5G enabled CCAM at Spain-Portugal X-border corridor

José Santa – Technical University of Cartagena
University of Murcia (UMU) group

Valencia, June,2019

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 825496

5G-MOBIX

5G for Cooperative, Connected and Automated Mobility

5G-MOBIX will develop and test automated vehicle functionalities along multiple cross-border corridors and urban trial sites, under all conditions of vehicular traffic, network coverage, service demand, as well as considering the inherently distinct legal, business and social local aspects.

OBJECTIVE 1: Formulate **5G technological requirements** for advanced Cooperative Connected and Automated Mobility use cases.
OBJECTIVE 2: Establish corridors to **evaluate 5G technologies and advanced CCAM** in both highway cross-border and urban mobility scenarios under all conditions.
OBJECTIVE 3: Analyse **costs and benefits** of dedicated and validated 5G architecture and CCAM to justify commercially the technologies and deployments.
OBJECTIVE 4: Explore and asses **new business opportunities** for CCAM with 5G.
OBJECTIVE 5: Provide **5G deployment scenarios** and recommendations to drive CCAM adoption and effective implementations from business and policy perspectives.
OBJECTIVE 6: Sustain **standardisation and spectrum allocation** by actively contributing to the discourse.
OBJECTIVE 7: **Scale up and replicate** for a global adoption of the 5G for CCAM.

