a V2X application before the change actually occurs. It also allows the system to modify the quality of service in line with the V2X application's quality of service needs.

[3] https://ec.europa.eu/inea/en/horizon-2020/projects/h2020-transport/intelligent-transport-systems/hights

Vehicle QoS can also be increased using dedicated ITS spectrum. Nevertheless, some key performance indicators first need to be achieved such as data rate, reliability, latency, reaction time, customer perception.

2.6. Vulnerable road users

Current technology discussions have shown that in order to improve road safety, attention must be paid to vulnerable road users.

There are different categories of vulnerable road users (motorised or pedestrians, cyclists, human versus non-human) for which different behavioural scenarios must be envisaged and developed. In addition, beyond the fact that high position accuracy is required, the information must reach the user at the right moment, in the right place.

The European Commission supports a Special Task Force (STF) in drafting standardisation reports, and standards are currently being developed at ETSI TC ITS[4]. In addition, the UNECE regulatory framework is considering developing connected solutions for VRUs[5]. The current status of the ETSI TR 103 300-1 shows that additional awareness, for example through collective perception messages will be the basis for VRU communication, but that a large set of additional warning messages will nevertheless be required.

2.7. Vehicle automation levels with initial vehicle platooning

Vehicle platooning enables vehicles to dynamically link up to travel in a group. Platooning operates a group of vehicles in a closely linked manner so that the vehicles move like a train with virtual strings attached between vehicles. Vehicles in the platoon receive periodic data from the leading vehicle or direct neighbours (such as speed, heading and intentions such as braking, acceleration), and may also receive information from other platoon members, in order to carry out platoon operations. This information allows the distance between vehicles to be significantly reduced; when converted into a unit of time, the distance between two vehicles is under a second.

Platooning applications are expected to allow the trailing vehicles to drive autonomously. In the EU ENSEMBLE project[6] all European truck manufacturers work together to realise the first platooning applications. Platooning allows for better traffic conditions, an overall reduction of fuel consumption and, in time, it may reduce the number of drivers required.

The following aspects need to be supported for platooning to perform adequately: join/leave/form a platoon, announcements/warnings when a platoon is operational, group communication, with support of at least 20 CAM/second[7]. Due to the fact that the size of the platoon can differ even on

[4] TR 103 300-1, TS 103 300-2 and TS 103 300-3
[5] See for details: General Safety UN VRU's awareness IWG website or Active Safety ADAS, eg UN ALKS IWG
[6] https://platooningensemble.eu, Project nr. 769115
[7] https://platooningensemble.eu/

the move, a resource-efficient distribution of messages and a dynamic control of the distribution area of the messages should be supported. To facilitate the platooning application, one additional channel at least is needed.

3. Summary and recommendations

The European automotive industry is committed to continue working closely with regulators in order to increase safety, traffic efficiency, and to deliver societal and environmental benefits. In this context, it is important to retain global leadership in this key industrial sector in Europe, while stimulating rapid growth and innovation to foster CCAM and deliver a smart digital Europe.

To this end, we want to:

- Continue the technical dialogue, especially regarding radio spectrum and C-ITS services.
- Work with regulatory and administrations to make sure the current safety ITS spectrum at 5.9GHz is being preserved and protected, for example from RLAN applications in adjacent bands, to enable current day-1 safety applications rollout.
- Work with regulators and administrations to show the potential of various use cases, identify a potential future spectrum for C-ITS and means by which European and international harmonisation can rapidly be achieved; to this extent, we are fully committed to providing technical expertise.
- Work within the existing and upcoming EU platforms and EU projects in order to promote the rapid adoption of C-ITS, with a view to fostering the development of CCAM.

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ACEA, the European Automobile Manufacturers' Association, represents the 15 Europe-based car, van, truck and bus manufacturers: BMW Group, CNH Industrial, DAF Trucks, Daimler, Fiat Chrysler Automobiles, Ford of Europe, Honda Motor Europe, Hyundai Motor Europe, Jaguar Land Rover, PSA Group, Renault Group, Toyota Motor Europe, Volkswagen Group, Volvo Cars, and Volvo Group. More information: www.acea.be

CLEPA is the European Association of Automotive Suppliers. More than 120 of the world's most prominent suppliers for car parts, systems and modules and 23 national trade associations and European sector associations are members of CLEPA, representing more than 3 thousand companies, employing more than 5 million people and covering all products and services within the automotive supply chain. More information: www.clepa.eu.

Annex: list of C-ITS related abbreviations

Abbreviation	Explanation
3GPP	3rd Generation Partnership Project
5GAA	5G Automotive Association
ACEA	European Automobile Manufacturers' Association
ARIB	Association of Radio Industries and Businesses (Japan)
ASECAP	European Association of Motorway Concessionaries and Toll Operators
ATC	Automatic Train Control
ATO	Automatic Train Operation
ATP	Automatic Train Protection
ATS	Automatic Train Supervision
CAM	Cooperative Awareness Messages
CBTC	Communication Based Train Control
CCAM	Cooperative, Connected and Automated Mobility
CEN DSRC	Dedicated Short Range Communications as standardised by CEN
CEN-CENELEC	European Committee for Standardisation - European Committee for Electrotechnical Standardisation
CEPT	European Conference of Postal and Telecommunications Administrations
C-ITS	Cooperative Intelligent Transport Systems
CLEPA	European Association of Automotive Suppliers
DCC	Decentralised Congestion Control
DENM	Decentralised Environmental Notification Messages
DOT	Department of Transportation (USA)
DSRC	Dedicated Short Range Communication, as specified in CEN EN 12253, CEN EN 12795, and ETSI EN 300 674
DSSS	Direct Sequence Spread Spectrum

DSSS/TDMA	DSSS/Time Division Multiple Access
EIRP	Equivalent Isotropically Radiated Power
eNodeB	A logical node responsible for radio transmission/reception in one or more cells to/from the user equipment
ETSI	European Telecommunications Standards Institute
FS	Fixed Service
FSS	Fixed-Satellite Service
FWA	Fixed Wireless Access
IEEE	Institute of Electrical and Electronic Engineers
IMDA	Infocomm Media Development Authority (Singapore)
ITS	Intelligent Transport Systems
ITS-G5	See section 3.1.1
ITU(-R)	International Telecommunication Union (Radiocommunication Sector)
JTFIR	ETSI Joint Task Force ITS-RT
LTE	3GPP Long Term Evolution (4G)
LTE-V2X	Cellular V2X
NHTSA	National Highway Traffic Safety Administration in the USA
OBU	On-board Unit
OFDM	Orthogonal Frequency Division Multiplex
OOB	Out-of-Band
PC5	3GPP LTE-V2X PC5 (also known as LTE sidelink)
RED	Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC
RLAN	Radio Local Area Network
RSPG	Radio Spectrum Policy Group

RSU	Roadside Unit
RTTT	Road Transport and Traffic Telematics (transport and traffic telematics systems for the dedicated use in road environments)
SAE (-C)	Society of Automobile Engineers (-China)
SRD	Short Range Device
TD-LTE	Time Division-LTE
TPC	Transmit Power Control
TTA	Telecommunications Technology Association (Korea)
TTT	Transport and traffic telematics
UAS	Unmanned Aircraft Systems
UGTMS	Urban Guided Transport Management and Control/Command Systems
UNIFE	Union of European Railways Industries
V2I	Vehicle to Infrastructure (V2I)
V2V	Vehicle to Vehicle (V2V)
V2X	Vehicle to everything
WRC	World Radiocommunications Conference