Fifth Generation Communication Automotive Research and innovation

Deliverable D6.2
Final Report on Standardization, Dissemination and Exploitation Activities

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Abstract

This deliverable reports the dissemination and exploitation activities conducted for the whole duration of the 5GCAR project. A complete list of workshops and conferences, presentations and panels, as well as publications is provided, together with per partner-based exploitation. It presents the 5GCAR final demonstration event and highlights the presence of 5GCAR at the social media to enhance the impact. Finally, it lists the 5GCAR participation to industrial alliances, standardization and regulation bodies meetings.

Executive Summary

The objective of this deliverable is to report the 5GCAR achievements in terms of dissemination of the 5GCAR results, contribution to the standardization and exploitation activities carried out for the whole duration of the project. The 5GCAR ambition was to conduct and contribute with significant research activities for the 5G V2X topic in the H2020 collaborative framework.

5GCAR has prepared and attended several communication and automotive workshops, conferences and events during the lifetime of the project. All these dissemination and exploitation activities were attended with focus on technical objectives and performance research as well as on better understanding societal impacts of various complexity levels of autonomous driving systems. In doing so, 5GCAR brought relevant knowledge into the collaboration with other significant 5G PPP projects, for instance in the 5G Automotive WG. The main events and dissemination activities were made available on the project website and were also advertised through 5G PPP channels and social media.

5GCAR addressed multiple topics towards the standardization and regulation both from ICT and automotive domain. The bodies and alliances where the members of 5GCAR consortium were active were mainly the 3GPP, ETSI, ITU, CEPT, 5GAA and partnership project forums like 5G PPP.

The 5GCAR dissemination has made numerous publications and presentations, as well as contributed to many standardization activities and organized a final demonstration event in June 2019. The 5GCAR project's exploitation activities made and will continue to make noticeable impact as a result of the individual partner exploitation plans.

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List of Abbreviations and Acronyms

3GPP	Third Generation Partnership Project		**IEEE**	Institute of Electrical and Electronics Engineers
5G	Fifth Generation		**ICT**	Information and Communications Technology
5G PPP	5G Private Public Partnership		**ITU**	International Telecommunication Union
5GAA	5G Automotive Association		**ITU-R**	ITU Radiocommunication Sector
5GCAR	5G Communication Automotive Research and innovation		**KPI**	Key Performance Indicator
ADAS	Advanced Driver Assist Systems		**LTE**	Long Term Evolution
BMSB	International Symposium on Broadband Multimedia Systems and Broadcasting		**MDPI**	Molecular Diversity Preservation International
C-V2X	Cellular V2X		**MWC**	Mobile World Congress
CEPT	European Conference of Postal and Telecommunications Administrations		**NR**	New Radio
			OBU	On-board Unit
EC	European Commission		**OEM**	Original Equipment Manufacture
ECC PT1	Electronic Communications Committee Project Team 1		**PC5**	ProSe direct communication interface 5
eMBB	enhanced Mobile Broadband		**PIMRC**	International Symposium on Personal, Indoor and Mobile Radio Communications
ETSI	European Telecommunications Standards Institute			
ETSI ITS	European Telecommunications Standards Institute Intelligent Transportation Systems		**QAM**	Quadrature amplitude modulation
			QoS	Quality of Service
ETSI TC ITS	European Telecommunications Standards Institute Technical Committee for Intelligent Transportation Systems		**R&D**	Research and Development
			RAN	Radio Access Network
			RAT	Radio Access Technologies
EU	European Union		**SAE**	Society of Automotive Engineers
EUCAD	European Conference on Connected and Automated Driving		**SE24**	Spectrum Engineering Working Group 24
			SIA	Sustainable Industrial Areas
EuCNC	European conference on networks and communications		**SME**	Small and medium-sized enterprises
Globecom	Global Communications Conference		**UE**	User Equipment
			URLLC	Ultra-Reliable Low Latency Communication
GSMA	Global System for Mobile Communications Association		**Uu**	Air interface between base station and UE
ICC	International Conference on Communications		**V2I**	Vehicle-to-Infrastructure

V2N	Vehicle-to-Network
V2P	Vehicle-to-Pedestrian
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Anything
VDTK	Vilnius Design and Technical College

VNC	Vehicular Networking Conference
VTC	Vehicular Technology Conference
WCNC	Wireless Communications and Networking Conference
WG	Working Group

1 Introduction

In this 5GCAR deliverable the final dissemination outcomes of the project are presented, such as listing the contributions to conferences, workshops, industrial alliances, standardization and regulation bodies until the end of the project.

The 5GCAR project [5GCAR] designed, developed and showcased a system for a mobile Radio Access Network (RAN) that is efficient, secure and allow interworking of short range and long range Cellular-Vehicle-to-Anything (C-V2X) components to support advanced V2X communication needs (e.g., for automation levels 4-5) [SAE14], build the technical foundation for 5G V2X standardization, and build a common understanding across the telecommunications and automotive sectors.

1.1 Objective of the document

The main objective of this deliverable is to enlist and evaluate the dissemination activities and outcomes conducted for the whole duration of the 5GCAR project. The aim of the project is to achieve high visibility and maximized impact. The report outlines the disseminating of 5GCAR results to standards, regulatory bodies, workshops, industrial alliances, scientific journals and conferences. The report pinpoints important events, meetings and workshops in which the 5GCAR project has participated and provided contributions.

1.2 Structure of the document

Section 1 gives a general introduction. Section 2 provides the dissemination activities that 5GCAR organized or participated in. Section 3 presents the standardization and regulation activities, where 5GCAR has monitored or participated and provided contributions. Section 4 discusses the exploitation of 5GCAR results. References are provided in Section 5, whereas more details for Sections 2 to 4 are provided in Annex A to Annex C respectively.

2 5GCAR Dissemination Activities

All 5GCAR partners actively contributed to the dissemination efforts which included demonstrating project results in the 5GCAR final demonstration event, publishing project results at scientific conferences, workshops, in journals and magazines, giving customer presentations and participating in industry groups, and by contributing to inter-project orchestration. Both the telecom and automotive industry members of 5GCAR had regular participation at conferences, journals and industrial forums. Most of these forums had major focus on connectivity addressing the need from both horizontal, such as telecom, and vertical sectors, such as automotive and smart cities, by having dedicated tracks for each sector. The number for different dissemination and communication activities is presented in Table 2.1.

Table 2.1 Number of different dissemination and communication activities

Dissemination & Communication Activities	Number of activities
Organization of workshops and special sessions	8
Booth exhibitions in industry forums and events	5
Conference papers published	25
Journal paper published or accepted	19
Talks and presentations by 5GCAR partners	72
Organization of plenary panels	2
Participation in panel as panelist	24
Participation in panel as moderator	7
Lectures and training activities	8
Press releases	2
Video/Film	3

2.1 Workshops and conferences

The 5GCAR project consortium focused on presenting and demonstrating the project's results in major telecommunication and automotive events as well as the organization of workshops in the highly impacting conferences. Most of these selected conferences have major focus on connectivity and telecommunication, as they do have dedicated tracks for connected vehicle domain. Whereas most of the legacy automotive conferences targeting purely automotive domain are without similar tracks addressing connectivity, with some exceptions. In addition, key members of the 5GCAR consortium already being part of the organization committees of prestigious conferences and chairs of several workshops have been promoting the 5GCAR results within these conferences and workshops.

The 5GCAR project has organized seven workshops during the entirety of the project. In 2017, 5GCAR organized the First International Workshop on V2X Channel Measurements and Modeling at the 28th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC) a 5GCAR workshop at the 39th Wireless World Research Forum (WWRF), and a 5GCAR member was lead organizer of the 6th International Workshop on Emerging Technologies for 5G and Beyond Wireless and Mobile Networks (ET5GB) in conjunction to IEEE GLobecom'2017 with a keynote presentation by a 5GCAR member. Furthermore, in 2018, 5GCAR organized a workshop in the 13th IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB), the 29th IEEE International Symposium on PIMRC and a workshop as well as a special session in the 27th European Conference on Networks and Communications (EuCNC).

Details of these events are provided in Annex A.1.

2.2   5GCAR final demonstration

On June 27, 2019, a final event was organized by the project, where the 5GCAR demonstrations were showcased to the visitors. Aside from general introductions and discussions on implementation details and evaluation results, the visitors experienced the demonstrations from within the respective cars. Representative photos from the event are shown in Figure 2.1.

Figure 2.1 Top left: Lane merge demonstration, Top right: Long range sensor sharing/see through demonstration, Bottom left: VRU protection demonstration, Bottom right: 5GCAR project vehicles in front of main event building.

The event and the demonstrations were received very positively, and a video documents the demonstrations, published online on 5GCAR website [5GC-WEB] and YouTube channel [5GC-YTB].

More details on the 5GCAR Final Demonstration are provided in Annex A.2.

2.3   Industry forums and events

A high level of visibility was achieved for the project by organizing and participating in public exhibitions and fairs, organized by industry and telecom operators. The main focus in such events was the demonstration of project achievements to approach business stakeholders. 5GCAR participated with exhibition booth in several such events such as Mobile World Congress in Barcelona in February 2018 and 2019 as well as ICT 2018 in Vienna and EuCNC in June 2018 and 2019. In other industry forums and events like the Global 5G Event, 13th ITS European Congress, MOVE 2019, Connected and Automated Driving, EUCAD, 5G Automotive Forum, and the TU-Automotive Europe the 5GCAR projected e.g. contributed with presentation and participated in panels.

The complete list of events is provided in Annex A.3.

2.4   Publications

The 5GCAR consortium has contributed to well repute peer reviewed conferences, journals and magazines that have good impact factor so that the results achieved in the project could get a good visibility. The results of 5GCAR have been published in a number of conferences, journals and magazines in the area of wireless communications in general and vehicular communication. All these conferences and journals have a very diverse readership with good balance among academic and industrial participants and readers.

The 5GCAR has actively contributed to journals and magazines dedicated to 5G networking and vehicular networks. The 5GCAR consortium members not only published articles in journals with good impact but have also been promoting the 5GCAR results within special issues being published on the topic of 5G V2X Communications. During the entirety of 5GCAR project, project partners have published 25 papers in conference proceedings and 19 papers in various journals including IEEE Transactions on Broadcasting, IEEE Vehicular Technology Magazine, and the European Conference on Networks and Communications. In addition, 5GCAR members organized a special issue in the MDPI Journal named Sensors, on "Enhances in V2X Communications for Connected Autonomous Vehicles".

Details of published journal and conference papers are provided in Annex A.4.

2.5   Talks and presentations

The larger industrial and academic forums and events especially those organized by IEEE, 5G PPP and SAE often are great medium of communication where it is very convenient to reach out to larger groups of people to disseminate project results. Keynotes and invited talks as well as presentation in the form of small demos and posters are very effective to showcase achieved

results in the project. 5GCAR members participated both as invited speakers and keynote speakers at several conferences, workshops, industrial technical and regulatory body events. To name a few of these events: 5G Automotive Forum, ET5GB workshop at Globecom, IEEE 5G World Forum, IEEE-CIC ICCC, ITS European Congress, China-EU Workshop, Global Pre-commercial 5G Industry Summit, URLLC conference and WWRF.

Details of already given talks and presentations are provided in Annex A.5.

2.6   Panels

The organization of panels and summer schools play an important role. It is a way to highlight project outcomes and to share knowledge among academic and industry peers.

5GCAR members have been invited to several panels, both in terms of participating as panelist as well as organizing and moderating the panels including panels at EuCNC 2018 and 2019, IEEE WCNC, TU-Automotive, EUCAD 2018 and so forth, as outlined in Annex A.6. Additionally, in IEEE WCNC 2018 and EuCNC 2018, 5GCAR organized plenary panels.

2.7   Lectures and training events

5GCAR has organized training events, lectures and summer school that are an important format for raising awareness of project knowledge and results to a wider audience within both industry and academia. Such events have been used as a training means for the younger, and future, generation of researchers in the field. 5GCAR results have been integrated in Master of Science level courses at 5GCAR member universities, and been used also in invited lectures at universities in China. In November 2017, 5GCAR organized a short-term course on the topic of "5G for connected vehicles" at Vilnius Design and Technical College in Vilnius. In June 2018, a two-days Summer School on 5G V2X Communications was held at King's College in London. Finally, in June 2019, another Summer School tutorial on 5G V2X Communications was held in Lund, Sweden. Details of these conducted 5GCAR school activities are provided in Annex A.7.

2.8   Public website, social channels, press releases and references to the project

The 5GCAR public website and other of its social channels along with the press releases and references to the project are presented in this section.

2.8.1   5GCAR website

The 5GCAR website [5GC-WEB] has been maintained and updated during the project [5GC-D11] and will continue its operation after the end of the project. The website contains relevant project information, such as the project vision and objectives, and consortium details. The relation of the project to the funding program as well as to other projects in the same domain is also visible. The site is continuously updated with the project public deliverables, publications, and public material. Relevant events were also made more visible through the website.

2.8.2 Social media and YouTube representation

Through social networks, the project advertises its results, announce events, inform about the most recent results and reports, and provides a platform for discussion. Social networking platforms such as Twitter and YouTube complement 5GCAR's website.

Twitter is used to inform about ongoing activities. The 5GCAR Twitter account [5GC-TWIT] is regularly used for online messaging of news (like conference participation etc.). 5GCAR has made more than 100 tweets and has more than 350 followers. Moreover, it is following the relevant groups and societies for constant updates, which is also a good means for the cross-project interaction (re-tweets by 5G PPP and other related Twitter accounts).

The 5GCAR YouTube channel [5GC-YTB] includes videos that concern the presentation of the project activities and outcomes to increase the impact of our dissemination efforts.

2.8.3 5GCAR press releases and others references to the project

As the strong impacting V2X project for the 5G PPP Phase 2, 5GCAR has been mentioned in the press quite often. The 5GCAR visibility has been further increased through its first project press release [5GC17-press] and its second press release regarding the 5GCAR Final Demonstration [5GC19-press].

The complete list of issued press releases together with what has been presented in the press is given in Annex A.8

3 Standardization, Regulation and Industrial Alliances Impact

The 5GCAR partners participated throughout the duration of the project to standardization and regulation bodies such as 3GPP and ETSI, industrial alliances such as 5GAA, and the 5G PPP EU project partnership. In this section, we provide an overview of the 5GCAR involvement and the resulting contributions.

3.1 Standardization bodies relevant for 5GCAR

The 5GCAR addressed multiple topics covering wide areas of interest, ranging from the telecommunications industry to automakers, which are domains covered by multiple standardization and regulation bodies, which are dealing, either directly or indirectly, with V2X communications. Since before the official beginning of the project, the consortium identified a list of possible relevant bodies, to be monitored and of interesting for contributions, with the purpose of promoting project outcome at standardization level. With the completion of the project, 5GCAR presented a total number of 40 project partner contributions as summarized in Table 3.1.

Table 3.1 Number of different standardization contributions

Standardization contributions	Number of activities
3GPP standardization contributions (RAN WG1)	25
3GPP standardization contributions (RAN WG2)	6
3GPP standardization contributions (SA WG6)	7
ETSI standardization contributions	2

3.1.1 3GPP

Starting from Release 14, 3GPP has been working on the development of cellular based V2X (C-V2X) technologies, covering V2X support with both Uu air interface (linking the base-station to the UE) and sidelink based solutions (PC5 interface, directly linking UEs). Within 5GCAR, we have been continuously monitoring the evolution of the discussions within the 3GPP working groups, with the objective of bringing the research outcome from the project into future releases.

