On the Fifth Generation Communication Automotive Research and Innovation Project

5GCAR – The Vehicular 5G PPP Phase 2 Project

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Abstract—**Connected vehicles and cooperative intelligent transport systems (ITS) are foreseen to improve road traffic safety and efficiency; vehicle-to-anything (V2X) communication is one important enabler. While first V2X services will target assisted driving, based on communication technologies like ITS G5 and in future LTE/LTE-A/5G V2X. In the longer run advanced V2X services will evolve towards cooperative automated driving and collective perception of complex road traffic situations. The upcoming 5G standard will target such advanced V2X use cases with a promise of ultra-reliable low latency communications (URLLC) with guaranteed latencies down to 5 ms, support for high data rates, a system scalable to high vehicles densities, and with a flexible network architecture that also supports new business models. Besides the development and evaluation of 5G concepts in time for the 5G standardization, the 5G PPP Phase 2 5GCAR project will demonstrate three advanced V2X use cases with prototype network equipment on an automotive test track.**

Keywords— ***5G V2X; URLLC; 5G demonstrator; 5G sidelink communication; automated driving; intelligent transport.***

I. INTRODUCTION

Two strong technology trends, one in the mobile communications industry and one in the automotive industry, are becoming interwoven and will jointly provide new capabilities and functionality for upcoming intelligent transport systems and future driving.

The automotive industry is on a path where vehicles are continuously becoming more aware of their environment due to the addition of various types of integrated sensors; at the same time the amount of automation in vehicles increases, which – with some intermediate steps – will eventually culminate in fully-automated driving without human intervention. Along this path, the amount of interactions increases, both in-between vehicles, as well as between vehicles and road users in general and an increasingly intelligent road infrastructure. As a consequence, the significance and reliance on capable communication systems for vehicle-to-anything (V2X) communication is becoming a key asset that will enhance the performance of automated driving and increase further road traffic safety with combination of sensor-based technologies.

On the other hand, the mobile communications industry has over the last 25 years connected more than 5 billion people and mobile phones have become part of our daily living. The next step in wireless connectivity is to connect all kinds of devices that can benefit from being connected, with a total of 28 billion connected devices predicted until 2021.

The 5GCAR project, which is a 5G PPP Phase 2 project, brings together a consortium from the automotive industry, the mobile communications industry and academia to develop innovation at the intersection of those sectors in order to support a fast and successful path towards safer and more efficient future driving.

II. CONCEPT AND METHODOLOGY

A. Concept

The 5GCAR project is mainly focused on the next generation of communication networks, 5G, to facilitate V2X services which are not feasible today due to the limitations of existing communication networks. The key objectives of the 5GCAR are aiming at improving wireless communication technologies so as to reduce end-to-end latency, improve reliability, ensure very high availability, guarantee interoperability of heterogeneous radio technologies, increase scalability (massive access), and secure vehicular communications. In Fig. 1 the 5GCAR concept is illustrated as well as its key technical components.

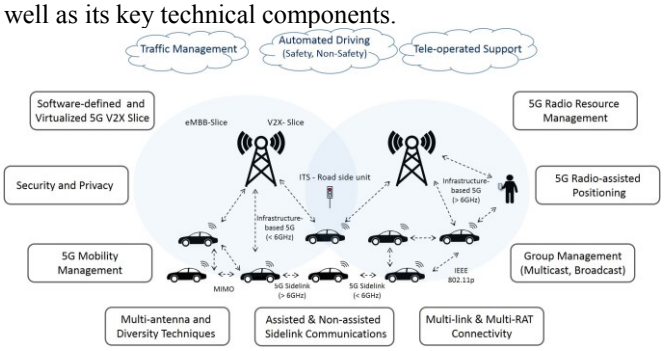

Fig. 1. The 5GCAR concept and its key technical components.

