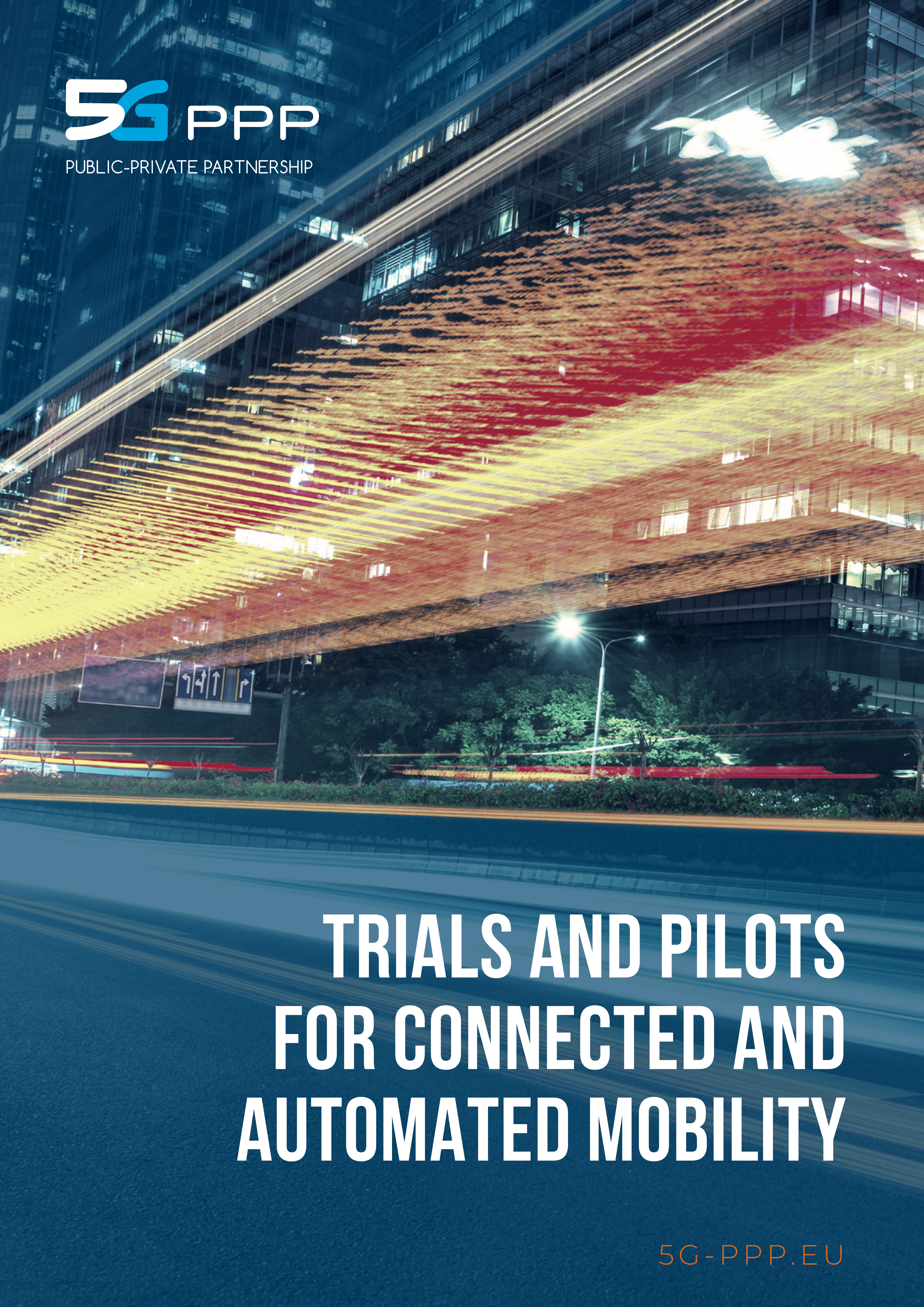

5G PPP

PUBLIC-PRIVATE PARTNERSHIP

TRIALS AND PILOTS FOR CONNECTED AND AUTOMATED MOBILITY

5G-PPP.EU

PUBLIC-PRIVATE PARTNERSHIP

TABLE OF CONTENT

INTRODUCTION

Undoubtably, society will benefit from Connected and Automated Mobility (CAM) in various ways. First, safety. Highly automated vehicles exchanging information will realize a collective artificial intelligence that can overcome the capabilities of humans to drastically reduce the number of accidents. Second, traffic efficiency. Exchanging information of maneuver intentions and real-time monitoring of real-traffic conditions for optimal traffic efficiency are just a couple of examples of the potential of CAM to improve the capacity and efficiency of roads. Third, passenger comfort. Vehicles driving in a highly automated manner will transform the concept of passenger, allowing for a more relaxed and fruitful traveling time on-road. Overall, reduction of environmental impact of road traffic is a final goal that can be boosted thanks to CAM.