3GPP has been the main SDO focusing on the design of the 5G system, supporting a variety of verticals, including automotive applications. Innovations also include enhancement of LTE system, with topics ranging from carrier aggregation, support of 64-QAM in sidelink, resource pool sharing between mode-3 and mode-4 users, feasibility study about transmit diversity over sidelink, and more. Considering the future release, especially from 5G, 5GCAR partners are actively involved in the discussion on evaluation methodology, channel modeling etc.

The 5GCAR partner contributions include contributions to three main work groups, namely RAN WG1 "radio layer 1", RAN WG2 "radio layer 2 and radio layer 3", and SA6 "mission-critical application", filed by several 5GCAR partners over the course of the project.

RAN WG1 (RAN1) is responsible for specification of the physical layer of the Uu radio Interface for UE, Evolved UTRAN, 5G New Radio and potential beyond, covering both FDD and TDD modes, as well as the physical layer of the Un Interface for Relay Nodes and the sidelink interface which is between Ues. 5GCAR has brought contributions towards RAN1 covering various topics: V2V channel modeling, sidelink design especially on synchronization signal and reference signal design, positioning methods and URLLC related topics including at least ways to multiplex eMBB and URLLC traffic, enhanced control channel reliability. 5GCAR project partners contributed in RAN WG1 with 25 standardization contributions.

RAN WG2 (RAN2) is in charge of the definition of the radio interface architecture, of the specification of the radio resource control and management protocols, and of defining the interface between the physical layer and the upper layers. 5GCAR contributed to the works of RAN2 with proposition involving improvements on the establishment of PC5 links, and concerning the definition of Smart Zones, which take care of the mobility management for PC5 communications between vehicular Ues, and between vehicular Ues towards Road Side Units. 5GCAR project partners contributed in RAN WG2 with 6 standardization contributions.

SA WG6 (SA6) is in charge of defining and maintaining the technical specifications, for the application layer functional interfaces, in particular with emphasis related to critical communication and to applications to support industry verticals. The 5GCAR contribution involves the service negotiation aspects, enabling the interaction between applications and the 3GPP system. 5GCAR project partners contributed in SA WG6 with 7 standardization contributions.

A detailed overview of 5GCAR contributions to 3GPP is provided in Annex B.

3.1.2   ETSI

5GCAR monitored standardization activities of ETSI and participated in ETSI ITS workshops. The network architecture considered for the contributions of 5GCAR is fully aligned with the end-to-end vision of ETSI TC ITS, which addresses direct communication between vehicles and the core networks.

The contributing partners will be able to provide the 5GCAR project with recommendations to the revision process of the ETSI ITS reference architecture and ITS sub-systems, e.g. with the integration of the connectivity framework. The main objective of this standardization task is to integrate the new connectivity framework into the ITS reference architecture and to study the impact of the mapping of the new technology into each ITS stack layer. This improved architecture will be promoted in the scope of the ETSI ITS Release 2 standard development, currently being discussed by ETSI TC ITS with the aim of providing a new enhanced architecture enabling additional applications and use cases for future deployments. 5GCAR will foresee to animate a

liaison with ETSI TC ITS to give information on relevant outcomes of the project to the ITS community.

The contributions of 5GCAR to ETSI ITS TC include a contribution to the WG1 ("Application Requirements and Services") concerning the use case "Network assisted vulnerable pedestrian protection", as detailed in [5GITS-WG1]. On top of use case related contributions, 5GCAR has contributed V2X channel measurement results and channel modeling to ETSI ITS WG4. Further, 5GCAR has given presentations at 9th and 10th ETSI ITS Workshops in March 2018 and 2019 respectively.

3.2   Regulation bodies relevant for 5GCAR

The 5GCAR work is also important and relevant at the European level to CEPT, especially through ECC PT1 and SE24 (Short Range Devices), at which the European administrations are jointly preparing the agreed European contributions to the ITU-R. As both CEPT and ITU are working on similar topics as 5GCAR, our work can thereby be relevant for consideration in their upcoming events.

3.3   5GAA

5GAA [5GAA-WEB] is working on several parallel activities that will allow automotive and telecommunications industries embrace and accelerate the global deployment of intelligent transport and communications solutions.

Many of the ongoing activities fall into 5GCAR project interests, wherein 5GCAR partners (that are also 5GAA members) are actively involved. Several active working items of the "Use Cases and Technical Requirements" and "System Architecture and Solution Development" working groups are relevant for the research work that is being conducted in the 5GCAR project. The definition of use cases and automotive requirements, the elaboration on technology solutions and a roadmap evolution strategy including spectrum allocation requirements are examples of the abovementioned activities in 5GAA. As the 5GCAR work is of strong interest to 5GAA as well, we have for instance given a 5GCAR presentation in a 5GAA Community Building session to share our learnings from the project. 5GAA were also invited and visited our 5GCAR final demonstration, that was earlier described in Section 2.2.

Cellular-V2X (C-V2X) is used in 5GAA to describe the technologies that will be used to achieve the level of connectivity required for V2X communication. C-V2X defines the unified technology platform for short range and long-range communication that is scalable and concurrently supports KPIs of demanding services. It provides one solution for integrated V2V, V2I and V2P operation with V2N by leveraging cellular network infrastructure. 5GCAR research directions and objectives are well aligned with the C-V2X framework.

The contributions of 5GCAR to 5GAA were realized in the form of liaisons or in the form of individual (or joint) contributions by involved partners. For instance, in the first part of the project, a joint contribution about "Service Level Requirements for the See-through Use Case" has been prepared by 5GCAR partners, submitted to and discussed within 5GAA. In the See-Through use

case, which is also part of the 5GCAR target use cases [5GC19-D21], a cooperative perception system exploits the exchange of video between vehicles via wireless communication to increase safety either by facilitating automated driving or by assisting the driver during maneuvers. The data representing the scene in front of the vehicle ahead of a line is captured by a camera vision system and transferred to the rear vehicle to allow it to see through the forward vehicle and bypass the occluded area. In this contribution, Service-level requirements for the "See-through sensor sharing" use case described in [5GC19-D21], have been contributed to 5GAA taking into consideration the list of Service-level requirements that have been defined in 5GAA.

Furthermore, 5GCAR contributed to [5GAA-Wpa], [5GAA-WPb], [5GAA-WPc] released by 5GAA. White paper [5GAA-Wpa] focuses on the business aspects of using cellular networks, while white paper [5GAA-WPc] focuses on use cases. Moreover, white paper [5GAA-WPb] analyses the architectural options for C-V2X communication and summarizes the considerations for the ability of the current networks to handle vehicular services by evaluating them against two particular use cases of interest, the Intersection Movement Assist (IMA) and the Vulnerable User (VRU) Discovery. The considered approaches in this study relate to PC5, Uu, and MEC architectural options. Additionally, multi operator aspects are being analysed in detail. The architectural options and solutions of the white paper relate to and have been influenced from the solutions developed in 5GCAR project.

3.4 Cooperation in 5G PPP

5GCAR is cooperating with 5G PPP in various ways, ranging from more direct discussions with other projects on specific topics to being involved and contributing to many of the Working Groups (WGs). Notably, throughout the project, 5GCAR contributed to e.g. the Automotive WG, the Architecture WG, and the Test, Measurement and KPIs Validation WG. Academic partners in 5GCAR are also active members in the related NetWorld2020 European Technology Platform (ETP) Expert Advisory Group [NW2020-EG].

The cooperation between 5GCAR and the 5G PPP Automotive WG has been particularly strong, where for instance the chairman and one of the two co-chairmen were also actively working in 5GCAR. The work resulted in two White Papers [5GA18-WP] and [5GA19-Wpa] that were released just before the Mobile World Congress 2018 and 2019 respectively. The chairman and the 5GCAR co-chairman were the editors of both these White Papers. In addition, the chairman led the internal Automotive WG meetings as well as most external representation of the WG.

The cooperation with the Architecture WG has seen 5GCAR participating to the editorial team of the 5G PPP 5G Architecture White Paper [5GA19-WPb] wherein 5GCAR was the editor of the Chapter "RAN and edge architecture".

5GCAR contributed with a combined automotive and communication perspective to the 5G PPP work on KPIs, for instance in the Test, Measurement and KPIs Validation WG. Further, the PPP Performance KPIs were in focus during the 5GCAR organized and hosted 5G PPP Technical Workshop in November 2018. For more details, see Annex A.1.1. 5GCAR also contributed to the 5G PPP work on 5G vertical perspectives and the golden nuggets as well as 5G Infrastructure Association roadmap work in the Trials WG [5GIA]. 5GCAR has also taken an active role in driving

the joint Strategic Deployment Agenda (SDA) work together with other 5G PPP projects, EC, 5GAA and GSMA. For instance, in the SDA workshop in February 2019 [SDA]. 5GCAR has also contributed with knowledge on how 5G can support transformation in the automotive industry in a Global5G webinar [G5G-WEB] as well as providing 5GCAR demonstration information [G5G-LMC], [G5G-PMC], [G5G-VRU].

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4 Exploitation of 5GCAR Activities

The exploitation activities in 5GCAR brought seemingly diverse areas together given the diversity of partners' sectors in the project. Thus, it was important to understand the various types of challenges that these industries are facing in terms of coming together as well as to address these challenges of these different perspectives.

Telecom infrastructure providers involved in the 5GCAR project acknowledge the importance of 5G wireless communications in the future automotive industry and business landscape in Europe V2X communication and collaboration. In this context, the manufacturers needed to have an influence on early harmonization and system specifications, in order to create the corresponding markets and address them with competitive products at the appropriate time.

The telecom operator involved in 5GCAR recognized the potentials the automotive sector offers to expand its total service offering, thereby increasing its market size and growth rate. The need to enhance existing infrastructure or functions was identified in order to achieve V2X Services' QoS metrics.

Car manufacturers in the 5GCAR consortium were interested in embedding both intelligence and communication components in vehicles. Vehicles that are smoothly collaborating with other vehicles or devices enhance awareness and problem-solving functions for safety, automation and traffic efficiency, under very strict time/space performance requirements.

Vendors of OBUs that participate in 5GCAR and provide V2X solutions recognized the need for de-virtualization. The generation and ownership of intellectual property is essential to ensure profitability of the manufacturer's business, and at the same time, to provide incentives for competition through open platforms or cross-license agreements on fair and reasonable terms.

Academic partners in the 5GCAR consortium are interested in building on and further developing existing research strength in V2X systems. The gained expertise permeated into the daily university life (e.g. student projects) and has been disseminated within academic education as preparation of future European ITS and 5G experts.

Finally, there are three **Small to medium sized enterprises (SME)** partners in the 5GCAR who mainly devoted their exploitation plans to create strong R&D links with both academia and leading industrial entities. The SMEs at the same time provided an innovative character with necessary edge competence, services and products.

In Table 4.1 an indication of where the different sectors mainly contributed in terms of exploitation activities are categories. Naturally the sectors can also contribute in other areas than what the table indicates.

Table 4.1: Different categories of exploitation and other relevant activities.

Sector	Exploitation Category	Details
OEM	Demonstrations, Use Cases, KPIs	5GAA
Telecom infrastructure provider, mobile operator	Standardization, regulation	3GPP, ETSI, ITU, CEPT
Vendors of OBU, telecom infrastructure provider	Future product development	OBU, telecom equipment
Academia	Educational material	Course material, dissertation subjects

Individual exploitation plans from each partner is provided in Annex C.

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Annex

A   5GCAR Dissemination Activities

The 5GCAR dissemination activities for the whole duration of the project are collected here. Organized workshops and panels in conference events are presented in Annex A.1. Additionally, the 5GCAR final demonstration event is presented in Annex A.2, while organized events in industry forums are presented in Annex A.3. Moreover, publications in conference papers and in journal papers are presented in Annex A.4 and given talks and presentations in various events are presented in Annex A.5. In addition, panel participation in various events and school organization are presented in Annexes A.6 and A.7 respectively. Finally, Annex A.8 contains information on the 5GCAR press releases and other references to the project.

A.1   Workshops and conferences

The 5GCAR workshops and conferences from June 2017 to July 2019 are collected here.

A.1.1   2018-11 5G PPP Technical Workshop

The 5GCAR project organized and hosted the 5G PPP Technical Workshop in Kista, Stockholm, Sweden in 20th to 22nd of November 2018.

Date	20-22 November 2018
Location	Stockholm, Sweden
Website	https://5g-ppp.eu/feedback-on-ppp-technical-workshop-20-22-11-18-kista/
Organization committee	Mikael Fallgren (Ericsson & 5GCAR member)
Contributions	The workshop gathered 30+ PPP Phase 2 and Phase 3 (ICT-17 Platforms) projects. Participants comprised Technical Managers, scientific experts, and specific Working Groups Chairs.
Scope	The Technical Workshop included the PPP Performance KPIs Workshop organized on 20th and 21st, followed by the Technical Board meeting on 22nd.

A.1.2   2018-09 Workshop in PIMRC

In the 29th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC), 9-12 September 2018, 5GCAR organized the Second International Workshop on V2X Communications and Channel Modeling.

Date	9 September 2018
Location	Bologna, Italy
Website	https://wvcm2018.wordpress.com/
Organization committee	Christian Schneider (TU Ilmenau), Massimo Condoluci (Ericsson & 5GCAR member), Taimoor Abbas (Volvo Cars & 5GCAR member), Mate Boban (Huawei & 5GCAR member), Apostolos

	Kousaridas (Huawei & 5GCAR member), Tommy Svensson (CHALMERS & 5GCAR member), Toktam Mahmoodi (KCL & 5GCAR member), Fredrik Tufvesson (Lund University)
Contributions	5GCAR partners conceived, organized, and attended the workshop
Scope	V2X communications, channel measurements and modeling

A.1.3 2018-06 Special session at EuCNC

In the 27th European Conference on Networks and Communications (EuCNC), 18-21 June 2018, the 5GCAR project organized a special session dedicated to advances in 5G V2X communications and the vision of deploying such advances in connected and autonomous cars.

Date	21 June 2018
Location	Ljubljana, Slovenia
Website	https://www.eucnc.eu/special-sessions/special-session-6/
Organization committee	Toktam Mahmoodi (KCL & 5GCAR member) Mikael Fallgren (Ericsson & 5GCAR member) Tommy Svensson (CHALMERS & 5GCAR member) Erik Ström (CHALMERS & 5GCAR member) Jesus Alonso-Zarate (CTTC & 5GCAR member) Taimoor Abbas (Volvo Car Corporation & 5GCAR member) Mate Boban (Huawei European Research Center & 5GCAR member)
Contributions	Keynote speech and panel discussions on advances in 5G V2X communications and the vision of deploying such advances in connected and autonomous cars.
Scope	With the development of ultra-low latency, extremely high reliability and massive device access in 5G, the ambitions for smart driving applications will soon become reality. Therefore, the session brings together experts from telecom and automotive industry to discuss: – What are the desired use cases in the connected and autonomous cars and when are we expecting them? – What are the challenges for telecommunication network, for device manufacturers as well as car manufacturers, and how each sector is addressing those? – What is the status of current standards and spectrum regulations in supporting those challenges? – What are the lessons learnt from experimentations?

A.1.4   2018-06 Workshop at EuCNC

In the 27th European Conference on Networks and Communications (EuCNC), 18-21 June 2018, 5GCAR organized the Workshop on Vertical Industries & Services for 5G.