B. *Objectives, Methodology, Research and Innovation Activities, and Ambitions*

The main objectives within the 5GCAR project are:

- Develop an overall 5G system architecture providing optimized end-to-end V2X network connectivity for highly reliable and low-latency V2X services, which supports security and privacy, manages quality-of-service and provides traffic flow management in a multiple Radio Access Technology (multi-RAT) and multi-link V2X communication system.
- Interworking of multi-RATs that allows embedding existing communication solutions (including short range technologies) and novel 5G V2X solutions.
- Develop an efficient, secure and scalable side-link interface for low-latency, high-reliability V2X communications leveraging 3GPP solutions.
- Propose 5G radio-assisted positioning techniques for both Vulnerable Road Users (VRUs) and vehicles to increase the availability of very accurate localization.
- Identify innovative business models and spectrum usage alternatives that support a wide range of 5G V2X services, which drive the functional design of the 5G V2X architecture.
- Demonstrate and validate the developed concepts and evaluate the quantitative benefits of 5G V2X solutions using highly and fully automated driving scenarios in test sites.
- Contribute to 5G standardization and regulatory bodies and 5G Automotive Association for enabling radio-supported and automated driving solutions.
- Collaborate and integrate the 5G V2X radio access network concepts of the 5GCAR project into the overall 5G RAN framework, through participation in the 5G PPP initiatives and events and interaction with other projects.

In order to meet these objectives, the approach of the 5GCAR project consists of three main building blocks that will interact with each other along the execution of the project following a continuous delivery approach:

1) Definition of Scenarios, Requirements, and Key Performance Indicators (KPIs); pivotal to the work of the project, it will be necessary to define the V2X scenarios for those representative applications that cannot be solved with today's technology.
2) Design and validation of innovative technical solutions; based on the scenarios and requirements defined in block 1), a set of advanced communication protocols and mechanisms will be designed.
3) Proof-of-concept and demonstration; one of the main objectives of the 5GCAR project is to show the feasibility and capability of the proposed solutions to fulfil the targeted objectives in real deployments. Towards this end, three representative applications will be showed, demonstrating that applications not realizable with today's technologies can be facilitated by the 5G technology developed in the project.

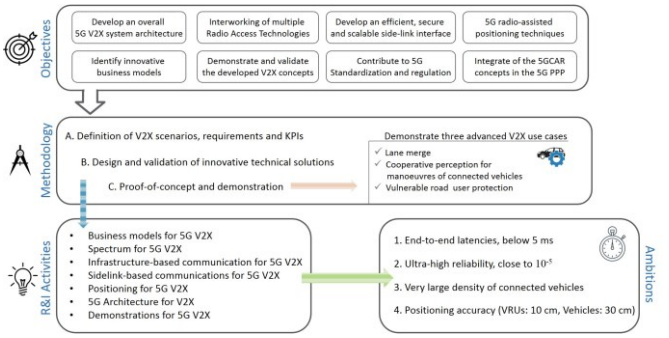

Fig. 2. 5GCAR objectives, methodology, research and innovation activities, and ambitions.

The project methodology is illustrated in Fig. 2 together with the described 5GCAR objectives, the research and innovation activities as well as the project ambitions. This illustration is summarizing the key components of the 5GCAR project.

III. Summary

In summary, the 5GCAR project will:

- clarify use cases and requirements for future connected vehicles;
- develop a 5G radio and architecture design that provides
  - very low latencies below 5 ms,
  - with very high reliability (99.999%),
  - at very high vehicle velocities,
  - which enables, even in a very high vehicle density, the support of a broad range of V2X services,
  - and achieves advanced positioning with accuracies below 1 m;
- develop a 5G system architecture that is flexible in its functional and topological configuration, with advanced quality-of-service management to efficiently support a wide range of V2X services and business models;
- demonstrate – with real 5G test equipment and vehicles – three exemplary V2X use cases for assisted/automated merging of multiple lanes, cooperative perception for maneuvers of connected vehicles, and vulnerable road user protection;
- disseminate results into the standardization, industry harmonization, and regulation via both the telecommunication and automotive industries as well as into international conferences, workshops, peer reviewed journals, magazines and books.

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