5GMOBIX

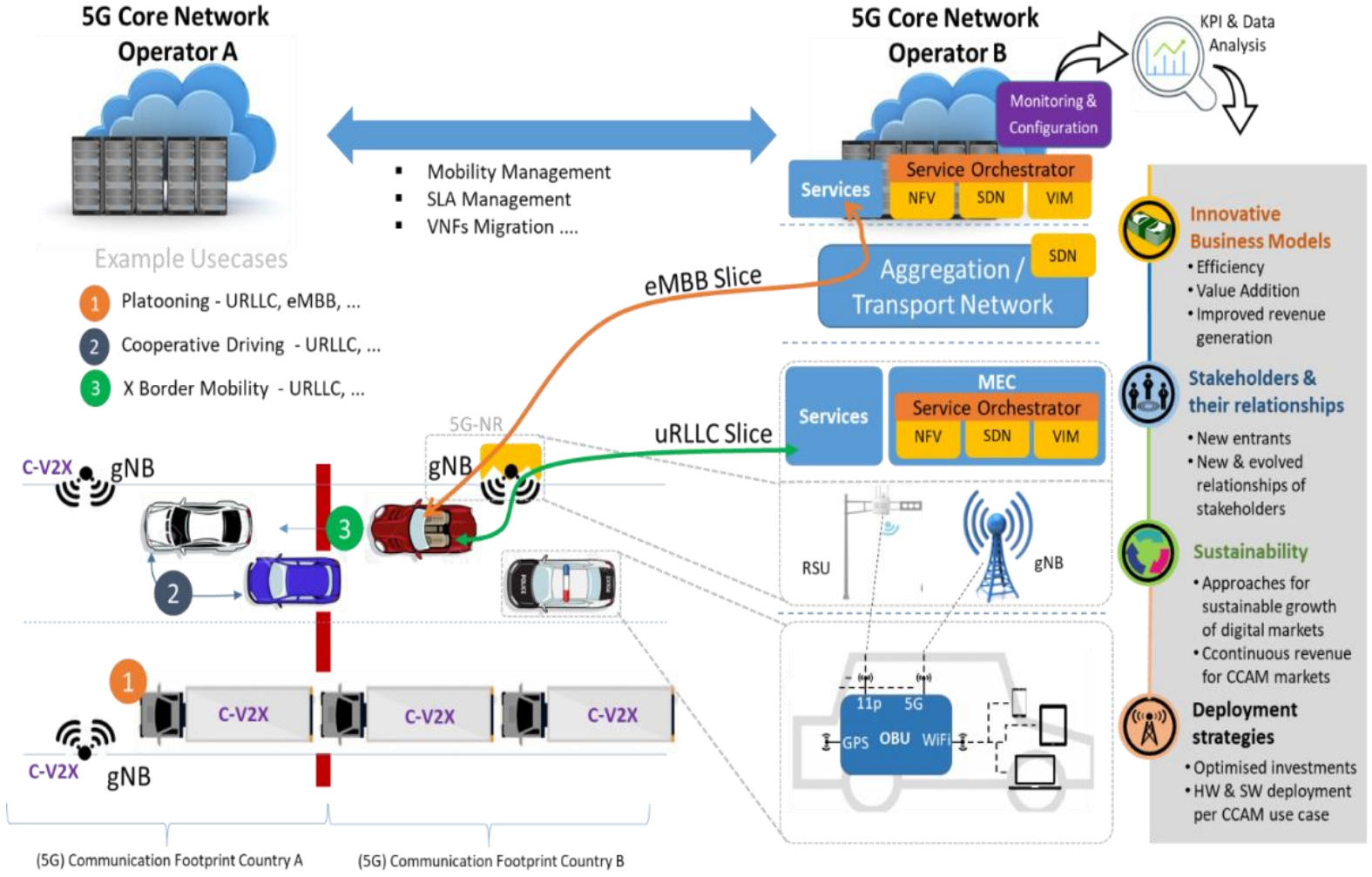
5G-MOBIX

Trials through 2 network slices:

- eMBB for high data throughputs
- uRLLC for low latency connectivity

Local and cross-border trials with challenging Automated driving scenarios:

- Cooperative manoeuver
- Platooning

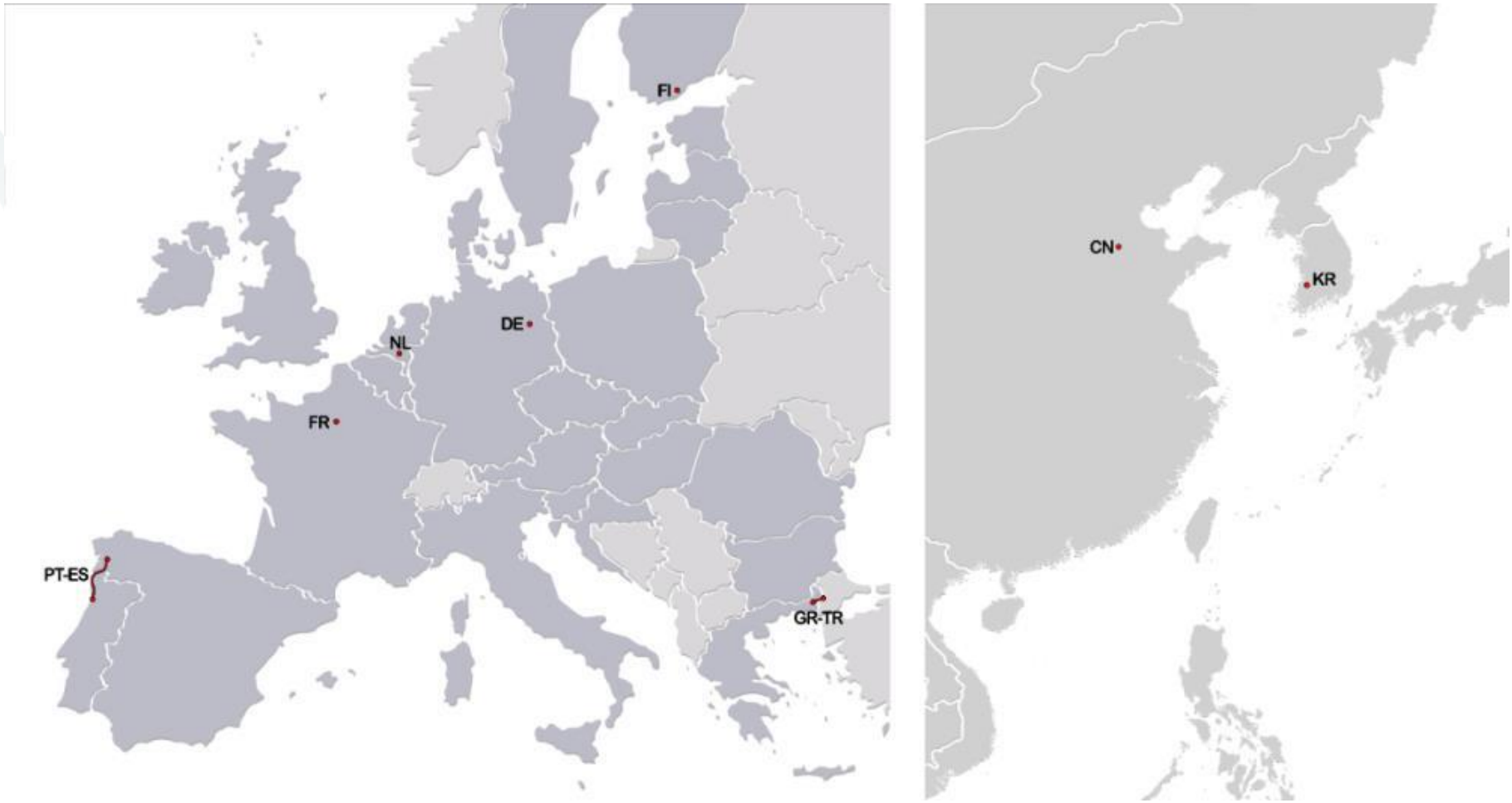


5GMOBIX

5G-MOBIX - Partners

5GMOBIX

5G-MOBIX – Trial Site



5GMOBIX

X-Border Trial. Site - Localization & Partnership

Objective: **5G-powered CCAM services and applications** in a cross-boarder fashion

Localization: The Spanish-Portuguese corridor connects the cities of Vigo and Porto, covering a road lenght around 250 Km, and using next roads/highways.

Partnership: car manufactures, telecom companies, public administrations and research institutions.

Spain

Portugal

DGT Dirección General de Tráfico · CTAG · Telefónica Telefónica I+D · ALSA · POLITÉCNICA · Infraestruturas de Portugal · IMT Instituto da Mobilidade e dos Transportes, I.P. · Centro de Computação Gráfica · norte litoral · NOKIA · SIEMENS · Universidad de Murcia · NOKIA Bell Labs · Concello de Vigo · DEKRA On the safe side. · AEVAC · 25 anos instituto de telecomunicações · OTIS · A-to-Be Powered by Brisa · NOS

Advisory Board: Telefónica

Associated Partners: Telefónica Móviles · PSA Groupe

Spain:

A55 (65 Km)
AP9 (50 Km)
Urban Roads in the city of Vigo (4 Km)

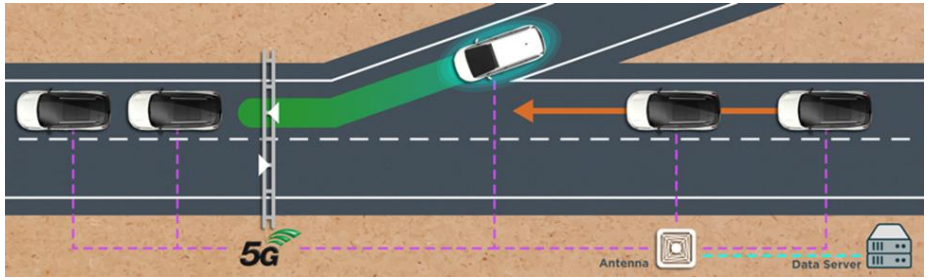
Portugal:

A3 (100 Km)
A28 Passenger Boat Terminal and Airport (7 Km)
N13 (55km)

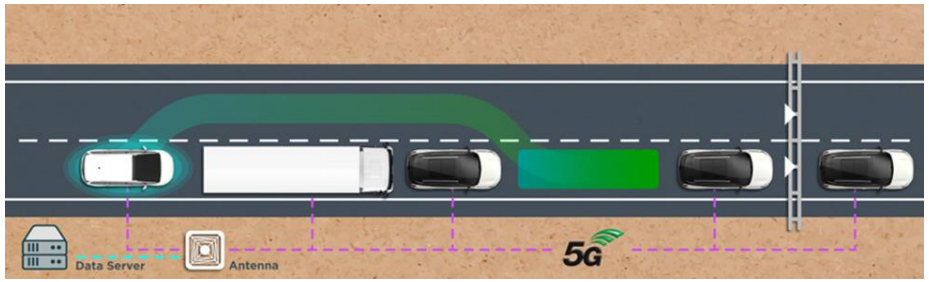
5GMOBIX

Use Case 1: Interurban complex scenarios for private automated vehicles

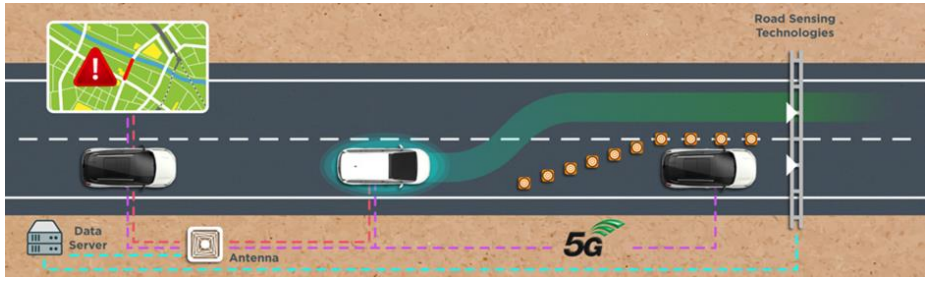
- **Scenario 1: Lane merge for automated vehicles.**
  - Receiving traffic data of vehicles in a line merge scenario will provide an extended perception layer to the automated system for determining the best merge manoeuvre.