Date	18 June 2018
Location	Ljubljana, Slovenia
Website	https://www.eucnc.eu/2018/www.eucnc.eu/workshops/workshop-1/
Organization committee	Erik Ström (CHALMERS & 5GCAR member) and Mikael Fallgren (Ericsson & 5GCAR member) from 5GCAR, as well as Woon Hau Chin (Toshiba Research Europe), Chiara Buratti (University of Bologna), Laura Baracchi (Trust-IT Services), Stephanie Parker (Trust-IT Services), Belkacem Mouhouche (Samsung Electronics Research)
Contributions	Erik Ström (CHALMERS & 5GCAR member) and Mikael Fallgren (Ericsson & 5GCAR member) from 5GCAR contributed to the organization of the workshop, and Tommy Svensson (CHALMERS & 5GCAR member) was moderator of the Panel session 2 – Impact of 5G on Verticals.
Scope	A full day workshop with four keynote speeches, several project presentations, and two panels

A.1.5   2018-06 Workshop in BMSB

In the 13th IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB), 6-8 June 2018, 5GCAR organized the 5G Connected Cars: Vehicular-to-Everything Communications workshop.

Date	7 June 2018
Location	Valencia, Spain
Website	https://www.mcg.upv.es/en/bmsb2018/workshops/
Organization committee	Mikael Fallgren (Ericsson & 5GCAR member)
Contributions	By paper acceptance (invitation)
Scope	This workshop, organized by the 5GCAR project consortium, was devoted to discussing the role of 5G technologies for the connected car. 5G technologies will enable vehicles to be connected to the networks and to be able to talk to each other ensuring low reliability and ultra-low latency. Disruptive new applications enabled from improved connectivity will allow improving driving efficiency and boosting road safety.

	The session was split into two parts. First, a series of talks were provided based on the accepted papers. Then, an interactive panel discussion followed.

A.1.6   2017-12 Workshop at IEEE Globecom

In conjunction to IEEE Globecom'2017, 4-8 December, 5GCAR member was lead organizer of the 6th International Workshop on Emerging Technologies for 5G and Beyond Wireless and Mobile Networks (ET5GB).

Date	8 December 2017
Location	Singapore
Website	http://www.et5gb.com/5G/2017/
Organization committee	Tommy Svensson (CHALMERS & 5GCAR member), Wei Yu, Peiying Zhu, Halim Yanikomeroglu, Lingjia Liu, Charlie (Jianzhong) Zhang
Contributions	Tommy Svensson (CHALMERS & 5GCAR member), Mikael Fallgren (Ericsson & 5GCAR member)
Scope	This workshop series is a venue to brainstorm on and to identify the emerging concepts, technologies, and analytical tools for 5G and beyond cellular and cell-less networks. The aim is to bring together leading researchers in both academia and industry, and to provide a forum for researchers from diverse backgrounds to share their views on 5G and beyond and to have an open dialogue on the future of wireless research. The goal is to identify key 5G and beyond technologies that can deliver significant capacity, coverage and user-experience benefits.
	One of the keynote titles of this 6th edition was on "5G Connected Vehicles", with a speech provided by Mikael Fallgren (Ericsson & 5GCAR member).
	More information about the workshop program, and download of the presentations, can be found at http://www.et5gb.com/5G/2017/program.html.

A.1.7   2017-10 Workshop in WWRF

In the 39th Wireless World Research Forum (WWRF), 18-20 October 2017, 5GCAR organized a workshop.

Date	18 October 2017
Location	CTTC, Castelldefels, Barcelona, Spain
Website	http://www.wwrf39.ch
Organization committee	Jesus Alonso-Zarate (CTTC & 5GCAR member) and Mikael Fallgren (Ericsson & 5GCAR member)

Contributions	Mate Boban (HUAWEI & 5GCAR member), Taimoor Abbas (Volvo Cars & 5GCAR member), Tommy Svensson (CHALMERS & 5GCAR member), Ricard Vilalta (CTTC & 5GCAR member), Andres Laya (Ericsson & 5GCAR member), Mikael Fallgren (Ericsson & 5GCAR member)
Scope	This special session, organized by the 5GCAR Project consortium, was devoted to discussing the role of 5G technologies for the connected car.
	5G technologies will enable cars and vehicles to be connected to the networks and also to be able to talk to each other ensuring low reliability and ultra-low latency. Enabling such kind of connectivity will leverage disruptive new applications that will allow to improve driving efficiency and boost road safety.
	The session was split in two parts. First, a series of talks were provided introducing key topics related to the topic of 5G and the automotive vertical sector. Then, a panel discussion was initiated for a highly interactive discussion about the topic.
	More information on the presentations and panel can be found in Annexes A.5 and A.6 respectively.

A.1.8   2017-10 Workshop in PIMRC

In the 28th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC), 8-13 October 2017, 5GCAR organized the First International Workshop on V2X Channel Measurements and Modeling.

Date	11 October 2017
Location	Montreal, Canada
Website	https://wvcm2017.wordpress.com/
Organization committee	Mate Boban (Huawei Technologies Duesseldorf Gmbh & 5GCAR member), Jian Luo (Huawei Technologies Duesseldorf Gmbh & 5GCAR member), Taimoor Abbas (Volvo Cars & 5GCAR member), Fredrik Tufvesson (Lund University) and Prof. Reiner S. Thomä (TU Ilmenau)
Contributions	5GCAR partners conceived, organized, and attended the workshop
Scope	Vehicular communication is characterized by diverse environments, high mobility of both the communicating entities and their surroundings, and comparatively low antenna heights on vehicles. These characteristics are very different from classical cellular cases and make the vehicular propagation and channel modeling particularly challenging. Additionally, the ultimate goal of next generation Vehicle-to-everything (V2X) communication systems is enabling accident-free cooperative automated driving. To achieve this goal, the communication system will need to enable a diverse set of use cases, which can result in channel conditions not fully explored in the past (e.g., blockage effects

	caused by densely packed platooning vehicles, communication between vehicles and vulnerable road users such as pedestrians and cyclists, etc.). Finally, in recent years, different frequency bands have been proposed for V2X communications (e.g., in centimeter wave bands, millimeter wave bands, and in visible light spectrum). The impact of frequency band and the propagation characteristics of high frequency (millimeter wave) V2X channels, etc. become very important objects of investigation.

A.2   5GCAR Final Demonstration

5GCAR organized and hosted its project Final Demonstration event in Linas, France, on the 27th of June 2019.

Date	27 June 2019
Location	Linas (Paris), France
Website	https://5gcar.eu/
Organization committee	Bastian Cellarius (Ericsson & 5GCAR member), Mikael Fallgren (Ericsson & 5GCAR member)
Contributions	5GCAR booth and 5GCAR presentation.
Scope	As representatives of the use cases defined in the architecture work of 5GCAR, four different demonstrations were implemented as field trials, and showcased in an event on June 27, 2019. These use cases are: 1. Lane Merge Coordination, from the Cooperative Maneuver use case class 2. See-Through Sensor Sharing, from the Cooperative Perception use case class 3. Long Range Sensor Sharing, also from the Cooperative Perception use case class 4. Vulnerable Road User Protection, from the Cooperative Safety use case class For executing the four demonstrations, different parts of the test track were used (as illustrated in Figure A.1), each reflecting the target environment of the respective use case. The purpose of the trials was to showcase and assess the benefit of 5G, and in general connectivity, for automotive use cases. The work on this is enhanced using a video, documenting the demonstrations, and a technical evaluation, captured in [5GC19-D52].
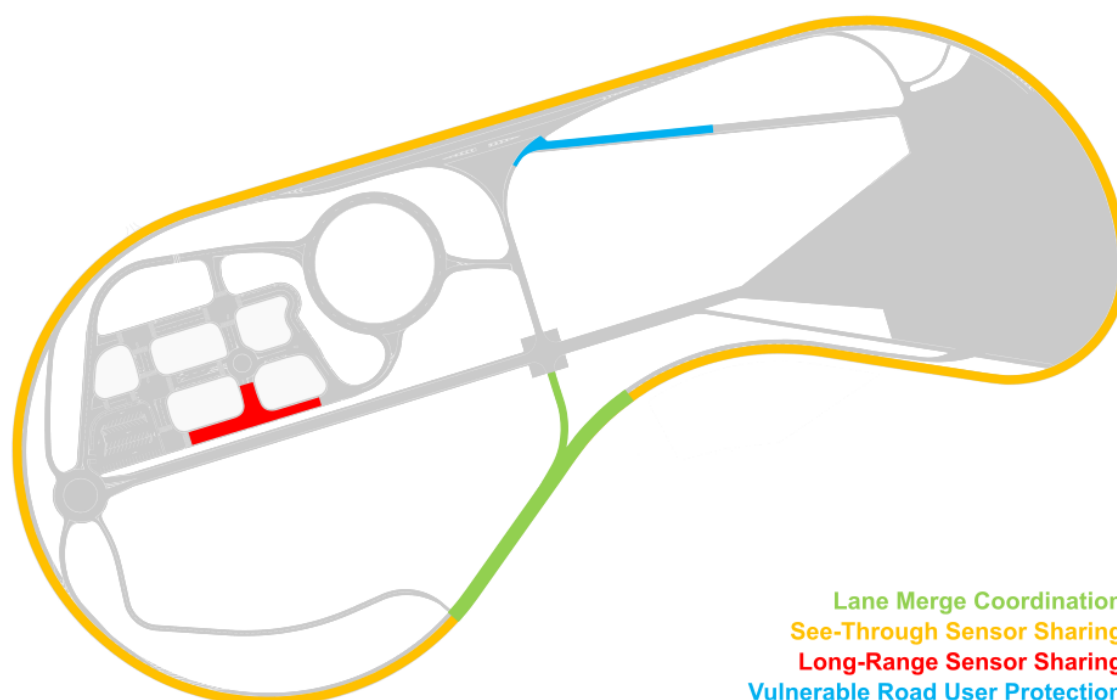
Figure A.1 Different areas of the test track were used for the four 5GCAR demonstrations, each representing the target environment of the respective use case.

A.3 Industry forums and events

5GCAR industry forums and events from June 2017 to July 2019 are collected here.

A.3.1 2019-06 Booth at EuCNC

In the 28th European Conference on Networks and Communications (EuCNC), 18-21 June 2019, the 5GCAR project organized a booth.

Date	18 June to 21 June 2019
Location	Valencia, Spain
Website	https://www.eucnc.eu/
Organization committee	Mikael Fallgren (Ericsson & 5GCAR member), Bastian Cellarius (Ericsson & 5GCAR member), Ricard Vilalta (CTTC & 5GCAR member)
Contributions	5GCAR booth and 5GCAR presentation.
Scope	Here knowledge was spread on the 5GCAR project as well as interactions and learnings from others.

Some of the final results from the 5GCAR project were demonstrated. Such as, background on key performance |

	indicators, use cases and their requirements. Learnings from the studies on V2X business and spectrum aspects. Highlight of promising V2X project and sidelink technology components as well as V2X architecture findings, together with pre-demonstration work and dissemination activities. To illustrate the (at this time) still ongoing demonstration work, a pre-demonstration video was showcased and explained. Flyers and Brochures were also provided to convey a summary of overall results.

A.3.2   2019-02 Booth at MWC

In the Mobile World Congress (MWC), 24 February to 27 February 2019, 5GCAR organized a booth.

Date	24 February to 27 February 2019
Location	Barcelona, Spain
Website	https://www.mwcbarcelona.com/
Organization committee	Mikael Fallgren (Ericsson & 5GCAR member), Bastian Cellarius (Ericsson & 5GCAR member)
Contributions	5GCAR booth and 5GCAR presentation.
Scope	In this event 5GCAR was present with a booth (joint with 5GcroCo) where we showcased our 5GCAR pre-demonstration video (also available on [5GC-YTB]). This video was also shown in the 5G-IA booth during the event. 5GCAR flyers and the 5G Automotive WG White Paper v2.0 were also provided in both locations. A 5GCAR presentation was also given during the event (on February 26) at the Mobile World Capital stand. Overall there was a good number of around 100 visitors to the booth (in addition, we had six tours where around 120 additional people passed by and listened to a shorter presentation about the project). The 5GCAR presentation attracted around 40 people in the audience.

A.3.3   2018-12 Booth at ICT

5GCAR participated in the ICT 2018 Exhibition 5G PPP stand in Vienna, December 4-6, 2018.

Date	4 December to 6 December 2018
Location	Vienna, Austria
Website	https://ec.europa.eu/digital-single-market/events/cf/ict2018/catalogue.cfm
	https://ec.europa.eu/digital-single-market/events/cf/ict2018/item-display.cfm?id=22148

Organization committee	Mikael Fallgren (Ericsson & 5GCAR member)
Contributions	5GCAR booth
Scope	To highlight research and innovation from the (at the time) ongoing 5GCAR project: 5GCAR advances the frontiers of wireless communications technologies for automotive to meet the future societal expectations and needs.
	For the driver as well as the passengers to enjoy a safe and efficient ride, boosted with infotainment services, new solutions are needed. With help from a cellular system each vehicle can learn about happenings not only in its most immediate surrounding but also from further away, enabling the vehicle to make smarter decisions. To enable these expectations, an overall 5G system architecture that can provide communication services with high reliability, low latency, and strong security and privacy for the vehicles is needed.
	Further, it is needed to integrate existing communication systems with novel, high-performance 5G solutions which add new communication schemes exploiting direct, infrastructure-based and multi-link communication among vehicles and other entities Very accurate 5G radio-assisted positioning techniques for both vulnerable road users and vehicles is also needed. It is also important to understand the new ecosystem being created around the telecom and automotive sectors. To define new business models and evaluate the existing spectrum usage alternatives that will support a wide range of 5G services are therefore important as well. 5GCAR is actively working and contributing to these solutions.

A.3.4 2018-06 Booth at EuCNC

In the 27th European Conference on Networks and Communications (EuCNC), 18-21 June 2018, the 5GCAR project organized a booth.

Date	18 June to 21 June 2018
Location	Valencia, Spain
Website	https://www.eucnc.eu/2018/www.eucnc.eu/
Organization committee	Mikael Fallgren (Ericsson & 5GCAR member), Fermín Mira (CTTC & 5GCAR member), Ricard Vilalta (CTTC & 5GCAR member)
Contributions	5GCAR booth and 5GCAR presentation.
Scope	The booth consisted of some high-level posters as well as more detailed public reports (known as deliverables) on the intermediate results from the 5GCAR project. Flyers and Brochures were also provided to convey a summary of the overall project objectives and goals. The booth also contained a small-scale demonstration

	replica of the actual demonstration, with robot-vehicles driving on a table to illustrate aspects of the Lane merge coordination use case.

A.3.5 2018-02 Booth at MWC

In the Mobile World Congress (MWC), 26 February to 1 March 2018, 5GCAR organized a booth.

