

5G-CARMEN NEWSLETTER #7

October 2022



Dear readers,

Welcome to the 7th and final newsletter of the project!

5G-CARMEN successfully completed its activity. We conducted extensive trials across an important 600 km road corridor from Bologna to Munich, which is connecting the three European regions Bavaria, Tirol and Trentino across borders.

5G-CARMEN validated a set of innovative Cooperative, Connected, and Automated Mobility (CCAM) use cases from both business and technical perspectives, focusing on cross-border 5G and advanced Automated Driving Assistance Systems (ADAS) on the way to Level 4.

To achieve this, 5G-CARMEN leveraged the most recent 5G technology enablers, including 5G New Radio (NR), C-V2X interfaces, Mobile Edge Computing (MEC), readiness for end-to-end network slicing in future 5G Stand-Alone networks (SA), highly accurate positioning and timing, predictive quality of service and Edge-to-Edge Service Orchestration.

5G-CARMEN has been originally investigating four cross-border application scenarios: cooperative manoeuvring, situation awareness, green driving, and infotainment.

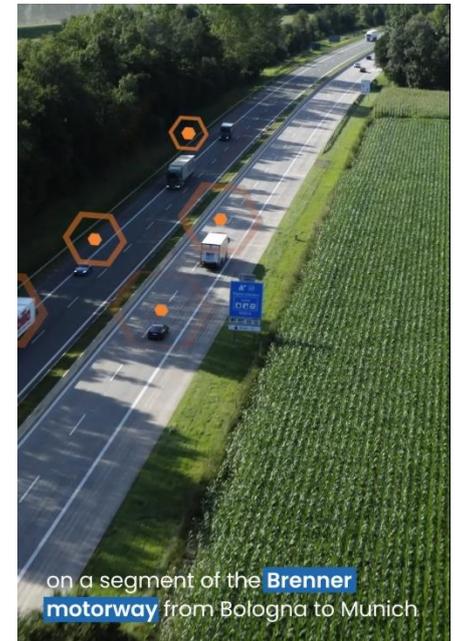
The focus was adjusted to concentrate on cooperative manoeuvring and situation awareness, as these scenarios are most demanding and requiring 5G features and performance gains over capabilities of previous network generations. For the use cases, the project targets supporting an automation level of up to SAE L4.

The data analysis and preliminary results focused on the lane change centralized approach and in-lane manoeuvres based on forward detection. Multiple trials followed: the last period was characterized by an intense, iterative onsite test activity by all partners involved in the pilot.

The main goals of the last period were to provide cross-border service continuity, an improved on-board HMI for an effective demonstration, and the fine-tuning of the current scenarios. In this period the project partners performed several times cross-border transitions in both borders.

In particular at Brennero a public demonstration of 5G-CARMEN was achieved, hosting Public Authorities, press and other stakeholders in test drives from Austria to Italy, while at the Kufstein border some unexpected issues with the production networks impacted the final tests, therefore, partners had to complement the

evaluation with previously collected data.



The 5G-CARMEN project was able to successfully reach all planned milestones and achieve important results. First of all, the final version of the 5G-CARMEN system architecture and its interfaces were provided, including technical specifications for its sub-components, their interfaces, and the protocols to be used for the data exchange.

The Munich-Bologna Corridor has been equipped with 5G in 4 locations (Munich, Trento, Italy-Austria border at Brennerpass and Germany-Austria border at Kufstein) and two important technical achievements were developed to minimise latency and service interruption caused by standard network reselection procedures across borders:



- **accelerated network reselection** was temporarily introduced in the three networks for 5G-CARMEN subscriptions/devices, yielding an interruption of the connectivity in the range of 2-4 seconds compared to tens of seconds or even minutes in standard roaming implementations
- **local break-out** in the visited network (i.e., the network of MTA in Austria, for 5G-CARMEN “visitors” with subscriptions from either TIM in Italy or DTAG in Germany) was implemented to allow low-latency communication to the respective MEC infrastructures hosting the 5G-CARMEN services, instead of the so-called “tromboning” of the communication flow common in standard roaming, where all traffic is routed via the home network.

The project refocused its effort and developed two new use-cases, namely Connected and Automated lane-change manoeuvres (with centralized approach and decentralized approach) and in-lane manoeuvres.

- The centralized lane-change manoeuvres were successfully demonstrated on 3 BMW vehicles and were based

on a novel setup running on the MEC systems: a dedicated Manoeuvring service gets information from a Server Local Dynamic Map (S-LDM) and provides response to the vehicles through a response router.

- The decentralized lane change and in the in-lane manoeuvres were demonstrated by CRF prototype vehicle. In these use cases, information is exchanged among vehicles utilizing the low-latency Geoservice southbound interface at 20Hz, which acts as message relay

dynamic load conditions of production cellular network, the 5G-CARMEN consortium achieved an extensive experimental campaign carried out in all sites, focussing on cross-border aspects, so that the system was demonstrated in both borders.