- **Scenario 2: Automated overtaking.**
  - Sharing and receiving perception data from near vehicles before doing an automated overtaking will improve safety in the manoeuvre by enriching the 360º perception layer of the own vehicle.



- **Scenario 3: HD Maps – FCD.**
  - Ability of automated vehicles to modify and update HD Maps in real time based on ITS Centre events and self defined new paths will provide an improvement in safety for other vehicles which can obtain the most updated road data.

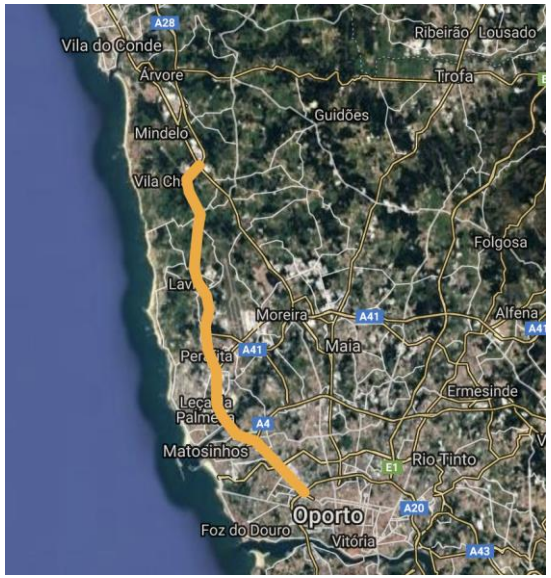


5GMOBIX

Use Case 1: Interurban complex scenarios for private automated vehicles

Deployment Spain

- A lane merge area and a overtaking area has been selected near Porriño (Vigo).
- For the HD-Maps-FCD the complete areas for the previous scenarios will be used.



Deployment Portugal

- Lane Merge and Automated Overtaking will be deployed in the A28 road near Porto (Airport and Sea Harbour).
- The same road will be used for HD-Maps-FCD scenario.

X-Border tests

- Lane Merge: two areas, one per country.
- Overtaking: both directions, single stretch.
- Areas used for the HD-Maps-FCD Scenario.

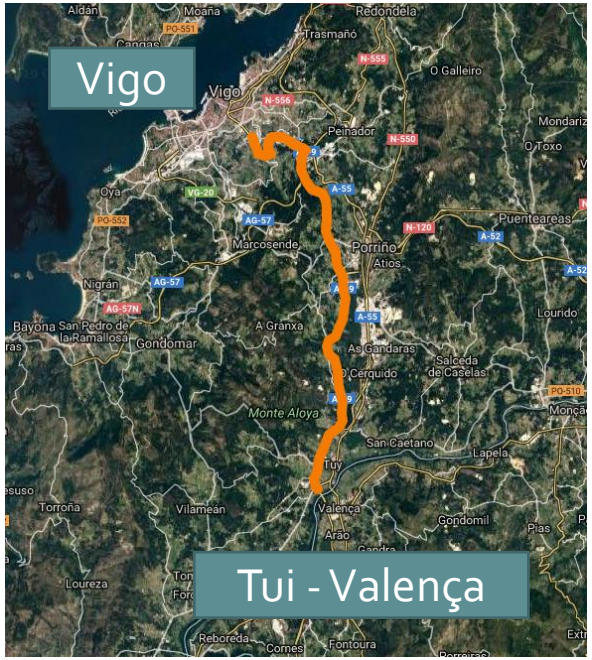
5GMOBIX

Use Case 2: Interurban Scenario for Public Transport

- Real time connected services in public transport fleet that connects the cities of Vigo and Porto.
  - **Streaming of 4K** camera and in-vehicle sensors data to the ALSA Control Centre.
  - Streaming the **in-vehicle sensors data** to near vehicles and to TMC.
  - User access to **high definition multimedia** content with great quality of service.