Date	26 February to 1 March 2018
Location	Barcelona, Spain
Website	https://www.mobileworldcongress.com/
Organization committee	Ricard Vilalta (CTTC & 5GCAR member), Mikael Fallgren (Ericsson & 5GCAR member), Kai Cordes (VISCODA & 5GCAR member), Jamie Slome (KCL), Selva Vía, Fermín Mira, Juan Luis de la Cruz, Jesús Alonso-Zarate (CTTC & 5GCAR member).
Contributions	5GCAR booth and 5GCAR presentation.
Scope	5GCAR presented a demo at this edition of the Mobile World Congress (MWC18). As part of the 5Gbarcelona initiative, aimed at promoting the city of Barcelona as a 5G hub in Europe, the Mobile World Capital invited the 5G Infrastructure Association (5GIA), the private sector side of the 5G PPP, to have a space at its booth at MWC18. The space showed demos of key projects now being undertaken under the 5G PPP umbrella.
	5GCAR MWC18 demo, led by Dr. Ricard Vilalta and a team of engineers and researchers brought together by CTTC, with the collaboration from other partners in the project (Ericsson, Huawei, VISCODA, and KCL), staged a fully operational demo showcasing some of the key innovations being explored in the project. These include the use of IoT-based V2X communications, Software-Defined Networking (SDN), Mobile Edge Computing (MEC), and Advanced Real-Time Image Processing, all orchestrated from a central computing "brain".
	The demo illustrated how all these technologies can be combined to enable safer driving in city streets. While the project is preparing a real demo using actual cars that will be ready by the end of the project, the demo presented by CTTC at this edition of the MWC18 was based on small-sized cars intended to validate the ideas explored in the project.
	The demo was held at the Mobile World Capital booth during all four days of MWC18. Visitors where able to see the demo and chat with experts from CTTC and other 5GCAR partners involved in the design and implementation of the demo, to learn more details about the technology being developed and ask any questions they may have.
	This demo at MWC18, the biggest event devoted to telecommunications worldwide, aimed to show just one of the

	potential benefits 5G technology can bring. The positive impact that 5G-enabled connected cars can have on traffic efficiency and safety is just one of the benefits 5G technologies will have on the economy and society overall.

A.3.6 2017-11 SIA dissemination event

In the SIA (Société des Ingenieurs de l'automobile) dissemination event, 29 November 2017, 5GCAR contributed with the organization.

Date	29 November 2017
Location	Paris, France
Website	http://www.sia.fr/evenements/105-technologies-telecommunication-pour-automobile
Organization committee	Bernadette Villeforceix (Orange & 5GCAR member), Antonio Eduardo Fernandez (PSA & 5GCAR member)
Contributions	Bernadette Villeforceix (Orange & 5GCAR member), Antonio Eduardo Fernandez (PSA & 5GCAR member)
Scope	5GCAR organized a dissemination event in Paris, 29 November 2017, with the SIA (Société des Ingenieurs de l'automobile). This is an association of French engineers, managers and technicians working in the automotive sector in France. Its main goal is to promote innovation and technical exchange between automotive professionals. The event was mainly addressed to people involved in electronics both for OEMs and providers in order to remark the possibilities of 5G in the connected and autonomous vehicle ecosystem.

A.4 Publications

5GCAR conference paper publications and journal paper publications from June 2017 to July 2019 are collected here.

A.4.1 Conference papers

5GCAR conference paper publications from June 2017 to July 2019 are collected here.

Date	Author(s)	Title of paper	Publisher	Conference	Location
June 2019	L. Sequeira, A. Szefer, J. Slome, T. Mahmoodi	A Lane-Merge Coordination Model for V2X Scenario	IEEE	28th European Conference on Networks and Communications,	Valencia

				EuCNC 2019, 18-21 June	
May 2019	G. Mountaser, M. Mahlouji, T. Mahmoodi	Latency Bounds of Packet-Based Fronthaul for Cloud-RAN with Functionality Split	IEEE	53rd IEEE International Conference on Communications (ICC),20-24 May 2019	Shanghai, China
Feb. 2019	Kai Cordes, Hellward Broszio	Constrained Multi Camera Calibration for Lane Merge Observation	SCITEPRESS	14th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications, 25-27 February 2019	Prague, Czech Republic
Dec. 2018	A. Kakkavas, M. H. Castaneda Garcia, R. A. Stirling-Gallacher, J. A. Nossek	Multi-Array 5G V2V Relative Positioning: Performance Bounds	IEEE	IEEE Global Communications Conference (Globecom) 2018, 9-13 December	Abu Dhabi
Dec. 2018	Zohair Abu-Shaban , Henk Wymeersch , Thushara Abhayapala , Gonzalo Seco-Granados	Distributed Two-Way Localization Bounds for 5G mmWave Systems	IEEE	IEEE Global Communications Conference (Globecom) 2018, 9-13 December	Abu Dhabi
Dec. 2018	Fuxi Wen, Nil Garcia, Josef Kulmer , Klaus Witrisal , Henk Wymeersch	Tensor Decomposition Based Beamspace ESPRIT for Millimeter Wave MIMO Channel Estimation	IEEE	IEEE Global Communications Conference (Globecom) 2018, 9-13 December	Abu Dhabi
Dec. 2018	H. Wymeersc, N. Garcia , H. Kim , G. Seco-Granados , S. Kim , F. Wen , M. Fröhle	5G mmWave Downlink Vehicular Positioning	IEEE	IEEE Global Communications Conference (Globecom) 2018, 9-13 December	Abu Dhabi

Dec. 2018	M. Mahlouji, T. Mahmoodi	Analysis of Uplink Scheduling for Haptic Communications	IEEE	IEEE Global Communications Conference (Globecom) 2018, 9-13 December	Abu Dhabi
Dec. 2018	T. Sahin, R. Khalili, M. Boban, A. Wolisz	Reinforcement Learning Scheduler for Vehicle-to-Vehicle Communications Outside Coverage	IEEE	IEEE Vehicular Networking Conference (VNC) 2019, 4-6 December 2018	Taipei
Oct. 2018	H. Kim, H. Wymeersch, N. Garcia, G. Seco-Granados, S. Kim,	5G mmWave Vehicular Tracking	IEEE	52nd Asilomar Conference on Signals, Systems, and Computers	Pacific Grove, CA, USA
Sept. 2018	J. Kulmer , F. Wen , N. Garcia , H. Wymeersch , K. Witrisal	Impact of Rough Surface Scattering on Stochastic Multipath Component Models	IEEE	29th Annual IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC), 9-12 September 2018	Bologna, Italy
2018, June 6-8	M. Fallgren, M. Dillinger, Z. Li, G. Vivier, T. Abbas, J. Alonso-Zarate, T. Mahmoodi, S. Allio, T. Svensson, G. Fodor	On Selected V2X Technology Components and Enablers from the 5GCAR Project	IEEE	IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB) 2018, June 6-8	Valencia, Spain
2018, June 26-28	M. Deghel, S. E. Elayoubi, A. Galindo-Serrano, R. Visoz	Joint Optimization of Link Adaptation and HARQ Retransmissions for URLLC Services	IEEE	ICT 2018, 25th International Conference on Telecommunication	St. Malo, France
2018, June 25-26	R. Vilalta, S. Via, F. Mira, R. Casellas, R.	Control and Management of a Connected Car	IEEE	4th IEEE International Conference on	Montreal

	Muñoz, J. Alonso-Zarate, A. Kousaridas and M. Dillinger	Using SDN/NFV, Fog Computing and YANG data models		Network Softwarization (NetSoft), June 25-29, 2018	
2018, June 18-21	A. Zafeiropoulos, P. Gouvas, E. Fotopoulou, G. Tsiolis, T. Xirofotos, J. Bonnet, G. Carrozzo, S. Rizou, A. Gavras, M. Joao, X. Costa-Perez, A. Prasad, M. Gramaglia, A. Tzanakaki, D. Simeonidou, J. Cosmas, M. Fallgren, R. Muñoz, R. Vilalta	Enabling Vertical Industries Adoption of 5G Technologies: a Cartography of evolving solutions	IEEE	27th European Conference on Networks and Communications, EuCNC 2018	Ljubljiana, Slovenia
2018, June 18-21	N. Kousaridas, P. Spapis, L. Gallo, B. Villeforceix, Y. Li, W. Sun, M. Condoluci, L. Hu, T. Mahmoodi, R. Vilalta, M. Dilinger	Architecture and Enablers of 5G V2X Network Slice for Reliable and Low-latency Communications	EuCNC	27th European Conference on Networks and Communications, EuCNC 2018	Ljubljiana, Slovenia
2018, June 3-6	A. Kousaridas, C. Zhou	Local End-to-End Paths for Low Latency Vehicular Communication	IEEE	IEEE 87th Vehicular Technology Conference, VTC 2018-Spring	Porto, Portugal
May 2018	J. Zhao, Y. Liu, T. Mahmoodi, K. K. Chai, Y. Chen, Z. Han	Resource Allocation in Cache-Enabled CRAN with Non-	IEEE	IEEE International Conference on Communications	Kansas City

		Orthogonal Multiple Access		(ICC) 2018, 20-24 May	
2018, April 15-18	G. Destino, J. Saloranta, H. Wymeersch, and G. Seco-Granados	Impact of Imperfect Beam Alignment on the Rate-Positioning Trade-Off	IEEE	Wireless Communications and Networking Conference (WCNC), 15-18 April 2018	Barcelona
2018, April 15-18	Z. Abu-Shaban, X. Zhou, T. Abhayapala, G. Seco-Granados, and H. Wymeersch	Location and Orientation Estimation Performance with Uplink and Downlink 5G mmWave Multipath Signals	IEEE	Wireless Communications and Networking Conference (WCNC), 15-18 April 2018	Barcelona
2018, March 14-16	D.-T. Phan-Huy, S. Wesemann, J. Bjorsell, M. Sternad	Adaptive Massive MIMO for fast moving connected vehicles: It will work with Predictor Antennas!	IEEE	22nd international workshop on smart antennas (WSA), 14-16 March 2018	Bochum
2017, Dec. 8	G. Mountaser, M. Condoluci, T. Mahmoodi, M. Dohler, and I. Mings	Cloud-RAN in Support of URLLC	IEEE	IEEE Global Communications Conference (Globecom), 4-8 December 2017	Singapore
2017, Dec. 8	J. Talvitie, M. Valkama, G. Destino, and H. Wymeersch	Novel Algorithms for High-Accuracy Joint Position and Orientation Estimation in 5G mmWave Systems	IEEE	IEEE Global Communications Conference (Globecom), 4-8 December 2017	Singapore
2017, November 22-24	R. Vilalta, S. Via, F. Mira, L. Sanabria, R. Martínez, R. Casellas, R..= Muñoz, and J. Alonso-Zarate	Control and Management of a Connected Car Using YANG/RESTCONF and Cloud Computing	IEEE	8th International Conference on Network of the Future (NoF), 22-24 November 2017	London

2017, October 10	H. Guo, B. Makki, and T. Svensson	A Comparison of Beam Refinement Algorithms for Millimeter Wave Initial Access	IEEE	28th annual international symposium on Personal, Indoor and Mobile Radio Communications (PIMRC), 8-13 October 2017	Montreal

A.4.2 Journal papers

5GCAR journal paper publications from June 2017 to July 2019 are collected here.

Date	Author(s)	Title of paper	Publisher	Journal
2019, June	M. Fallgren et al.	5GCAR contribution to: The European 5G Annual Journal/2019	To-Euro-5G	The European 5G Annual Journal
2019, June	Mikael Fallgren, T. Abbas, Sylvain, Allio, Jesus Alonso-Zarate, G. Fodor, Laurent Gallo, A. Kousaridas, Yilin Li, Zexian Li, Zhongfeng Li, Jian Luo, Toktam Mahmoodi, Tommy Svensson, Guillaume Vivier	Multicast and Broadcast Enablers for High-Performing Cellular V2X Systems	IEEE	Transactions on Broadcasting, Volume: 65, Issue: 2, pp. 454-463.
2019, 15 May	Anver Hisham, Erik G. Ström, Fredrik Brännström, and Li Yan	Scheduling and power control for broadcast V2V communications with adjacent channel interference	IEEE	IEEE Access
2019, 25 February	N. Jamaly, Anders Derneryd, T. Svensson	Effects of coupling and overspeeding on performance of predictor antenna systems in wireless moving relays	IET	IET Microwaves, Antennas & Propagation
2019, January	B. Makki, T. Svensson, G. Caire, M. Zorzi,	Fast HARQ Over Finite Blocklength Codes: A Technique for Low-	IEEE	IEEE Transactions on Wireless Communications

		Latency Reliable Communication		
2018, December	M. Condoluci, T. Mahmoodi	Softwarization and Virtualization in 5G mobile networks: Benefits, Trends and Challenges	Elsevier	Computer Networks
2018, 30 October	R. Mendrzik, H. Wymeersch, G. Bauch, Z. Abu-Shaban	Harnessing NLOS Components for Position and Orientation Estimation in 5G Millimeter Wave MIMO	IEEE	IEEE Transactions on Wireless Communications
2018, 24 September	A. Abrardo, G. Fodor, M. Moretti and M. Telek	MMSE Receiver Design and SINR Calculation in MU MIMO Systems with Imperfect CSI	IEEE	IEEE Wireless Communications Letters
2018, 1 September	M. Fallgren, M. Dillinger, J. Alonso-Zarate, M. Boban, T. Abbas, K. Manolakis, T. Mahmoodi, T. Svensson, A. Laya, R. Vilalta	Fifth-Generation Technologies for the Connected Car Capable Systems for Vehicle-to-Anything Communications	IEEE	IEEE Vehicular Technology Magazine, Volume: 13, Issue: 3, pp. 28-38.
2018, 30 August	X. Jiang, H. Shokri-Ghadikolaei, G. Fodor, E. Modiano, Z. Pang, M. Zorzi, C. Fischione	Low-Latency Networking: Where Latency Lurks and How to Tame It	IEEE	Proceedings of the IEEE
2018, June	M. Fallgren et al.	5GCAR contribution to: The European 5G Annual Journal/2018	To-Euro-5G	The European 5G Annual Journal
2018, June	H. Guo, B. Makki, T. Svensson,	Genetic-Algorithm Based Beam Refinement for Initial Access in Millimeter-Wave Mobile Networks	Wiley-Hindawi	Wireless Communications and Mobile Computing: Special Issue on Recent Advances in 5G Technologies: New

				Radio Access and Networking
2018, May	M. Buehrer, H. Wymeersch, and R. Vaghefi	Collaborative Sensor Network Localization: Algorithms and Practical Issues	IEEE	Proceedings of the IEEE
2018, May	G. Fodor	Mode Selection Schemes for Unicasting Device-to-Device Communications Supported by Network Coding	Wiley	International Journal of Communication Systems
2018, April	R. Muñoz, R. Vilalta, N. Yoshikane, R. Casellas, R. Martínez, T. Tsuritani, I. Morita	Integration of IoT, Transport SDN and Edge/Cloud computing for Dynamic Distribution of IoT Analytics and Efficient Use of Network Resources	IEEE	Journal of lightwave Technologies, Vol. 36, No. 7, pp. 1420 – 1428, April 2018.
2018, March	P. Zhao, G Fodor, G. Dan, and M. Telek	A Game Theoretic Approach to Setting the Pilot Power Ratio in Multi-User MIMO Systems	IEEE	Transactions on Communications
2018, January	G. Fodor	Performance Comparison of Practical Resource Allocation Schemes for Device-to-Device Communications	Wiley	Wireless Communications and Mobile Computing
2017, December	H. Wymeersch, G. Seco-Granados, G. Destino, D. Dardari, and F. Tufvesson	5G mm-Wave Positioning for Vehicular Networks	IEEE	Wireless Communication Magazine
2017, September	B. Martinez de Aragon, J. Alonso-Zarate, and A. Laya	How Connectivity is Transforming the Automotive Ecosystem	Wiley	Transactions on Emerging Telecommunications Technologies (ETT) Technology Letters

A.4.3　　2018-10 Special Issue in MDPI Sensor

5GCAR organized a special issue in MDPI Sensors, with deadline in October 2018. This special issue was dedicated to "Enhances in V2X Communications for Connected Autonomous Vehicles."