As it was stated in the Strategic Deployment Agenda released in October 2019 by key stakeholder associations, 5G will be a booster for the realization of CAM and thus, bring all societal benefits to reality.

For this reason, the 5G Public Private Partnership, which aims at ensuring that Europe leads the development and deployment of 5G in Europe, has been continuously funding along the last years several projects which contribute to designing, developing, testing, validating, and promoting the potential of 5G-based vehicular communications (so-called V2X communications) for CAM.

It is worth noting that the term V2X refers to communication between a vehicle and anything else, yielding terms such as V2V (vehicle-to-vehicle), V2N (vehicle-to-network), V2I (network-to-infrastructure), or V2P (vehicle-to-pedestrian).

This brochure aims at providing a schematic and visual summary of the key use cases, key performance indicators, and tests and pilots being conducted in the context of research and innovation projects funded by the 5G-PPP which contribute to enabling efficient and reliable 5G-V2X communications for CAM.

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V2X USE CASES

5GMOBIX

As the number of use cases distributed in the different 5G-MOBIX Test-Sites is very high, they have been classified in some Use Case Categories (UCCs), classification extracted form 3GPP technical specifications.

Advanced driving use case: Advanced driving enables semi-automated or fully-automated driving. Each participant shares its local data and driving intentions on the vehicles case, with cooperating entities in the proximity. This allows the participating vehicles to coordinate trajectories and maneuvers.

Platooning use case: Enables vehicles to form groups dynamically while traveling together. Information is exchanged among members and maneuvers are coordinated by the platoon leader, allowing them to drive as compact groups and the following vehicles to be driven autonomously.

Extended sensors use case: This use case contemplates raw sensors data and live video to be exchanged among participating members. This enables every participant to be aware beyond what can be perceived by its own sensors, enabling a more complete view of the local environment.

Remote driving use case: Remote driving enables a vehicle to be commandeered from a remote location for when the occupants cannot drive themselves or for vehicles on hazardous environments. This use case is also considered for cloud-enabled public transportation.

Vehicle quality of service reporting support use case: This use case enables V2X applications to be informed on the CCAM system status. Notifying participants on current quality of service and expected variations, delivering a smoother experience.

www.5g-mobix.com

5GMED

Teleoperated driving: 5GMED will demonstrate that a teleoperator can control the car from a remote location and ensure the Dynamic Driving Task Fallback with full safety, adding a new reliable mode to the dynamic driving task (DDT) fallback procedure specified by SAE J3016.

Road infrastructure digitalization: 5GMED will move forward the road infrastructure closer to Inframix level A. Two different services will be tested: 1) automatic incident detection, with a 5G connected camera processed by an IA in the Edge, and 2) Traffic Flow Regulation in Real time by providing speed recommendations to a selected group of Connected Autonomous vehicles, improving road safety.

Follow Me infotainment: 5GMED will demonstrate service continuity of intense infotainment and media applications in cross-border situation with dynamic service migration from MEC to MEC.

www.5gmed.eu

5GCroCo

Tele-operated Driving (ToD): is defined as remote control of an automated vehicle through a mobile radio network. ToD is meant to complement automated driving by bringing the tele-operator, located in the Vehicle Control Centre (VCoC), into the control loop in situations where an automated vehicle cannot handle on its own.

High Definition (HD) maps: being considered one of the corner stones of an autonomous car, the generation and distribution of these maps allow integrating information such as lane markings, barriers and other information which can be used by the automated driving functions. The HD maps can also be used as the base upon which more dynamic information can be stored, e.g., road works and accidents.

Anticipated Cooperative Collision Avoidance (ACCA): this use case relates to the possibility to anticipate certain road hazards to reduce the probability of collisions, particularly in situations when these hazards are out of the field of view of the vehicles' sensors. It allows to build a situational awareness of the road in quasi real-time manner, and to notify nearby vehicles about collision risks.

www.5gcroco.eu

5G CARMEN

Cooperative and automated lane-change maneuvers: a vehicle needs to change lane from overtaking to first lane or vice-versa, and it performs lateral control in level 4 (L4) automated driving thanks to a very accurate and timely awareness of the surroundings, enabled by 5G.