The test results collected towards the end of the project have been presented in standard entities and industrial associations (mainly ETSI, 5GAA, IETF and GSMA), especially for topics that directly impacted standardization and industrial associations activities:

- the definition of 5G-CARMEN architecture and use cases that was captured in ETSI
- technological enablers such as Fast Network Reselection and Precise Positioning that affected both 5GAA and GSMA studies
- results coming from on-field testing of the use-cases and V2X communication that were input to ETSI TC ITS and 5GAA
- all the studies related to the Strategic Deployment Agenda (SDA) that were shared with 5G PPP / 6G-IA-SNS. In conclusion, the 5G-CARMEN project was able to reach its objectives and provide valuable lessons for the
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**HAVE A LOOK
AT OUR
FINAL PROJECT
VIDEO!**

<https://www.youtube.com/watch?v=daxpthOXTI4>

Despite use case testing on public roads had to cope with very dynamic road and traffic conditions, as well as with the



future deployment of 5G in Europe.

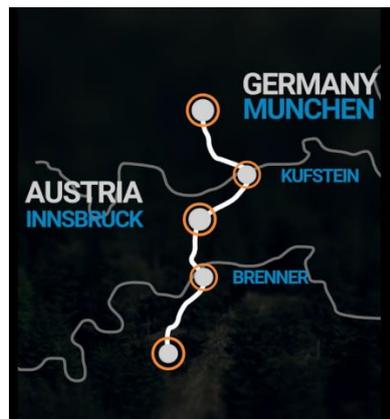
5G-CARMEN completed also a business and techno-economic analysis with a focus on market issues and strategy. Optimistic predictions for the adoption of 5G V2X 2021-2025 yield similarly optimistic prospects for the profitability of such V2X deployments.

The potential co-funding by the European Commission is one of the key elements making such 5G V2X deployments possible but co-financing 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. 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 5G-CARMEN's duration.

Fine-tuning of business models, based on field trials results showed that the need to realize the proposed business models and then we highlighted the impacted business entities and potential solutions.

It is clear that CAM will have very high requirements to 5G infrastructure; however, a broad

market introduction of CAM cannot be expected within the next 5 years, so it's unlikely that the data requirements of CAM will be an important driver of 5G rollouts. Rather, CAM may be a driver of 6G and other future mobile communication technologies. Finally, the C-ITS adoption has been investigated and can be helpful for several stakeholders including European Commission and its Member States by evaluating penetration rates in the light of European goals.



DISSEMINATION ACTIVITIES

Communication of the project results to the community was as one of the key activities of the last period.

The team took part to most of the events available, contributing to conferences, workshops, journals, and organized several project webinars.

EUCNC 2022

A primary target event to this end was the EuCNC & 6G Summit that was held 8-10 June 2022 in Grenoble, where 5G-CARMEN was present with a booth where our latest project achievements were presented.

The project was also involved in the EUCNC Special Session "5G for CAM towards Deployment" that was held during the Conference together with the other two European corridor projects.



ITS EUROPEAN CONGRESS

Another relevant event was the participation at ITS EUROPEAN CONGRESS 2022 in Toulouse at the end of May 2022, which attracted quite some audience for further discussions of the project's scope and results, as well as the general future of such advanced use cases for the future of Connected and Automated Mobility.

NEXT GENERATION MOBILITY

On 3, 4 and 5 May, the project took part to the yearly Next Generation Mobility conference in Turin, bringing together the stakeholders developing



Sustainable Urban Mobility Plans.

Three days of events during which institutions, companies, start-ups and universities have the opportunity to present mobility services and products that can be physically and virtually tested.

Three days of debate and discussion through conferences and networking with the opportunity to increase professional skills and business.

Roberto Fantini of TIM presented 5G CARMEN during the session “Connected and Meta-mobility”

IOT WEEK, DUBLIN

In June 2022 the project team also took part to the IOT Week in Dublin and presented the 5G-CARMEN project in the first session on the 21st of June dedicated to “Cross-Border Corridors: 5G for Connected and Automated Mobility” with a focus on sharing experience and presenting results for exploitation and deployment.



5G-CARMEN FINAL EVENT, BRENNER PASS BORDER

A conference was held on the 22 and 23 June 2022, at the Plessi Museum facilities at the Brenner Pass border, with institutional interventions illustrating the 5G-CARMEN project, its technological context, the results obtained.

The attendants were then given the possibility to participate in the demos on the road, thanks to vehicles equipped with the technologies resulting from the 5G-CARMEN project. While crossing the border from Austria to Italy, these vehicles performed the semi-autonomous maneuvers enabled by 5G.

A centralized connected and automated lane change was also demonstrated at the Kufstein border between Germany and Austria and presented to journalists and Public Authorities.

See [Press release](#)

5G-CARMEN WEBINARS

Over the last year, 5G-CARMEN has carried out several webinars dedicated to specific topics to further promote and disseminate our activities. They have all been recorded and are available at the links below:

[5G-CARMEN webinar on “System Architecture and Interfaces”](#)

[5G-CARMEN webinar on “5G Enabling Technologies for Cooperative, Connected and Automated Mobility”](#)

[5G-CARMEN webinar on “Advanced prototype for secure, cross-border, and multi-domain service orchestration”](#)

[5G-CARMEN webinar on “Business and techno-economic analysis”](#)

[5G-CARMEN project on Cybersecurity SMEs and funding opportunities for SMEs in Horizon Europe](#)

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