Date	Submission deadline October 2018 and publication in the last quarter of 2018
Venue	MDPI Sensors
Website	http://www.mdpi.com/journal/sensors/special_issues/V2X_communications_autonomous_vehicles
Guest Editors	Toktam Mahmoodi (KCL & 5GCAR member), Massimo Condoluci (Ericsson & 5GCAR member), Taimoor Abbas (Volvo Cars & 5GCAR member), Apostolos Kousaridas (Huawei & 5GCAR member), Jesus Alonso-Zarate (CTTC & 5GCAR member)
Contributions	Open to all
Publications	11 papers published out of 20 submissions
Scope	V2X communications
CFP Summary	This Special Issue was dedicated to advances in 5G V2X communications and the vision of deploying such advances in connected and autonomous cars. With the development of ultra-low latency, extremely high reliability and massive device access in 5G, the ambitions for smart driving applications will soon become a reality

A.5　　Talks and presentations

5GCAR talks and presentations from June 2017 to July 2019 are collected here.

Date	Presenter(s)	Title of talk	Event	Location
2019.06.19	M. Fallgren	On the Role of 5G in Automotive Industry	Workshop 5: "Emerging 5G Business Models: Opportunities for SMEs and large companies-lesson from 5G PPP (5G-EBM)" in 28th European Conference on Networks and Communications, EuCNC 2019, 18-21 June	Valencia, Spain
2019.06.19	K. Cordes, B. Cellarius, T. Frye, S. Saur, J. Otterbach , M. Lefebvre, F. Gardes, M.	Use Case Representations of Connected and Automated Driving	Poster Session 1 in 28th European Conference on Networks and Communications, EuCNC 2019, 18-21 June	Valencia, Spain

	Fallgren, J. Tiphène			
2019.06.18	R. Vilalta	Network Slicing with NFV/SDN architectures and Multi-Access Edge Computing network orchestration for V2I communications	Workshop: "Photonic Technologies in 5G and Beyond" in 28th European Conference on Networks and Communications, EuCNC 2019, 18-21 June	Valencia, Spain
2019.06.18	M. Fallgren	Introduction to 5GCAR, and the Role of 5G in Automotive Industry	Workshop 4: "2nd 5G in the Era of Connected Cars" in 28th European Conference on Networks and Communications, EuCNC 2019, 18-21 June	Valencia, Spain
2019.06.18	M. Fallgren	5G for Business: Automotive	The 7th Global 5G Event, Session 3: 5G for Business	Valencia, Spain
2019.06.11	T. Svensson	5GCAR	IEEE Swedish Communication Technologies Workshop (Swe-CTW) Summer School	Lund, Sweden
2019.06.05	M. Fallgren	5G Strategic Deployment Agenda for Connected Automated Mobility	13th ITS European Congress, Workshop: 5G deployment for Automated Mobility	Eindhoven, Netherlands
2019.06.04	M. Fallgren	5GCAR Positioning	13th ITS European Congress, Session SIS26: 5G and GNSS high-accuracy positioning for Connected and Automated Driving	Eindhoven, Netherlands
2019.05.23	T. Svensson	Integrated Moving Networks – Mutual Opportunities for Connected Vehicles and Mobile Networks	4th Global Pre-commercial 5G Industry Summit 2019	Shanghai, China
2019.05.21	M. Fallgren	5GCAR	5GAA Community Building Session	Berlin, Germany
2019.05.02	A. Servel	5G V2X Experimentations	TechDay organized by Rhode&Schwarz	Linas, France

2019.03.05	Michael Gundlach	Use Cases for 3GPP Based V2X and Combined Solutions	ETSI ITS workshop	Sophia Antipolis, France
2019.02.26	M. Fallgren	5GCAR	Mobile World Congress	Barcelona, Spain
2019.02.26	T. Svensson	Integrated Moving Networks – Mutual Opportunities for Connected Vehicles and Mobile Networks	Volvo Cars	Gothenburg, Sweden
2019.02.12	L. Sequeira	Connected Vehicles Empowered by Connectivity (Lane Merge Coordination)	MOVE 2019, 11-12 February	London
2019.02.07	M. Fallgren	Presentation of the draft SDA outline	5G Strategic Deployment Agenda (SDA) for Connected and Automated Mobility (CAM) Workshop	Brussels, Belgium
2018.11.30	M. Fallgren	On the Role of 5G in Automotive Industry	IEEE 5G Summit Rio	Rio de Janeiro, Brazil
2018.11.15	T. Abbas	Connected and autonomous driving vehicles	International Scientific-Practical Conference, "Technological Innovations" 2018	Vilnius, Lithuania
2018.11.01	T. Svensson	Integrated Moving Networks – Mutual Opportunities for Connected Vehicles and Mobile Networks	Wireless World Research Forum (WWRF) #41	Herning, Denmark
2018.10.10	M. Fallgren	Cellular V2X, and Introduction	Global5G.org Webinar: How 5G Can Support Transformation in the Automotive Industry	Web
2018.09.25	T. Mahmoodi	Autonomous Driving Empowered by Connectivity	5G Automotive Forum, 25th – 27th September 2018	Berlin, Germany
2018.09.25	T. Svensson	Integrated Moving Networks – Mutual Opportunities for Connected	5G Automotive Forum, 25th – 27th September 2018	Berlin, Germany

		Vehicles and Mobile Networks		
2018.09.25	G. Vivier	Connected Objects: From IoT to Automotive, a Chipmaker Perspective	5G Automotive Forum, 25th – 27th September 2018	Berlin, Germany
2018.09.07	M. Condoluci	5GCAR: Objectives, Technology Components and Enablers	IEEE PIMRC – International workshop on V2X communications and channel modeling	Bologna, Italy
2018.08.17	T. Svensson	Integrated Moving Networks – Mutual Opportunities for Connected Vehicles and Mobile Networks	IEEE-CIC ICCC'2018	Beijing, China
2018.07.09	T. Svensson	Integrated Moving Networks – Mutual Opportunities for Connected Vehicles and Mobile Networks	IEEE 5G World Forum 2018	Santa Clara, USA
2018.06.21	M. Muehleisen	Vision of Connected Autonomous Driving: Telecom perspective	27th European Conference on Networks and Communications, EuCNC 2018	Ljubljana, Slovenia
2018.06.21	M. Nilsson	Vision of Connected Autonomous Driving: Automotive perspective	27th European Conference on Networks and Communications, EuCNC 2018	Ljubljana, Slovenia
2018.06.21	T. Svensson	Vision of Connected Autonomous Driving: Academia perspective	27th European Conference on Networks and Communications, EuCNC 2018	Ljubljana, Slovenia
2018.06.19	A. Mueller	5G in Manufacturing	27th European Conference on Networks and Communications, EuCNC 2018	Ljubljana, Slovenia
2018.06.19	M. Nilsson	5G for Verticals: Evolving Requirements, deployment challenges and Business Cases	27th European Conference on Networks and Communications, EuCNC 2018	Ljubljana, Slovenia

2018.06.19	M. Fallgren	5G for Verticals: Evolving Requirements, deployment challenges and Business Cases	27th European Conference on Networks and Communications, EuCNC 2018	Ljubljana, Slovenia
2018.06.19	Z. Li	5G for Verticals: Looking beyond the horizon	27th European Conference on Networks and Communications, EuCNC 2018	Ljubljana, Slovenia
2018.06.19	M. Dillinger	5G for Verticals: Evolving Requirements, Deployment, Challenges and Business Cases	27th European Conference on Networks and Communications, EuCNC 2018	Ljubljana, Slovenia
2018.06.18	E. Ström	Keynote 2: Wireless Channel Models for 5G Verticals	27th European Conference on Networks and Communications, EuCNC 2018	Ljubljana, Slovenia
2018.06.18	M. Fallgren	5GCAR: 5G for V2X	27th European Conference on Networks and Communications, EuCNC 2018	Ljubljana, Slovenia
2018.06.18	M. Fallgren	5G Automotive WG: 5G V2X Deployment	27th European Conference on Networks and Communications, EuCNC 2018	Ljubljana, Slovenia
2018.06.12	E. Katranaras	Ultra-Reliable Low Latency Communication for V2X, Standardization Perspective	5G V2X Communications Summer School, 11-12 June	London, UK
2018.06.12	A. Kousaridas	Multi-RAT, Multi-Link, Multi-operator Communications	5G V2X Communications Summer School, 11-12 June	London, UK
2018.06.12	G. Destino	5G Positioning for Connected Cars	5G V2X Communications Summer School, 11-12 June	London, UK
2018.06.12	S. Mandelli	Bayesian Tracking of Road Users Position and Collision Prediction	5G V2X Communications Summer School, 11-12 June	London, UK
2018.06.12	M. Condoluci	QoS in 5G: Enhancements for Connected Cars	5G V2X Communications Summer School, 11-12 June	London, UK

2018.06.12	K. Manolakis	5G enablers for Enhanced Reliability and Low Latency in V2X Communications	5G V2X Communications Summer School, 11-12 June	London, UK
2018.06.12	T. Abbas	V2X Wireless Channel Modelling for Connected Cars	5G V2X Communications Summer School, 11-12 June	London, UK
2018.06.12	K. Manolakis	Deployment of 5G V2X and Techno-Economic Aspects	5G V2X Communications Summer School, 11-12 June	London, UK
2018.06.12	M. Fallgren	Introduction to 5GCAR, and the Role of 5G in Automotive Industry	5G V2X Communications Summer School, 11-12 June	London, UK
2018.06.11	T. Svensson	Principles of V2X Radio Interface Design	5G V2X Communications Summer School, 11-12 June	London, UK
2018.06.07	M. Fallgren	On Selected V2X Technology Components and Enablers from the 5GCAR Project	13th IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB)	Valencia, Spain
2018.04.13	T. Svensson	Integrated Moving Networks – Mutual Opportunities for Connected Vehicles and Mobile Networks	Vehicle Electronics and Connected Services (VECS) 2018	Gothenburg, Sweden
2018.03.07	Y. Zang	5GCAR	Invited speaker at 9th ETSI ITS Workshop, 6-8 March 2018	Berlin, Germany
2018.03.06	T. Mahmoodi	What we really can do with 5G ultra-low latency	IEEE 5G Summit	Trento
2018.02.28	M. Fallgren	5GCAR	Speaker at the Mobile World Capital in Mobile World Congress, 26 February to 1 March 2018	Barcelona, Spain
2017.12.12	M. Fallgren	H2020 5G PPP Phase 2 Project 5GCAR	Invited speaker at Automated Road Transports cluster meeting	Brussels

2017.12.12	T. Abbas	H2020 5GCAR Project: Objectives, Methodology and R&I Activities	IEEE VTS Workshop on Wireless Vehicular Communications	Halmstad
2017.12.08	M. Fallgren	5G Connected Vehicles	Invited workshop keynote speaker in ET5GB at IEEE GLOBECOM, 4-8 December 2017	Singapore
2017.11.14	A. Servel	Vertical spotlight – highlighting the requirements of the automotive industry	Invited keynote speaker at Ultra Reliable Low Latency Communications (URLLC) 2017 Conference Summary, 14 November 2018	London, UK
2017.11.09	T. Abbas	5G connected cars for sustainable society	International conference on technological innovation and sustainable society	Vilnius
2017.11.01	T. Svensson	Integrated Moving Networks	Invited speaker at Beijing University of Posts and Telecommunications (BUPT), High-Performance Computing and Networking Laboratory	Beijing
2017.10.30	T. Svensson	Integrated Moving Networks	Invited speaker at Beijing University of Posts and Telecommunications (BUPT), Wireless Technology Innovation Institute	Beijing
2017.10.26	T. Svensson	Integrated Moving Networks	Invited speaker at Tsinghua University	Beijing
2017.10.18	A. Laya	5G and the transformation of the automotive ecosystem	Invited speaker at Wireless World Research Forum (WWRF) Meeting 39, 18-20 October 2017	Castelldefels, Spain
2017.10.18	R. Vilalta	Fog computing and the connected car	Invited speaker at Wireless World Research Forum (WWRF) Meeting 39, 18-20 October 2017	Castelldefels, Spain
2017.10.18	T. Svensson	Integrated Moving Networks	Invited speaker at Wireless World Research Forum	Castelldefels, Spain

			(WWRF) Meeting 39, 18-20 October 2017	
2017.10.18	M. Boban and T. Abbas	V2X channel measurements and modeling	Invited speaker at Wireless World Research Forum (WWRF) Meeting 39, 18-20 October 2017	Castelldefels, Spain
2017.10.18	M. Fallgren	The 5GCAR Project	Invited speaker at Wireless World Research Forum (WWRF) Meeting 39, 18-20 October 2017	Castelldefels, Spain
2017.10.18	M. Fallgren	On 5G Connected Cars	Invited keynote speaker at Elastic Networks organizes a series of free tutorials on 5G topics	Castelldefels, Spain
2017.10.09	T. Mahmoodi	Shaving the Milliseconds of Communication and Networking Protocols	Invited speaker at IEEE 5G Summit	Montreal, Canada
2017.07.12	T. Abbas	5G connected cars - From myth to reality	Invited speaker at China-EU Workshop	Brussels, Belgium
2017.07.12	M. Fallgren	The 5G Infrastructure Public-Private Partnership: 5G and Connected Car in EU	Invited speaker at China-EU Workshop	Brussels, Belgium
2017.06.14	M. Fallgren	5G PPP: Introduction of Phase 2 - 5GCAR	Invited speaker at 5G PPP session in European Conference on Networks and Communications (EuCNC), 12-15 June 2017	Oulu, Finland
2017.06.14	M. Fallgren, M. Dillinger, A. Servel, Z. Li, B. Villeforceix, T. Abbas, N. Brahmi, P. Cuer, T. Svensson, F. Sanchez, J. Alonso-Zarate, T. Mahmoodi, G. Vivier, M. Narroschke	On the Fifth Generation Communication Automotive Research and Innovation Project5GCAR	Poster Session 2 in European Conference on Networks and Communications (EuCNC), 12-15 June 2017	Oulu, Finland

2017.06.01	M. Fallgren	Fifth Generation Communication Automotive Research and innovation	Invited speaker at Phase 2 introduction day	Brussels, Belgium

A.6 Panels

5GCAR panels from June 2017 to July 2019 are collected here.