Cooperative and automated in-lane manoeuvers: a vehicle is on the first lane and 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 L4, and stay in lane, re-planning the exit without disturbing the driver.

Cooperative Lane Merge: vehicles orchestrate a lane merging operation by exchanging information via PC5 direct communication (localized case) and via 5G network using MEC-based Services (centralized case).

Back Situation Awareness: emergency vehicles inform other vehicles of their arrival through 5G connectivity (both V2N and V2V), giving them enough time to take relevant actions (create a clear corridor for the emergency vehicle).

Vehicle Sensors and State Sharing: dangerous conditions (e.g., fog, icy roads, traffic jam) are detected by sensors in Road Side Units (RSU) or vehicles on the road, and communicated to nearby vehicles using 5G connectivity (both V2N and V2V).

Video Streaming: using predictive network Quality of Service capabilities (pQoS), more pleasant experience on board can be granted to passengers in the fruition of multimedia content, exploiting proactive adaptation of streaming to minimize interruptions of service or low data-rate conditions, especially at country borders

Green Driving: it increases the sustainability of mobility, suggesting virtuous driving behavior (e.g. via speed recommendations) based on the environmental and traffic characteristics of the motorway section that is being traversed or better exploiting the hybrid traction systems on hybrid vehicle.

www.5gcarmen.eu

5G BLUEPRINT

Automated driver-in-loop docking functionality: Within this use case, 5G-Blueprint explores a driver assistant system for docking articulated vehicles within warehouses and distribution centers, as a well as enabling a mobile harbor crane with teleoperation functionality, so that it can be operated from a remote-control center by a teleoperator. Communicating optimal driving paths to the tractor and maneuvering the crane in safety-critical situations will be highly time-critical.

Cooperative Adaptive Cruise Control based platooning: Platooning of trucks has been a widely discussed topic in logistics for a while now. However, this use case revolves around the fundamental strategy of platooning by relying of 5G, while the driver is removed from the cabin of the truck and placed in a remote location from where they can control the vehicle. The system is aimed at being partly automated wherein the lead vehicle can be driven by a driver in the cabin or a teleoperator and the following vehicle(s) can be automated.

Remote takeover operations: Remote takeover defines the process in which a remote operator takes control of a distant vehicle. To enable remote takeover, it is necessary to monitor and adjust the vehicles to steer and drive remotely from the control center. Remote takeover operations are integration tests verifying the function of all major components (vehicle, remote station, teleoperation center) of the teleoperation solution.

Automated Barge Control: the channel navigation of the barges will be teleoperated along with partial automation. Cross-border passing will be given a priority whereas channel navigation, port entry, and exit efficiency will be enhanced by reducing crew requirements for barge navigation.

www.5gblueprint.eu

5G ROUTES

Automated Cooperative Driving: MEC-enabled 5G RAN nodes, enhanced with AI, continue to gain more intelligence and capacity to support dynamic vehicles platooning, cooperative lane change and see-through view for safe automated overtake capabilities.

Awareness Driving: enables reliable exchange of road traffic status data to provide V2X real-time traffic info and cooperative intersection collision control and user comfort through traffic jam chauffeur.

Sensing Driving: share observations gained by sensors, and advanced environmental information, to gain enhanced situational awareness for Vulnerable Road User (VRU) collision avoidance and preventive framework through connected maintenance.

Uninterrupted infotainment passenger services on the go: enable multimodal passengers to exploit the high-performance capabilities for 360° immersive multi-user gaming on the go and 3D real-time virtual collaboration on the go.

Multimodal services in uninterrupted and seamless service delivery to goods tracking visibility in multimodal cross border logistics and 5G-based Proactive and Multimodal Management of Passengers and Freight.

www.5g-routes.eu

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Automated & Remote Vessel navigation in busy port environment: Demonstration of Port Digital Twin based on 5G connectivity and slicing will be used to control semi-autonomous vessels in the challenging environment of a port area. High-bandwidth (preferably full HD) camera feeds and sensor data are sent in real-time from the vessels to the command centre, and real-time steering commands are sent to the remote vessel. KPIs: Port safety, reduced dwell times, reduced personnel, etc.

