

Dear readers,

During this last period, the 5G-CARMEN project went through a significant refocusing of its activities that led to the definition of two new and more challenging use cases, generated from the merging of the original cooperative manoeuvring and situation awareness use cases. This activity had important impact also on different functional elements, technical enablers, and final 5G-CARMEN architecture, leading to a new pilot plan for the use cases.

5G-CARMEN partners have decided to prioritize and focus their efforts on those use cases and scenarios deployment where the benefits of a seamless 5G communication, especially on cross-border scenarios can be showcased.

The outcome of this work is the following set of cooperative manoeuvring use cases, where a seamless, low-latency communication is crucial, specially towards higher levels of automated driving:

1. Cooperative and automated lane-change manoeuvres with both vehicle-to-vehicle and vehicle-to-network communication, where the network may provide maneuver recommendations

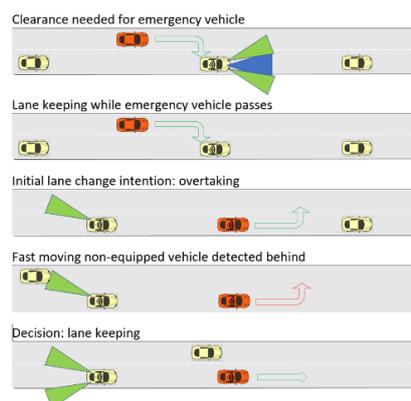
2. Cooperative and automated in-lane manoeuvres, where longitudinal control and lane keeping/centring is based

on both the vehicle's detection of events and the communication of this information to other vehicles on the road.

These two use cases for connected and collaborative automated driving have been investigated, targeting 5G connectivity to enable Level 4 automation, thanks to improved awareness of the surroundings, integrated Edge Services a dynamic end-to-end Service Orchestration:

1-Cooperative and automated lane-change maneuvers

A vehicle needs to change lane from overtaking to first lane or vice-versa. It performs lateral control thanks to a very accurate and timely awareness of the surroundings, enabled by 5G and supported by the redundant PC5 direct communication. The use case includes two sub-use cases: the cooperative lane merge in the new lane as originally planned by the AD vehicle, and the lane change in presence of oncoming emergency vehicles.



KEY FACTORS

Stay tuned for our next webinars!

5G-CARMEN System Architecture and interfaces

Wednesday 15/09 4pm-5pm

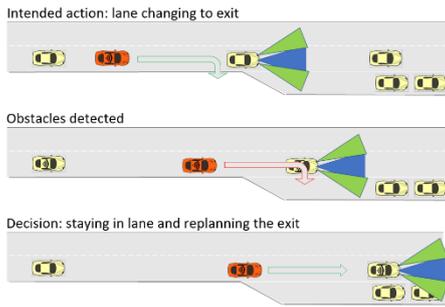
5G Technological Enablers for CCAM

Wednesday 06/10 4pm-5pm

2 - Cooperative and automated In-lane maneuvers

A vehicle plans to exit the motorway in moderate-high traffic situation, with vehicles in front obstructing the view. A queue or obstacle on the exit lane would require the driver to take over.

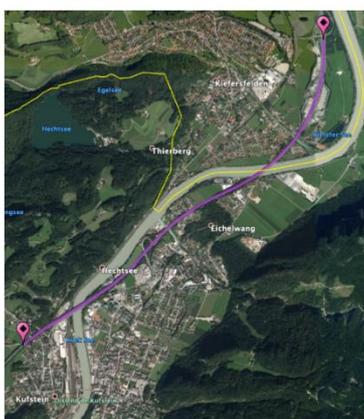
Thanks to 5G, however, the vehicle can sense what the vehicle in front senses and thus decide to keep Level 4 automation, and stay in lane, re-planning the exit without involving the driver. The perception is supported by PC5 direct communication.



Current mobile networks coverage at the Brenner International borders

An evaluation of current mobile networks coverage was hence conducted on portions of the motorway at both German-Austrian and Austrian-Italian borders.

The involved measurement setup was composed of one single vehicle, including an on-board GNSS receiver synchronized with standard commercial mobile phones, thus emulating a geo-referenced car endowed with V2N capabilities. In each tested environment, the experience of crossing the border was repeated many times (in opposite driving directions) to reveal possible asymmetries in terms of network coverage/selection.



Satellite view of the selected *Grenzübergang* Kufstein-Kiefersfelden segment



Satellite view of the selected Brennero Pass segment

Business models for 5G cooperative and automated mobility services.

5G-CARMEN partners have focused their efforts on the synergy between simulation of selected use cases, measurements of existing networks, advanced techno economics and business models (including different clustering MEC models), in order to provide an accurate framework for the deployment study and market analysis of 5G cooperative and automated mobility services, especially in cross-borders cases.