Date	Panelist, or Moderator	Title	Event	Location
2019.06.18	T. Mahmoodi as moderator	Workshop 4: 2nd 5G in the Era of Connected Cars	28th European Conference on Networks and Communications, EuCNC 2019, 18-21 June	Valencia
2019.06.18	M. Fallgren as panelist	Workshop 4: 2nd 5G in the Era of Connected Cars	28th European Conference on Networks and Communications, EuCNC 2019, 18-21 June	Valencia
2019.06.18	M. Fallgren as panelist	Session 3: 5G for Business	The 7th Global 5G Event	Valencia
2019.04.11	M. Fallgren as panelist	Session: Making the Conneciton	Smart Transportation and Mobility conference, London, UK, 10-11 April 2019	London
2019.04.03	M. Fallgren as panelist	Breakout Session 9: Large scale testing in Europe	Connected and Automated Driving, EUCAD 2019	Brussels
2018.09.25	T. Svensson as panelist	Addressing Cyber-Security Issues for 5G in the Automotive Industry	5G Automotive Forum, 25th – 27th September 2018	Berlin, Germany
2018.08.29	M. Fallgren as panelist	Advanced Connectivity for Cooperative Mobility	15th International Symposium on Wireless Communication Systems (ISWCS)	Lisbon

2018.08.21	T. Mahmoodi as moderator	Reality check for Connected Autonomous Driving	27th European Conference on Networks and Communications, EuCNC 2018	Ljubljana, Slovenia
2018.08.21	M. Muehleisen as panelist	Reality check for Connected Autonomous Driving	27th European Conference on Networks and Communications, EuCNC 2018	Ljubljana, Slovenia
2018.08.21	M. Nilsson as panelist	Reality check for Connected Autonomous Driving	27th European Conference on Networks and Communications, EuCNC 2018	Ljubljana, Slovenia
2018.08.21	M. Dillinger as panelist	Reality check for Connected Autonomous Driving	27th European Conference on Networks and Communications, EuCNC 2018	Ljubljana, Slovenia
2018.06.21	T. Svensson as panelist	Reality check for Connected Autonomous Driving	27th European Conference on Networks and Communications, EuCNC 2018	Ljubljana, Slovenia
2018.06.19	M. Dillinger as moderator	5G for Verticals: Evolving Requirements, deployment challenges and Business Cases	27th European Conference on Networks and Communications, EuCNC 2018	Ljubljana, Slovenia
2018.06.19	Z. Li as panelist	5G for Verticals: Evolving Requirements, deployment challenges and Business Cases	27th European Conference on Networks and Communications, EuCNC 2018	Ljubljana, Slovenia
2018.06.19	M. Fallgren as panelist	5G for Verticals: Evolving Requirements, deployment challenges and Business Cases	27th European Conference on Networks and Communications, EuCNC 2018	Ljubljana, Slovenia
2018.06.19	M. Nilsson as panelist	5G for Verticals: Evolving Requirements,	27th European Conference on	Ljubljana, Slovenia

		deployment challenges and Business Cases	Networks and Communications, EuCNC 2018	
2018.06.19	A. Mueller as panelist	5G for Verticals: Evolving Requirements, deployment challenges and Business Cases	27th European Conference on Networks and Communications, EuCNC 2018	Ljubljana, Slovenia
2018.06.18	T. Svensson as moderator	Panel 2 – Impact of 5G on Verticals	27th European Conference on Networks and Communications, EuCNC 2018	Ljubljana, Slovenia
2018.06.07	M. Fallgren as moderator	V2X Workshop: Panel session on V2X	13th IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB)	Valencia
2018.04.20	M. Fallgren as panelist	Connectivity	Interactive Symposium on Research & Innovation for Connected and Automated Driving in Europe (EUCAD), 19-20 April 2018	Vienna
2018.04.17	M. Fallgren as panelist	New Perspectives on Wireless Communications and Networking for Industrial Automation	IEEE Wireless Communications and Networking Conference (WCNC), 15-18 April 2018	Barcelona
2018.04.17	M. Dillinger as moderator	5G and Verticals - The Connected and Automated Driving (CAD) Case	IEEE Wireless Communications and Networking Conference (WCNC), 15-18 April 2018	Barcelona
2018.04.17	M. Fallgren as panelist	5G and Verticals - The Connected and Automated Driving (CAD) Case	IEEE Wireless Communications and Networking	Barcelona

			Conference (WCNC), 15-18 April 2018	
2018.04.17	T. Abbas as panelist	5G and Verticals - The Connected and Automated Driving (CAD) Case	IEEE Wireless Communications and Networking Conference (WCNC), 15-18 April 2018	Barcelona
2017.11.06	M. Fallgren as panelist	5G: Rolling Out the Network for True Connectivity	TU-Automotive Europe, 6-7 November 2017	Munich
2017.10.18	R. Vilalta as moderator	5G Connected Car: Discussion panel	Wireless World Research Forum (WWRF) Meeting 39, 18-20 October 2017	Castelldefels
2017.10.18	M. Fallgren as panelist	5G Connected Car: Discussion panel	Wireless World Research Forum (WWRF) Meeting 39, 18-20 October 2017	Castelldefels
2017.10.18	T. Abbas as panelist	5G Connected Car: Discussion panel	Wireless World Research Forum (WWRF) Meeting 39, 18-20 October 2017	Castelldefels
2017.10.18	M. Boban as panelist	5G Connected Car: Discussion panel	Wireless World Research Forum (WWRF) Meeting 39, 18-20 October 2017	Castelldefels
2017.10.18	T. Svensson as panelist	5G Connected Car: Discussion panel	Wireless World Research Forum (WWRF) Meeting 39, 18-20 October 2017	Castelldefels
2017.10.18	A. Laya as panelist	5G Connected Car: Discussion panel	Wireless World Research Forum (WWRF) Meeting 39, 18-20 October 2017	Castelldefels

A.6.1   2018-06 Panel at EuCNC

In the 27th European Conference on Networks and Communications (EuCNC), 18-21 June 2018, 5GCAR is organizing the Panel on 5G for Verticals: Evolving Requirements, deployment challenges and Business Cases.

Date	19 June 2018
Location	Ljubljana, Slovenia
Website	https://www.eucnc.eu/2018/www.eucnc.eu/panels-1/index.html
Organization committee	Markus Dillinger
Contributions	Chair: Markus Dillinger. Panelists from 5GCAR: Zexian Li, Mikael Fallgren, Mikael Nilsson. Other panelists: Andreas Mueller, Bo Andersson
Scope	Vertical industries like Automation Industry and Car Industry are expected to be the major topics in coming years for 5G networks. However, requirements are still evolving and sustainable business models and cases are still to be developed. An important ingredient are spectrum requirements for verticals in terms of licensed or unlicensed spectrum and the targeted amount of bandwidth. Cooperation models and business cases between involved stakeholders need to be created and monetized. Moreover, to jointly identify standardization requirements roadmaps for 3GPP, ETSI, SAE, etc. and certification challenges is key in coming years. The panelist from verticals (e.g. car industry), telecom industry and academia will elaborate on business, technical and regulatory challenges to help identify the barriers for a potential market introduction. **Questions** 1. What are the potential business cases and roles for 5G vertical stakeholders? 2. What is the role between public and private 5G networks? 3. What is the business model for service providers (e.g. drones, connected and autonomous driving, etc.)? 4. What are the spectrum licensing options and spectrum usage models for verticals? 5. What role and timeframe do you see for communication technologies and 5G to impact vertical business?

A.6.2   2018-04 Panel in WCNC

In the IEEE Wireless Communications and Networking Conference (WCNC), 15-18 April 2018, 5GCAR organized the "5G and Verticals: The Connected and Automated Driving (CAD) Case" panel.

Date	17 April 2018
Location	Barcelona, Spain

Website	http://wcnc2018.ieee-wcnc.org/program/panels#p3
Organization committee	Markus Dillinger
Contributions	5GCAR Panelists: Taimoor Abbas, Mikael Fallgren, Jesus Alonso
	Other Panelists: Xavier Costa, Andreas Kwoczek
Scope	5G V2X will provide the long awaited service level agreements and features for mobile networks and the so-called vertical industry will strongly benefit from these new capabilities. In particular the automotive industry is on a path where vehicles are continuously becoming more aware of their environment, due to a permanent increase in various types of integrated sensors, machine learning or should be say advances in artificial intelligence and an increasingly intelligent network and road infrastructure.
	Autonomous-driving is already here and in its maturing phase. As a consequence, the significance and reliance on capable communication systems for vehicle-to-anything (5G-V2X) communication is becoming a key asset with new requirements on traffic safety. This, combined with sensor-based technologies will enhance the performance of automated driving and increase further traffic safety. Ever changing situations — traffic and weather conditions.
	The truly intelligent, fully connected car will require a massive amount of computing power and super-high-speed communications systems such as 5G V2X.
	Whereas, the mobile communications industry is striving towards targeting communication needs of vertical industry with corresponding requirements being set for the standardization of 5G V2X until 2020 (3GPP Rel16 completed) with large commercial launches around 2025. The size and potential impact of the automotive revolution requires more than gut feeling to drive the right decisions for a successful mobility strategy. Only a good understanding of the potential outcomes and a data-driven mind-set can enable actors to adjust to the full impact of the disruption on their business. Therefore, navigating what's ahead will require a long-term vision with developing connectivity platforms, creating in-vehicle-services ecosystems, or even unique car features with respect to applications, data, and media besides efficiently support a wide range of 5G V2X services and business models.
	This panel will discuss how the Automotive Industry can best benefit from 5G V2X that is flexible in its functional and topological configuration. What are the missing components, where more research and innovative solutions would be appreciated. As well as,

| | what are the actions required consisting primarily of accompanying measures such as Industry forums solutions, standardization or policy and the time lines for execution.

Connected and Autonomous Driving supported by radio technologies is one of the most challenging market and research fields today. To jointly identify standardization requirements for 3GPP, ETSI, SAE, etc. and certification challenges is key in next 1-2 years. In addition, spectrum usage modalities between car and classical telecom industry will be a prerequisite to implement CAD in coming years. The panelist from car, telecom industry and academia will elaborate on technical and regulatory challenges to help identify the barriers for a smooth market introduction. |
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A.7 Lectures and training events

5GCAR schools and training events from June 2017 to July 2019 are collected here.

A.7.1 2019-06 5G V2X Summer School

5GCAR organized a summer school session in the IEEE Swedish Communication Technologies Workshop (Swe-CTW) 2019 which included a tutorial in 5G Cellular-V2X communications.

Date	11 June 2019
Venue	Lund, Sweden
Website	http://sites.ieee.org/swe-ctw/files/2019/06/20190611-5GCAR-Summer-School-5GCAR-Presentation_public.pdf
Presenter	Tommy Svensson (CHALMERS & 5GCAR member)
Contributors	Tommy Svensson (CHALMERS & 5GCAR member), Mikael Fallgren (Ericsson & 5GCAR member), Antonio Eduardo Fernandez Barciela (PSA Group & 5GCAR member), Zexian Li (Nokia & 5GCAR member), Laurent Gallo (Orange Labs & 5GCAR member), Toktam Mahmoodi (KCL & 5GCAR member), Bastian Cellarius (Ericsson & 5GCAR member)
Participation	Approximately 30 participants
Scope	This tutorial was an introduction to 5G cellular V2X (Vehicle-to-Everything), and elaborated on key use cases, requirements and technical enablers with a special focus on the research outcomes from the EU H2020 5G PPP 5GCAR project.

A.7.2   2019-05 Integrated Moving Networks Lecture

Partly based on 5GCAR results, a lecture was given on Introduction to 5G - Part 2: Integrated Moving Networks at CHALMERS within the Master of Science course SSY150 Multimedia and Video Communications in 7 May 2019.

Event	Lecture in Master of Science course SSY150 Multimedia and Video Communications
Date	7 May 2019
Location	Gothenburg, Sweden
Organization Team	Chalmers University of Technology
Presenter	Tommy Svensson (CHALMERS & 5GCAR member)
Participation	The course is open to all eligible students at CHALMERS
Title	Introduction to 5G - Part 2: Integrated Moving Networks

A.7.3   2019-04 Integrated Moving Networks Lecture

Partly based on 5GCAR results, a lecture was given on Integrated Moving Networks at CHALMERS within the Master of Science course SSY145 Wireless Networks in 15 April 2019.

Event	Lecture in Master of Science course SSY145 Wireless Networks
Date	15 April 2019
Location	Gothenburg, Sweden
Organization Team	Chalmers University of Technology
Presenter	Tommy Svensson (CHALMERS & 5GCAR member)
Participation	The course is open to all eligible students at CHALMERS
Title	Integrated Moving Networks

A.7.4   2018-11 Connected Cars Towards Autonomous Driving School

5GCAR organized a connected cars towards autonomous driving school at the Vilnius Design and Technical College (VDTK), 6-17 November 2018.

Event	Short Course
Date	6-17 November 2018
Location	Vilnius, Lithuanian
Organization Team	Vilnius Design and Technical College (VDTK)

Presenter	Taimoor Abbas (Volvo Cars & 5GCAR member)
Participation	Open to all students at VDTK college
Title	Connected Cars Towards Autonomous Driving

A.7.5   2018-11 Integrated Moving Networks Lecture

5GCAR was invited to present a lecture on Integrated Moving Networks organized by Linköping University, Campus Norrköping on 30 November 2018.

Event	Short Course
Date	30 November 2018
Location	Norrköping, Sweden
Organization Team	Linköping University, Campus Norrköping
Presenter	Tommy Svensson (CHALMERS & 5GCAR member)
Participation	Open to all students at Linköping University, Campus Norrköping
Title	Integrated Moving Networks – Mutual Opportunities for Connected Vehicles and Mobile Networks

A.7.6   2018-06 5G V2X Summer School

5GCAR organized a two-day summer school dedicated to 5G V2X communications. The first day provided detailed academic advances in the 5G V2X and the second day focused more on applied and industry 5GCAR solutions and visions.

Date	11-12 June 2018
Venue	London
Website	https://nms.kcl.ac.uk/toktam.mahmoodi/v2x-summer-school/index.htm
Organization Team	Toktam Mahmoodi, Luis Sequeira, Giuseppe Destino, Jingjing Zhang (KCL & 5GCAR members).
Contributions	Presenters: Taimoor Abbas (Volvo & 5GCAR member), Stefano Buzzi (Univ. of Cassino), Massimo Condoluci (Ericsson & 5GCAR member), Mikael Fallgren (Ericsson & 5GCAR member), Vasilis Friderikos (KCL), Efstathios Katranaras (Sequans & 5GCAR member), Apostolos Kousaridas (Huawei & 5GCAR member), Konstantinos Manolakis (Huawei & 5GCAR member), Sylvio Mandelli (Nokia Bell-Labs), Petar Popovski (Aalborg Univ.), Gonzalo Seco-Granados (Univ. Autonoma of Barcelona), Malte Schellmann (Huawei), Osvaldo Simeone (KCL), Tommy Svensson (CHALMERS & member of 5GCAR)

Participation	Open to all with free registration, 200+ registered, and ~140 participants.
Scope	V2X communications, URLLC, Machine Learning, NFV, Positioning, Techno-economics

A.7.7 2017-10/11 Integrated Moving Networks Lecture

5GCAR was invited to present a lecture on Integrated Moving Networks organized by the High-Performance Computing and Networking Laboratory and Wireless Technology Innovations Institute of Beijing University of Posts and Telecommunications (BUPT) in 30 October 2017 and 1 November 2017, respectively.

Event	Short Course
Date	30 October 2017 and 1 November 2017
Location	Beijing, China
Organization Team	Beijing University of Posts and Telecommunications (BUPT)
Presenter	Tommy Svensson (CHALMERS & 5GCAR member)
Participation	Open to all students at BUPT
Title	Integrated Moving Networks

A.7.8 2017-10 Integrated Moving Networks Lecture

5GCAR was invited to present a lecture on Integrated Moving Networks organized by the Network Integration for Ubiquitous Linkage and Broadband lab (NIULAB) of Tsinghua University in 26 October 2017.

Event	Short Course
Date	26 October 2017
Location	Beijing, China
Organization Team	Tsinghua University
Presenter	Tommy Svensson (CHALMERS & 5GCAR member)
Participation	Open to all students at Tsinghua University
Title	Integrated Moving Networks

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A.8   References to the Project

The 5GCAR related press releases together with some press references to 5GCAR for the whole project duration are presented in this Annex.