Data-enabled assisted navigation in severe weather/water conditions: Demonstration of remote inspection, fraud detection, insurance by implementation of a data-enabled assisted navigation application using IoT sensing system and video cameras installed in port and on a ship and barges (cargos). The UC application that we propose will permit a safer port operation and more security regarding navigation of ships with the help of assisted operation / navigation even in severe weather and water conditions. KPIs: Increased safety, electronic map accuracy, etc.

Smart warehouse / freight logistics: Demonstration of lean warehouse, human-AGV collaboration, remote monitoring & control the feasibility by applying the 5G technology in an overall logistics context, for optimizing warehousing operations through an integrated state-of-the-art operational system based on Automated Guided Vehicles (AGVs). KPIs: Increased operational efficiency, productivity, warehouse capacity, etc.

www.vital5g.eu

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USE CASE	TELE-OPERATED DRIVING	HD MAPPING	ANTICIPATED COOPERATIVE COLLISION AVOIDANCE	VEHICLE PLATOONING	ADVANCED DRIVING
KEY 5G KPI	RELIABILITY	DATA RATE	DELAY, LOCALIZATION ACCURACY	RELIABILITY / E2E LATENCY	E2E LATENCY
5GMOBIX	√	√	√	√	√
5GMED	√				
5GCroCo	√	√	√		
5GCARMEN			√		
5G-Blueprint	√			√	√
5GROUTES			√	√	√
VITAL-5G		√	√		

2/3

USE CASE	EXTENDED SENSORS	COOPERATIVE AND AUTOMATED MANEU-VERING	BACK SITUATION AWARENESS	VEHICLE SENSORS AND STATE SHARING	VIDEO STREAMING
KEY 5G KPI	E2E LATENCY	LATENCY	COVERAGE, RELIABILITY	LOCALIZATION ACCURACY	LATENCY, DATA RATE
5GMOBIX	√				
5GMED					
5GCroCo					
5GCARMEN		√	√	√	√
5G-Blueprint				√	
5GROUTES	√	√		√	√
VITAL-5G	√			√	√

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USE CASE	GREEN DRIVING	ROAD INFRASTRUCTURE DIGITALIZATION	FOLLOW-ME INFOTAINMENT	DISTRIBUTED PERCEPTION	VEHICLE QoS SUPPORT
KEY 5G KPI	SERVICE CONTINUITY	RELIABILITY	DATA RATE, CONTINUITY	DATA RATE, LOW LATENCY	DATA RATE, RELIABILITY
5GMOBIX					√
5GMED		√	√		
5GCroCo					
5GCARMEN	√				
5G-Blueprint				√	
5GROUTES					
VITAL-5G					