Major results of this work can be summarized as follows:

(i) The higher the number of simultaneous connected cars, the higher the TCO (Total Cost of Ownership) of the required

deployment is to meet the defined KPIs,

(ii) Optimistic predictions for the adoption of 5G V2X 2021-2025 yield similarly optimistic prospects for the profitability of V2X deployments,

(iii) Co-financing by the European Commission (alone) could not be sufficient for assuring the economic success of V2I deployments without the advent of novel, sustainable, and innovative business models in conservative adoption scenarios,

(iv) All proposed MEC clustering models (star, aggregation) are less costly than the generic, non-clustering topology,

(v) The current networks have long ranges into neighboring countries and connection changes to the neighboring network take place as late as possible.

Business, market and societal aspects of underlying technologies and services have seen strong stakeholder statements in an ongoing political negotiation process and significant procedural lessons learnt during the project duration.

5G-CARMEN has therefore focused on techno-economic analysis and business models and has mitigated potential risks derived from prematurely presenting isolated societal benefit views. From the



perspective of European value added, the blend of kind of Europe-wide “always online connectivity” and various forms of “assisted driving” have the potential to release some of the limiting factors in European individual motorized travel behaviour - where environmentally sensitive alpine areas are kind of a bottleneck and constraint for peak traffic loads between economically prosperous European regions. The positive impact cannot be underestimated for environmentally sensitive road segments like Autostrada del Brenner and Tyrol.

Considering the roadmap for the adoption of 5G V2X services and their KPIs stated by 5GAA, 5G CARMEN has emulated the role of both:

- i) A road infrastructure operator deploying communications infrastructure and RSUs for V2I
- ii) An MNO deploying cellular communications infrastructure for V2N

V2N and V2I deployments have factored with both a more conservative and a more optimistic adoption forecast.

Dissemination activities

The dissemination activities in the first half of 2021 included 14 contributions to conferences, one workshop, 3 journal contributions (published or

accepted), one panel participation and one project presentation.

Two of the most relevant events were the participation to the IEEE 5G for CAM (Connected and Automated Mobility) Summit (CAM 21), on the 12th of May 2021, and the participation to EuCNC 2021 (8-11 June 2021).



For the IEEE 5G for CAM Summit 5G-CARMEN delivered an invited speech giving an overview of the project goals and achievements, and two more technical presentations, one on edge-to-edge service continuity for CAM in a sliced network, and one describing an optimized application-context relocation approach for CCAM services.



For EuCNC 2021, 5G-CARMEN organized together with the two other corridor projects (5GCroCo and 5G-MOBIX), a joint workshop titled “Cross-border 5G for CCAM: challenges, solutions and results”, on the 8th of June. For this workshop 5G-CARMEN prepared a paper describing the objectives of the project, the evolution of the four original use cases in the new more challenging ones, the key

enabling technologies and the overall 5G-CARMEN architecture that have been deployed to support use case testing along the corridor. A second presentation was also featured in the workshop, focusing on the key challenges of CAM service continuity and associated management, with the focus on roaming scenarios, when connected vehicles switch to a new Mobile Network Operator (MNO) while crossing country borders. 5G-CARMEN was also present in EUCNC Special Session 8 (Autonomous Network Management towards 6G), held on the 11th of June 2021, participating to the final panel with a speech on cross border issues, presenting a solution to facilitate RAN Data Sharing between Mobile Network Operators. In May 2021 5G-CARMEN was also presented in one of the sessions of Next Generation Mobility 2021 virtual conference, a three days Italian event dedicated to mobility, that attracted more than 4000 participants.

To communicate the results of refocusing of 5G-CARMEN activities to the wide public and all the stakeholders of the project, a set of webinars is being organized in the second half of 2021. The first two webinars have already been set (on the 15th of September and the 6th of October), while the other two will be delivered by the end of October / beginning of November.

5G-CARMEN started working on the realization of a



promotional video that will be released in autumn through the various dissemination channels (social channels, newsletter, website, and YouTube video playlist).

As concerns SMEs, in the last months 5G-CARMEN kept track of potential events that could be suitable to host dedicated workshops for small-medium enterprise, similar to the two already organized in Italy in

2020, targeting this time SMEs in Austria and Germany. However, the ongoing Covid pandemic prevented from the organization of live events around Europe in the first half of 2021: considering that one of the main goals of this kind of workshop is to create networking, share ideas and foster collaboration with SMEs,

it was decided to postpone their organization, hoping to be able to host them in future physical events. The current plan is to have a workshop dedicated to small and medium enterprise in the second half of 2021 in Austria, and one in the first half of 2022 in Germany, hopefully in live events.

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