A.8.1   5GCAR second press releases

The second 5GCAR press release [5GC19-press] was made publicly available on 27 June 2019 to announce the 5GCAR Final Demonstration event and included a description of the as well as the purpose, benefits and impact of the project partner contributions.

Other press releases on 5GCAR that have been made by partners within the consortium, are:

2019-07-01, Ericsson Research tweet,
https://twitter.com/EricssonLabs/status/1144135794778677254

2019-07-01, Nokia Bell Labs Facebook post
https://www.facebook.com/belllabs/posts/2284318221816647

A.8.2   5GCAR first press releases

The first 5GCAR project press release [5GC17-press] was made publicly available on 17 October 2017 and marked the release of the 5GCAR use cases in [5GC19-D21] which was made publicly available at the same time.

Other press releases on 5GCAR that has been made by partners within the consortium, are:

2018-03-23, CTAG: "Meeting at CTAG on 5GCAR: Fifth Generation Communication Automotive Research and innovation project" http://ctag.com/en/reunion-en-ctag-del-proyecto-5gcar-fifth-generation-communication-automotive-research-and-innovation/

2018-03-22, Orange: "Network slicing: 'Innovation 5G connectivity for connected vehicles'" https://hellofuture.orange.com/en/network-slicing-innovative-5g-connectivity-connected-vehicles/

2018-02-23, CTTC: "5G Technology for the Connected Car: CTTC researchers Demonstrate the 5GCAR Research Project at the 2018 Mobile World Congress in Barcelona" http://www.cttc.es/5g-technology-for-the-connected-car-cttc-researchers-demonstrate-the-5gcar-research-project-at-the-2018-mobile-world-congress-in-barcelona/

2017-09-12, CHALMERS: "The project that sets the standard for 5G in vehicles" https://www.chalmers.se/en/departments/e2/news/Pages/The-project-that-sets-the-standard-for-5G-in-vehicles.aspx

2017-06-07, Ericsson Press Release, "Ericsson leads European 5GCAR project" http://mb.cision.com/Main/15448/2293682/691493.pdf

https://www.ericsson.com/en/press-releases/2017/6/ericsson-leads-european-5gcar-project

A.8.3   Other references to the project

In this section we list references to 5GCAR that is coming from outside the project consortium.

2019-07-01,ViPress.net: "L'initiative européenne 5GCAR en démonstration à Linas-Monthléry" https://www.vipress.net/linitiative-europeenne-5gcar-en-demonstration-a-linas-monthlery/

2019-07-01, ELECTRONIQUES: "Communications sans fil à bord des véhicules : la démonstration du projet 5GCAR a eu lieu à Montlhéry" http://www.electroniques.biz/index.php/economie/vie-de-la-profession/item/65207-communications-sans-fil-a-bord-des-vehicules-la-demonstration-du-projet-5gcar-a-eu-lieu-a-montlhery

2019-06-27, 5GAA CTO tweet https://twitter.com/maximeflament/status/1144146039877832704

2018-05-17, European Commission: "COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE, THE COMMITTEE OF THE REGIONS" https://ec.europa.eu/transport/sites/transport/files/3rd-mobility-pack/com20180283_en.pdf

2018-03-08, 5G PPP, "5G – THE megatrend at the MWC 2018" https://5g-ppp.eu/5g-the-megatrend-at-the-mwc-2018/

2017-09-26, Ny Teknik: https://www.nyteknik.se/digitalisering/chalmers-ar-med-och-satter-standarden-for-5g-i-fordon-6873672

2017-09-14, Science Business: "5GCAR project to set the standard for 5G in vehicles" https://sciencebusiness.net/network-news/5gcar-project-set-standard-5g-vehicles

2017-09-14, SAMENA Daily: "5GCAR project to set the standard for 5G in vehicles" https://samenacouncil.org/samena_daily_news?news=64326

September 2017, GSMA: "SAFER AND SMARTER DRIVING: The Rollout of Cellular V2X Services in Europe" https://www.gsma.com/iot/wp-content/uploads/2017/09/GSMA-position-on-C-V2X-in-Europe_Final.pdf

2017-06-20, Above Ground Level (agl) Media Group, "Ericsson leads European 5GCAR Project" https://www.aglmediagroup.com/ericsson-leads-european-5gcar-project/

2017-06-12, Digital Terminal (DT), "Ericsson Leads European 5GCAR Project" http://digitalterminal.in/news/ericsson-leads-european-5gcar-project/9807.html

2017-06-12, FierceWireless: "Ericsson-led 5GCAR project gets EU funding" https://www.fiercewireless.com/wireless/ericsson-led-5gcar-project-gets-eu-funding

2017-06-09, Auto connected car news: "5GCAR Project will develop 5G optimized for V2X" http://www.autoconnectedcar.com/2017/06/5gcar-project-will-develop-5g-optimized-for-v2x/

2017-06-09, Telematics wire: "Ericsson led consortium awarded 5GCAR project"

http://www.telematicswire.net/connected-vehicles-with-internet-access-or-wireless-local-area-network-lte/ericsson-led-consortium-awarded-5gcar-project/

2017-06-09, Thestack: "Ericsson 5GCAR project wins EU funding" https://techerati.com/the-stack-archive/iot/2017/06/09/ericsson-5gcar-project-wins-eu-funding/

2017-06-08, Emergent Tech: "Ericsson leads 5G connected car gang towards pot of EU gold" http://telematicswire.net/tag/5gcar/

2017-06-08, Enterprise iot insights: "Ericsson 5GCAR project wins EU funding" https://enterpriseiotinsights.com/20170608/news/ericsson-5gcar-project-wins-eu-funding-tag4

2017-06-07, DQChannels: "Ericsson LEADs European 5GCAR PROJECT" https://www.bnamericas.com/en/news/ict/ericsson-leads-5gcar-project/

2017-06-07, BNamericas: "Ericsson leads 5GCAR project" https://www.bnamericas.com/en/news/ict/ericsson-leads-5gcar-project/

2017-06-07, Telecoms.com: "Ericsson gets green light for connected car initiative" https://samenacouncil.org/samena_daily_news?news=64326

2017-06-07, Evertiq: "Ericsson leads European 5GCAR project" https://evertiq.com/design/41817

2017-06-07, Telecomstechnews: "Ericsson takes pole position on 5GCAR project" https://www.telecomstechnews.com/news/2017/jun/07/ericsson-takes-pole-position-5gcar-project/

2017-06-07, Globenewswire: "Ericsson leads European 5GCAR project" https://www.globenewswire.com/news-release/2017/06/07/1009182/0/en/Ericsson-leads-European-5GCAR-project.html

http://inpublic.globenewswire.com/2017/06/07/Ericsson+leads+European+5GCAR+project+HUG2111074.html

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B Standardization activities

The 5GCAR standardization activities for the whole duration of the project are collected here.

Tdoc number	Meeting	Agenda item	Company	Title	5GCAR Technology Component
RAN WG1 – radio layer 1					
R1-1900025	RAN1# AH_1901	7.2.4.1.3	Huawei, HiSilicon	Sidelink synchronization mechanisms for NR V2X	Synchronization for the V2V Sidelink: Sequences and Algorithms [5GC19-D33, Section 3.3.1]
R1-1901539	RAN1 #96	7.2.4.1.3	Huawei, HiSilicon	Sidelink synchronization mechanisms for NR V2X	Synchronization for the V2V Sidelink: Sequences and Algorithms [5GC19-D33, Section 3.3.1]
R1-1903163	RAN1 #96	7.2.4.1.1	Ericsson	Remaining details on physical structure for NR SL	Reference signals design for direct V2X communication [5GC19-D33, Section 3.3.2]
R1-1903175	RAN1 #96	7.2.4.1.5	Ericsson	Details on CSIT acquisition for SL unicast	Reference signals design for direct V2X communication [5GC19-D33, Section 3.3.2]
R1-1901228	RAN1# AH_1901	7.2.4.1.5	Ericsson	Link level evaluations of NR PSSCH	Reference signals design for direct V2X communication [5GC19-D33, Section 3.3.2]
R1-1907134	RAN1 #97	7.2.4.1	Ericsson	PHY layer structure for NR sidelink	Reference signals design for direct V2X communication [5GC19-D33, Section 3.3.2]
R1-1907149	RAN1 #97	7.2.4.8	Ericsson	On data–DMRS collision for SL	Reference signals design for direct V2X communication

					[5GC19-D33, Section 3.3.2]
R1-1811029	RAN1 #94b	7.2.10.3	Nokia, Nokia Shanghai Bell	Potential techniques for NR positioning	Trajectory Prediction with Channel Bias Compensation and Tracking [5GC19-D33, Section 3.6.1]
R1-1813143	RAN1 #95	7.2.10.3	Nokia, Nokia Shanghai Bell	RAT-dependent techniques for NR Positioning	Trajectory Prediction with Channel Bias Compensation and Tracking [5GC19-D33, Section 3.6.1]
R1-1901022	RAN1# AH-1901	7.2.10.1.1	Nokia, Nokia Shanghai Bell	Potential Positioning Techniques - DL based solutions	Trajectory Prediction with Channel Bias Compensation and Tracking [5GC19-D33, Section 3.6.1]
R1-1901847	RAN1 #96	7.2.10.1.1	Nokia, Nokia Shanghai Bell	DL based NR positioning	Trajectory Prediction with Channel Bias Compensation and Tracking [5GC19-D33, Section 3.6.1]
R1-1905262	RAN1 #96b	7.2.10.1	Nokia, Nokia Shanghai Bell	Views on DL and UL reference signals for NR Positioning	Trajectory Prediction with Channel Bias Compensation and Tracking [5GC19-D33, Section 3.6.1]
R1-1906658	RAN1 #97	7.2.10.1	Nokia, Nokia Shanghai Bell	Views on DL reference signals for NR Positioning	Trajectory Prediction with Channel Bias Compensation and Tracking [5GC19-D33, Section 3.6.1]
R1-1805914	RAN1 #93	7.5.2	Huawei, HiSilicon	V2X sidelink channel model	Channel modeling [5GC18-D32]
R1-1804298	RAN1 #92b	7,9	Huawei, HiSilicon	V2X sidelink measurement results	Channel modeling [5GC18-D32]
R1-1803671	RAN1 #92b	7,9	Huawei, HiSilicon	V2X sidelink channel model	Channel modeling [5GC18-D32]
R1-1802720	RAN1 #92	7,7	Huawei, HiSilicon	V2X path loss and shadowing	Channel modeling [5GC18-D32]

R1-1802721	RAN1 #92	7,7	Huawei, HiSilicon	V2X fast fading model	Channel modeling [5GC18-D32]
R1-1801398	RAN1 #92	7,7	Huawei, HiSilicon	V2X sidelink measurement results	Channel modeling [5GC18-D32]
R1-1808973	RAN1 #94	7.2.6.4	Sequans	Enhancements for eMBB/URLLC multiplexing in DL	Efficient Preemption-based Multiplexing of Services [5GC19-D33, Section 3.2.1]
R1-1718708	RAN1 #90bis	7.3.3.3	Sequans	CBG A/N multiplexing for CA and cross-slot scheduling	Efficient Preemption-based Multiplexing of Services [5GC19-D33, Section 3.2.1]
R1-1806959	RAN1 #93	7.2.2	Sequans	On UL multiplexing between grant-based URLLC and eMBB	Efficient Preemption-based Multiplexing of Services [5GC19-D33, Section 3.2.1]
R1-1900683	RAN1# AH_1901	7.2.6.2	Sequans	Considerations on UL inter-UE multiplexing for URLLC	Efficient Preemption-based Multiplexing of Services [5GC19-D33, Section 3.2.1]
R1-1902129	RAN1 #96	7.2.6.2	Sequans	Considerations on UL inter-UE multiplexing for URLLC	Efficient Preemption-based Multiplexing of Services [5GC19-D33, Section 3.2.1]
R1-1806958	RAN1 #93	7.2.2	Sequans	On PDCCH repetition for NR URLLC	Enhancing Control Channel Reliability by Using Repetitions [5GC19-D33, Section 3.5.4]
RAN WG2 – Radio layer 2 and radio layer 3					
R2-1900606	RAN2#105	11.4.5	Nokia, Nokia Shanghai Bell	Mobility challenges for NR V2X platooning	RSU-enabled smart zone
R2-1904277	RAN2#105 bis	11.4.5	Nokia, Nokia Shanghai Bell	Mobility challenges for NR V2X groupcast/platooning	RSU-enabled smart zone

R2-1900604	RAN2#105	11.4.2.2	Nokia, Nokia Shanghai Bell	Validity area for NR Sidelink resource allocation in V2X communications	Fast application-aware setup of unicast SL
R2-1904275	RAN2#105 bis	11.4.3	Nokia, Nokia Shanghai Bell	Validity area for SL Mode 2 resource allocation in NR V2X	Fast application-aware setup of unicast SL
R2-1817681	RAN2#104	11.4.2.3	Nokia, Nokia Shanghai Bell	Discussion on Connection-based versus Connectionless NR Sidelink	Fast application-aware setup of unicast SL
R2-1817680	RAN2#104	11.4.2.4	Nokia, Nokia Shanghai Bell	NR Sidelink resource allocation for V2X communications	Fast application-aware setup of unicast SL
SA WG6 – Mission-critical applications					
S6-180782	SA6#24	10.2	Ericsson	New key issue on interaction between V2X application and 3GPP system for V2X application and QoS adaptation	V2X service negotiation
S6-181048	SA6#25	10.1 - FS_V2X APP	Ericsson GmbH, Eurolab	Solution proposal for key issue #13 communicating application requirements from the V2X application server	V2X service negotiation
S6-181154	SA6#25	10.1 - FS_V2X APP	Ericsson GmbH, Eurolab	Solution proposal for key issue #13 Communicating application requirements from the V2X application server	V2X service negotiation
S6-181229	SA6#25	10.1 - FS_V2X APP	Ericsson GmbH, Eurolab	Solution proposal for key issue #13 Communicating application requirements from the V2X application server	V2X service negotiation
S6-181352	SA6#26	9.7 - V2XAPP	Ericsson France S.A.S	Procedures for service negotiation	V2X service negotiation

S6-181501	SA6#26	9.7 - V2XAPP	Ericsson	Procedures for service negotiation	V2X service negotiation
S6-181556	SA6#26	9.7 - V2XAPP	Ericsson	Procedures for service negotiation	V2X service negotiation

ETSI TC ITS					
TR 103 257-1	ITS#34	ITSWG4#46	Huawei	V2X sidelink measurement results V2X sidelink channel model V2X path loss and shadowing V2X fast fading model	Channel modeling [5GC18-D32]
TR 103 300-1		ITSWG1#44	Nokia, Ericsson	Text Proposal Use Case Network assisted vulnerable pedestrian protection	N/A

C   Individual Exploitation of 5GCAR activities and results

The exploitation strategy is dependent to the participant's category, i.e., telecom infrastructure providers, mobile network operators, industrial equipment vendors, car manufacturers, small to medium sized enterprises, and academia. The partners will have the results of the 5GCAR project at their disposal for further research.

C.1   Telecom infrastructure providers

Telecom infrastructure providers involved in the 5GCAR project acknowledge the importance of 5G wireless communications in the future automotive industry and business landscape in Europe V2X communication and collaboration. In this context, the manufacturers need to have an influence on early harmonization and system specifications, in order to create the corresponding markets and address them with competitive products at the appropriate time.