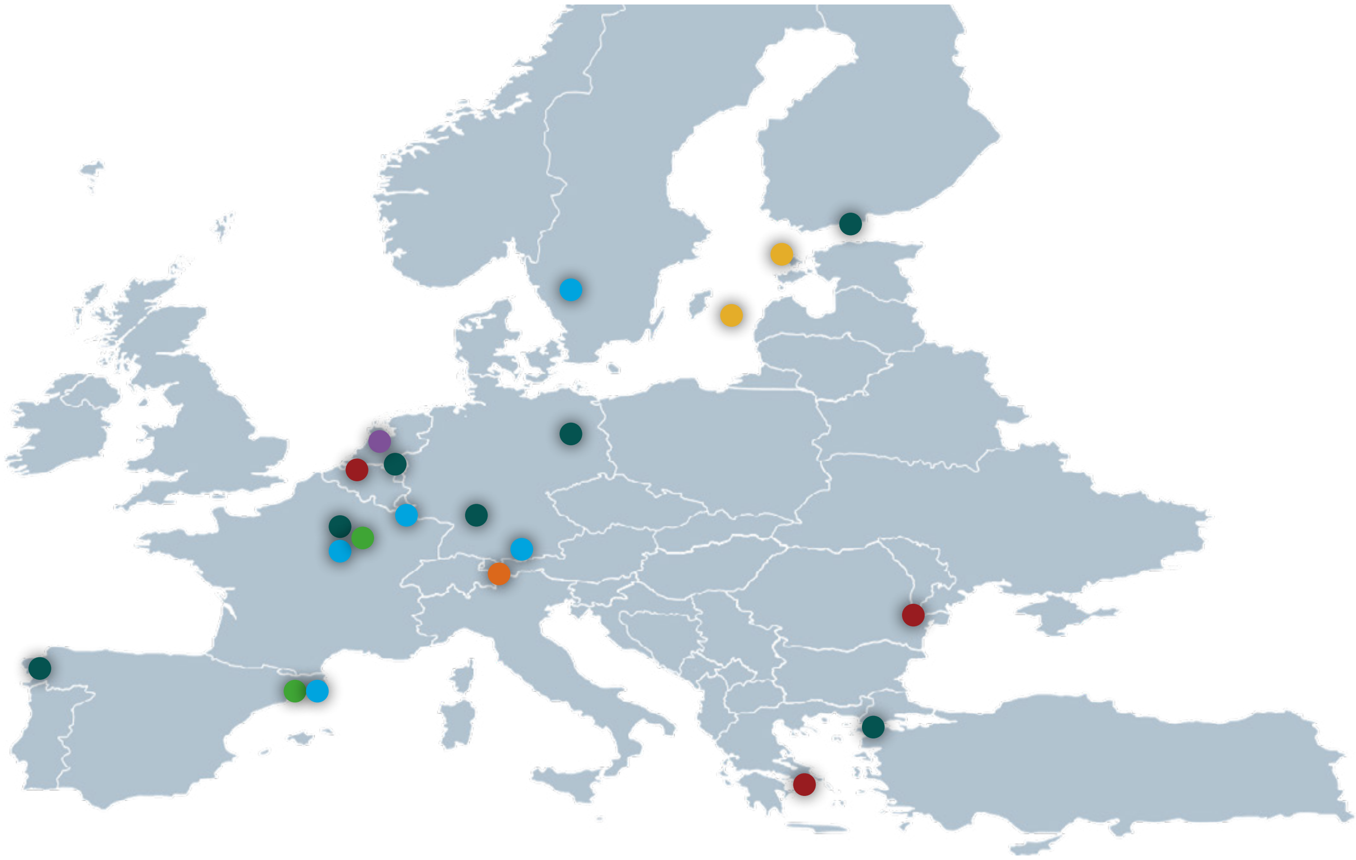
TESTED 5G TECHNOLOGIES

	RELEASE TESTED	5G DEPLOYMENT		TECHNICAL FEATURES					
		NSA	SA	5G NR	MEC	NET. SLICING	PQOS	AI	PC5
5GMOBIX	15/16	√	√	√	√	√			√
5GMED	16		√	√	√	√	√	√	√
5GCroCo	15	√		√	√		√		
5GCARMEN	15	√		√	√		√		√
5G-Blueprint	16/17	√	√	√	√	√		√	√
5GROUTES	16/17	√	√	√	√	√		√	
VITAL-5G	15/16		√		√	√			

TERMINOLOGY

- **NSA:** Non-standalone;
- **SA:** Standalone;
- **5G NR:** 5G New Radio;
- **MEC:** Mobile Edge Computing;
- **Net.** Slicing: Network Slicing;
- **pQoS:** predictive Quality of Service;
- **AI:** Artificial Intelligence;
- **PC5:** interface to allow direction communication between devices in a 5G network.

CARTOGRAPHY



5GMOBIX

- Vigo - Porto *(Spain-Portugal Corridor)*
- Kipoi – Ipsala *(Greece-Turkey Corridor)* Hard borders
- Berlin and Stuttgart *(German)*
- Espoo *(Finland)*
- Paris *(France)*
- Eindhoven-Helmond *(Netherland)*
- **China Test Site: Jinan*
- **South Korea Test Site: Yeonggwang*

5GMED

- Corridor E-15 Figueres – Perpignan
- Castellolí Track *(Spain)*
- TEQMO Centre, Paris *(France)*

5GCARMEN

- Corridor Germany-Austria-Italy
- Trento *(Italy)*
- Munich *(Germany)*
- Brenner Pass *(Italy-Austria)*
- Kufstein *(Austria-Germany)*

5GCroCo

- Corridor France-Germany-Luxembourg
- Barcelona *(Spain)*
- Monthléry *(France)*
- Munich *(Germany)*
- A9 5G-ConnectedMobility Testbed *(Germany)*
- AstaZero *(Sweden)*

5G-Blueprint

- 5G cross-border in waterways and high-ways between Belgium and The Netherlands

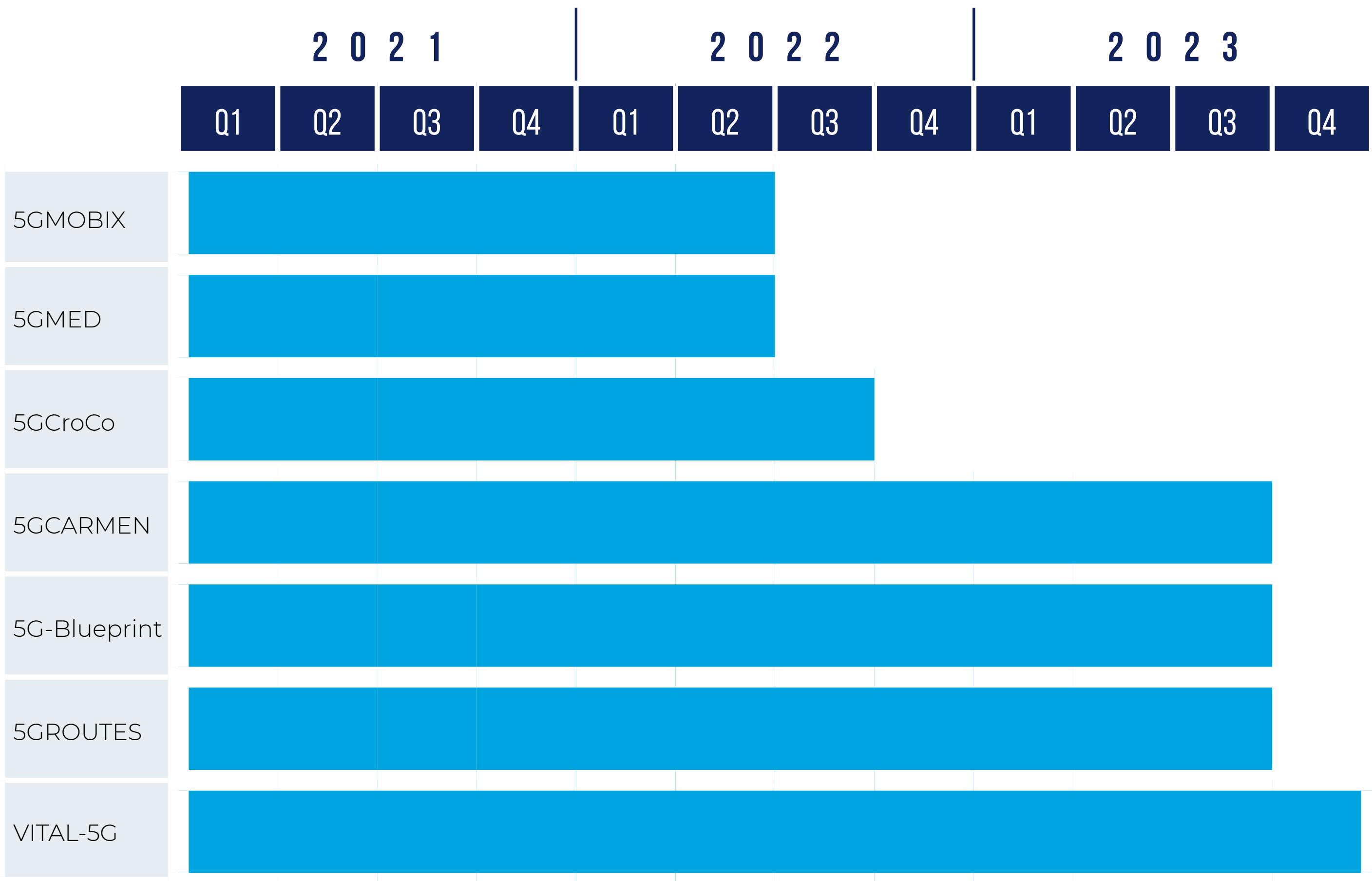
5GROUTES

- 5G cross-border Via Baltica-North corridor
- Latvia-Estonia-Finland

VITAL-5G

- Port of Galati *(Romania)*
- Port of Antwerp *(Belgium)*
- Port warehouse/logistics hub of Athens *(Greece)*

TIMELINE



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This material has been designed and printed with support from the Full 5G project and the 5G Infrastructure Association. The Full 5G Project has received funding by the European Commission's Horizon 2020 Programme under the grant agreement number: 856777. The European Commission support for the production of this publication does not constitute endorsement of the contents, which reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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Design by Martel Innovate