C.1.1   Ericsson

For ERICSSON, the 5G V2X communication platform is one central component for realizing its networked society vision. The 5GCAR project has been crucial in terms of creating the required alignment among the involved industries from car manufacturers and their tier 1 suppliers over device and telecom infrastructure vendors to mobile network operators to form a common consensus regarding requirements and solutions.

ERICSSON will exploit technical solutions that has been developed in the project in various ways. Results and insights will be presented to the business units and will thereby have an impact on future product decisions that target the V2X use cases. Promising solutions have been contributed to relevant standardization bodies like 3GPP and ETSI-ITS, and has also been used in the context of pre-standardization forums like the 5G Automotive Association (5GAA), where ERICSSON is a founding member. The 5GCAR results will also help in regulatory discussions and decisions to ensure the availability of spectrum to operate critical V2X related services. Overall, we believe that the joined effort of the 5GCAR project partners have helped to speed up the market introduction of V2X services.

C.1.2   Huawei

HWDU is leading the European innovation activities of HUAWEI, the globally leading telecommunication vendor. HWDU is working to push innovation in 5G in Europe and to foster a quick market penetration of V2V, V2I and V2N applications. 5GCAR will facilitate to bring the different value-chain stakeholders to the same table and help them better explore this new market. We first benefit from an envelope of requirements and interworking that is new for the telecommunication industry. This will help us to enhance our existing product portfolio and even to create new products for different types of V2X communications. To this end, we aim at driving the required standardization activities in 3GPP and ETSI-ITS, as well as to pre-standardization

bodies such as the 5G Automotive Association (5GAA), where HUAWEI is one of the founding members. Early acceptance of new technology trends by the customers will be achieved by promoting these through Huawei's Customer Innovations Centers located in Germany, UK, France, Spain and Sweden. Our ultimate benefit from 5GCAR is to eventually deliver the essential communication modules and tools for device manufacturers, car industry and mobile network operators so that 5G V2X solutions becomes a reality in Europe first and then exported to the world.

C.1.3   Nokia

NOKIA intends to use the results from the 5GCAR project to influence and make recommendations to future product decisions related to V2X and/or positioning support, existing standardization organizations as well as global cross-industry pre-standardization associations, including at least 3GPP and 5GAA (5G Automotive Association). We have contributed the developed solutions to different groups in 3GPP, at least covering two Technical Specification Groups (TSGs): Radio Access Network (RAN) and TSG Service and System Aspects (SA). In addition, we have contributed the VRU protection use case to ETSI. Moreover, NOKIA is a founding member of 5GAA and we plan to contribute and collaborate within the association on technical, business and regulatory aspects towards the development and accelerated deployment of solutions for the automotive use cases. Such collaboration will also include the validation of the technical solutions through demonstrations, pilots and testbeds that will help provide guidance to NOKIA Business Units for the development and evolution of future products and services.

C.2   Telecom operator

Mobile network operator involved in 5GCAR recognize the potentials the automotive sector offers to expand their total service offering, thereby increasing their market size and growth rate. The need to enhance existing infrastructure or functions has also been identified in order to achieve V2X Services' QoS metrics.

C.2.1   Orange

ORANGE is willing to assess future 5G deployment scenarios and infrastructure investments and to build the rolling plan according to related business. ORANGE will first use 5G PPP Phase 2 research and innovation projects to design jointly relevant applications with vertical industries, to build European ecosystems around these applications and to demonstrate that a shared infrastructure can support several vertical applications in parallel. 5GCAR will be the place to benchmark and select technologies and architectures for future standards and infrastructure enablers. The 5GCAR project will also help ORANGE ensure that future network services will offer the best experience to our customers and will be sustainable (in terms of energy, costs and social issues) and operationally manageable. Orange is contributing to the WP6, being task leader for T6.2, for the dissemination of information relative to the standardization in ETSI TC ITS in 5GCAR project and potentially animate the liaison created between 5GCAR and ETSI TC ITS.

C.3 Car manufacturers

Car manufacturers in the 5GCAR consortium are interested in embedding both intelligence and communication components in vehicles. Vehicles that are smoothly collaborating with other vehicles or devices will enhance awareness and problem-solving functions for safety, automation and traffic efficiency, under very strict time/space performance requirements

C.3.1 PSA Group

PSA Group has been a pioneer in communicating cars. Since 2003, the Group has been renowned for its best-selling emergency call and automated assistance systems, which automatically call for help in case of an accident. To date, more than 1.8 million Peugeot, Citroën and DS vehicles have been equipped with this system. The PSA Group has a connectivity roadmap which consists of three key stages, namely: "Save Time" (2016), "Easy Life" (2016-2018), and "Enjoy Life" (2018-2020). Based on this roadmap, the Group will gradually introduce a series of technological solutions, such as remote services and Car-to-Car and Car-to-Infrastructure communications technology. In this set of solutions, the V2X communications are an enabler for the 5G are a crucial tool to get drive and emergency context awareness.

Continuous and integrated connectivity will pave the way for automated driving, a huge opportunity to improve road safety (nearly 90% of road accidents are caused by human error). PSA has defined three stages for its advanced driver assistance systems (ADAS) where the last Eyes-Off", is planned for 2020-2025. It includes remote parking capabilities and the advent of a fully automated, driverless vehicle ("Mind Off").

PSA projections see the European mobility market growing to more than €13.6 billion in 2020, from €7.7 billion in 2014, an explosion of over 56%. 1.7 million vehicles would be required to serve this market in 2020 (compared to 1.27 million in 2014) in G10 Europe, including 500,000 in the area of car-sharing alone (B2B business car-sharing and B2C urban car-pooling). For this the new business model which will be enabled by 5G will be studied in the project.

C.3.2 Volvo Car Corporation

Everything we do starts with people. Our mission is to make people's lives easier, safer and better is something that comes naturally to us. It's the Volvo Cars way. Volvo Cars focus always on innovation and world-leading safety technology. We aim to continue leading the global automotive industry in safety technology, electrification and autonomous drive and we continually challenge ourselves.

Cars should protect everyone, some people are less safe on the road than others. Through the E.V.A initiative at Volvo Cars, we are now sharing more than 40 years of safety research – to make cars safer for everyone. https://group.volvocars.com/company/safety-vision/research

Through Volvo On Call (launched 2001), we offer a connected technology that makes your life easier (control and convenience), deliveries direct to your car, remote climate control and in case

of emergency, the Volvo On Call assists with road assistance or emergency services. Today, Volvo Cars delivers connected safety through the cloud with functions such as slippery road and hazard alerts (presented 2015 at Mobile World Congress and introduced in 2016 on Volvo and available to Volvo drivers across Europe. Connected Safety come as standard on all new model year 2020 Volvo's.

Volvo Cars has been and is involved in various wireless research projects related to V2X communication, both on a national level (Swedish) and international level. The H2020 5GCAR project has been an important step towards enabling cooperative awareness. Investigation of new business models using 5G could improve customer experience and enable new business opportunities for our customers. The H2020 5GCAR project and the research with a high accuracy radio-based positioning system could be one key contribution to improve the positioning on vehicles and assist with identification of VRUs.

Volvo Cars engineers have been contributing in various work packages and feed in experience from previous wireless research projects and learn more on how to integrate the 5G technology with potential antenna designs into the vehicle and enable faster time to market.

C.4 Industrial equipment vendor

Industrial equipment vendor that participate in 5GCAR and provide V2X solutions recognize that the collaboration between the industrial equipment vendors, OEMs and telecom industry is crucial. The generation and ownership of intellectual property is essential to ensure profitability of the manufacturer's business, and at the same time, to provide incentives for competition through open platforms or cross-license agreements on fair and reasonable terms

C.4.1 Bosch

BOSCH has been regularly disseminating the results of the project within different business units focusing on connected and automated mobility (Car Multimedia, Engineering Connectivity Unit, Chassis Systems Control). The findings from the project will be used directly to make future product decisions and will speed up the adoption of the 5G technology for the automotive domain and strengthen the position of BOSCH as a world leading solution provider for automated and connected mobility. For a profound product development phase, we need the cooperation with network operators, service providers and tier 2 equipment vendors, and research organizations. The results achieved in the project with respect to cooperative systems and the supporting communication technologies will be used to provide valuable contributions to the work of the Car-to-Car Communication Consortium (e.g. the work on cooperative perception) as well as the newly formed European Automotive–Telecom Alliance. Finally, the results from 5GCAR with regard to communication technologies and systems will serve as a starting point for further research activities to support our product development of in-vehicle Connectivity Control Units and Connected Driver Assistance Systems/ Highly Automated Driving Systems

C.5   Academics

Academic partners, i.e., universities and research institutions, that participate in the 5GCAR consortium are interested in building on and further developing existing research strength in V2X systems. The gained expertise will permeate into the daily university life and will be disseminated within academic education as preparation of future European ITS and 5G experts.

C.5.1   Centre Tecnològic de Telecomunicacions de Catalunya

The participation of the Centre Tecnològic de Telecomunicacions de Catalunya (CTTC) in 5GCAR has: i) generated knowledge in the area of wireless technologies for V2X within 5G, strengthening the international reputation of CTTC as a key reference institution within the field of V2X communications for 5G and, in particular, for the automotive vertical sector, ii) strengthened the visibility of CTTC as a key player in the specification of V2X communications for 5G, thus facilitating further collaboration in future research programs involving Machine-Type Communications and Software Defined Networking, and iii) strengthened the collaboration with leading European and National industry players, thus maximizing the technology transfer generated by CTTC. One of the main objectives of CTTC was to build bridges between academia and industry, promoting a new economy based on knowledge and technology. The participation of CTTC in 5GCAR has facilitated the involvement of SMEs and academia in 5G-related activities, and has allowed to establish connections with big industrial players in Europe, both within the automotive sector and also in other sectors with similar communication requirements to those of automotive use cases, e.g., Industry 4.0. Therefore, the expertise, knowledge and visibility gained in 5GCAR has put CTTC in an ideal position to interconnect all players (universities, research centres, and industry) in the 5G ecosystem. Indeed, the participation in 5GCAR has allowed CTTC to increase the number of publications in the area of V2X communications for 5G, accounting with a total of 7 publications in international conferences, and a total of 5 journal publications, thanks to the direct contribution of 5GCAR activities. The reputation of CTTC in the 5G and V2X field has dramatically increased during and after the participation in 5GCAR. A clear example of this, is the fact that CTTC is the current project coordinator of 5GCroCo (ICT-18 project), where some of the 5GCAR participants are also involved. In particular, Dr. Jesus Alonso-Zarate, involved in 5GCAR, is the project coordinator of 5GCroCo. The rest of the CTTC team involved in 5GCAR are also key contributors to 5GCroCo. Therefore, the exploitation plan of CTTC has been largely achieved.

C.5.2   Centro Tecnológico de Automoción de Galicia

Having gathered a strong background in development and deployment of C-ITS services based on ETSI ITS G5 technology during last years, CTAG (Centro Tecnológico de Automoción de Galicia) is now working to include into this V2X solution to also support 4G and 5G communication modes. Participation in the 5GCAR project will allow CTAG not only to go on exploiting C-ITS services potential by increasing its offer in terms of availability and capability but also to analyse and compare the different technology approaches depicted for C-ITS systems. The extension and enhancement of CTAG competences that the 5GCAR project will bring should pave the way to keep CTAG updated and in good position at European level as C-ITS service provider. Support

to different stakeholders (e.g., OEMs, Road Authorities) not only to deploy in a coherent manner C-ITS services then leading large scale deployment in urban and interurban environments, but also to test and validate them being technological agnostic (hybrid approach) is the aspiration. Finally, results from 5GCAR will act as trigger for further research initiatives where experience gathered will support development of other systems and services.

C.5.3   Chalmers University of Technology

CHALMERS has used the 5GCAR project to build on and further develop our existing research strengths in the targeted fields of the project. The involved senior researchers have increased their knowledge, which has permeated into the daily university life and been disseminated within the academic research and education. For the involved post docs, this means has meant a chance to qualify for further academic positions. For the Ph.D. and M.Sc. students in the project, the research and knowledge gained during the project has helped them to achieve their Ph.D. and M.Sc. titles, respectively. By actively contributing to this project, when graduated, the students will be highly attractive for further career in industry and academia. No patent applications have been submitted in this project.

CHALMERS has extensively disseminated project results to the scientific community via international peer-reviewed conferences and journals with high impact factor in the fields of signal processing, information theory, communications theory, and wireless networks. CHALMERS has also actively contributed to project dissemination at international workshops, such as the International Workshop on Emerging Technologies for 5G and Beyond Wireless and Mobile Networks (ET5GB) in conjunction with IEEE Globecom that we have been co-organizing the last years and the European Conference on Networks and Communications (EuCNC) and at technical and management meetings of the COST Action CA15104 (IRACON). CHALMERS has also been involved in proposals for special issues in journals, as well as organized tutorials on selected topics in conjunction with the top international conferences. The results have also been included in M.Sc. and Ph.D. theses.

C.5.4   King's College London

King's College London (KCL) used the knowhow gained, and the technical solutions developed, during the 5GCAR project to develop master and bachelor dissertation projects. In particular, four dissertations were defined during 2018-19, based on the 5GCAR use case scenarios and learnings from the demonstrations.

Furthermore, KCL used the 5GCAR results to strengthen their links to the Transport for London (TfL) and build on their existing efforts in the city of London in introducing 5G to various services in the city including public transportations.

C.6   Small to medium sized enterprises

Small and Medium-sized Enterprises (SMEs) engaged in 5GCAR will create strong R&D links with both academia and leading industrial entities which positions them within a very strong value

chain. The SMEs at the same time provide an innovative character with necessary edge competence, services and products.

C.6.1   MARBEN

MARBEN V2X software product is today a complete and proven solution supporting both EU and US standards for, respectively, ITS-G5 and DSRC (over 802.11p). It includes both a protocol stack and V2V/V2I/I2V applications, for vehicles, road-stations and vulnerable users (e.g. pedestrians). MARBEN V2X roadmap includes supporting the protocol stack (above the MAC layer) and applications over 5G interfaces, as well as new applications taking advantage of 5G unique network capabilities. The 5GCAR project will greatly help MARBEN Products achieving this roadmap, and validating its solutions, quickly acquiring knowledge about 5G architecture and technologies, thanks to the expertise of 5GCAR partners and 5GCAR project outcomes.

C.6.2   SEQUANS

SEQUANS is developing chipset for 4G terminals. The 5GCAR project is important for SEQUANS to open new possible markets related to connecting the car, one of the particular objects to be connected with 4G evolution and 5G. Moreover, the presence of the main V2X actors in the project will allow SEQUANS to identify and adopt the mainstream solution for V2X and thus provides to the company a possible time to market advantage. The project outcomes will help SEQUANS to define next generation products features, in particular those related to V2X communications.

C.6.3   VISCODA

The technology of VISCODA is applied in various pre- and series developments in the European automotive industry, e.g., for real time 3D-reconstruction and semantic interpretation of the car surrounding by the use of cost-efficient monocular cameras for driver assistance systems.

In the 5GCAR project, VISCODA contributes the reliable and accurate localization of vehicles based on road side cameras. In the final demonstration on the test track (27th June), these results were used for the computation of maneuver recommendations for the lane merge use case. Therefore, various state of the art algorithms for detecting and locating vehicles were evaluated and further new algorithms for multi camera calibration and multi camera object tracking and localization have been developed.

It is planned to use the results of the 5GCAR project to acquire new pre- and series developments and to access new markets in the context of V2X. The technical achievements and the network among the participants within the 5GCAR project give VISCODA a market advantage.