Deployment Spain & Portugal

- ALSA bus route between Vigo and Oporto, with X-border area



5GMOBIX

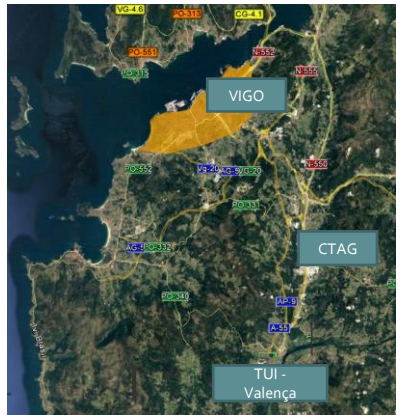
Use Case 3: Last Mile EV Automated Shuttle vehicles in crossborder and urban environments

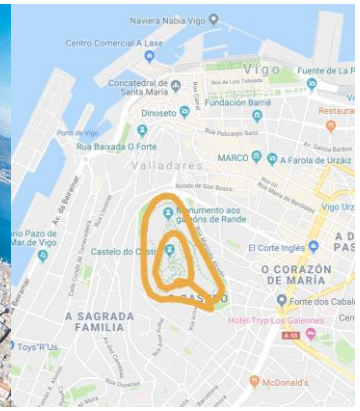
- Solutions for Last Mile EV Automated Shuttle vehicles in different environments:
  - **Cross-border environment**: route between Tui (SP) and Valença (PT).
  - **Urban environment**: route in the city of Vigo.
- **Scenario 1: Cooperative automated operation**
  - The EV Autonomous Shuttle will be able to receive information coming from other actors (like a Vulnerable Road User), and adapt its behaviour according to specific needs.
- **Scenario 2: Remote control**
  - The EV Autonomous Shuttle will be remotely controlled by an operator for avoiding an obstacle when its predefined route is blocked.

5GMOBIX

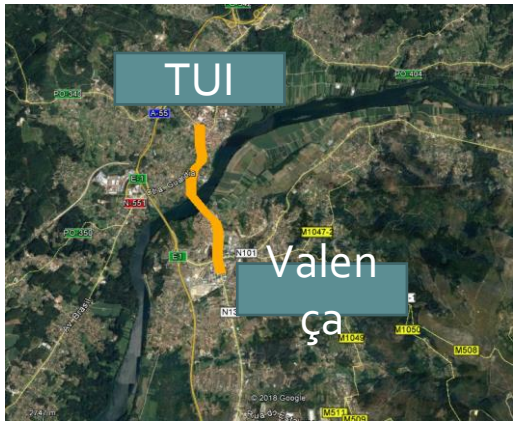
Use Case 3: Last Mile EV Automated Shuttle vehicles in crossborder and urban environments

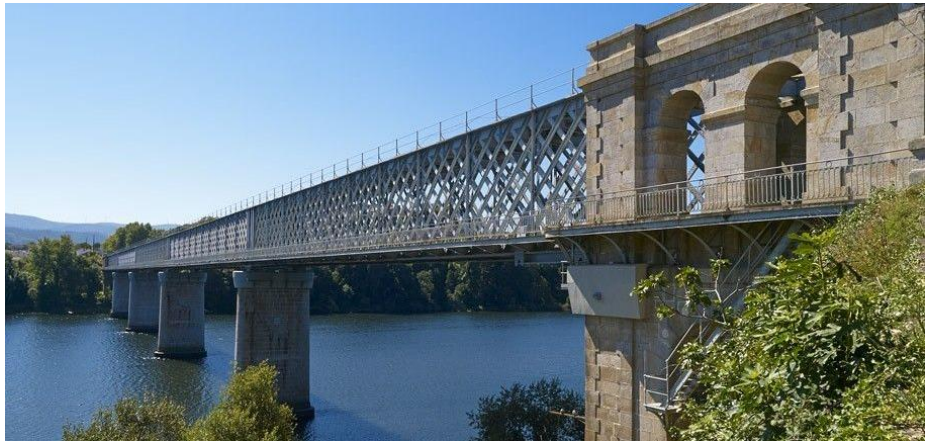
- First deployment at the city of Vigo





- X-Border deployment Tui-Valença old bridge





5GMOBIX

Vehicles

- **ALSA Bus with Premium services:**
  - Interior and exterior cameras.
  - Communication unit developed by CTAG.
  - Currently legal and in service between the cities of Porto and Vigo.

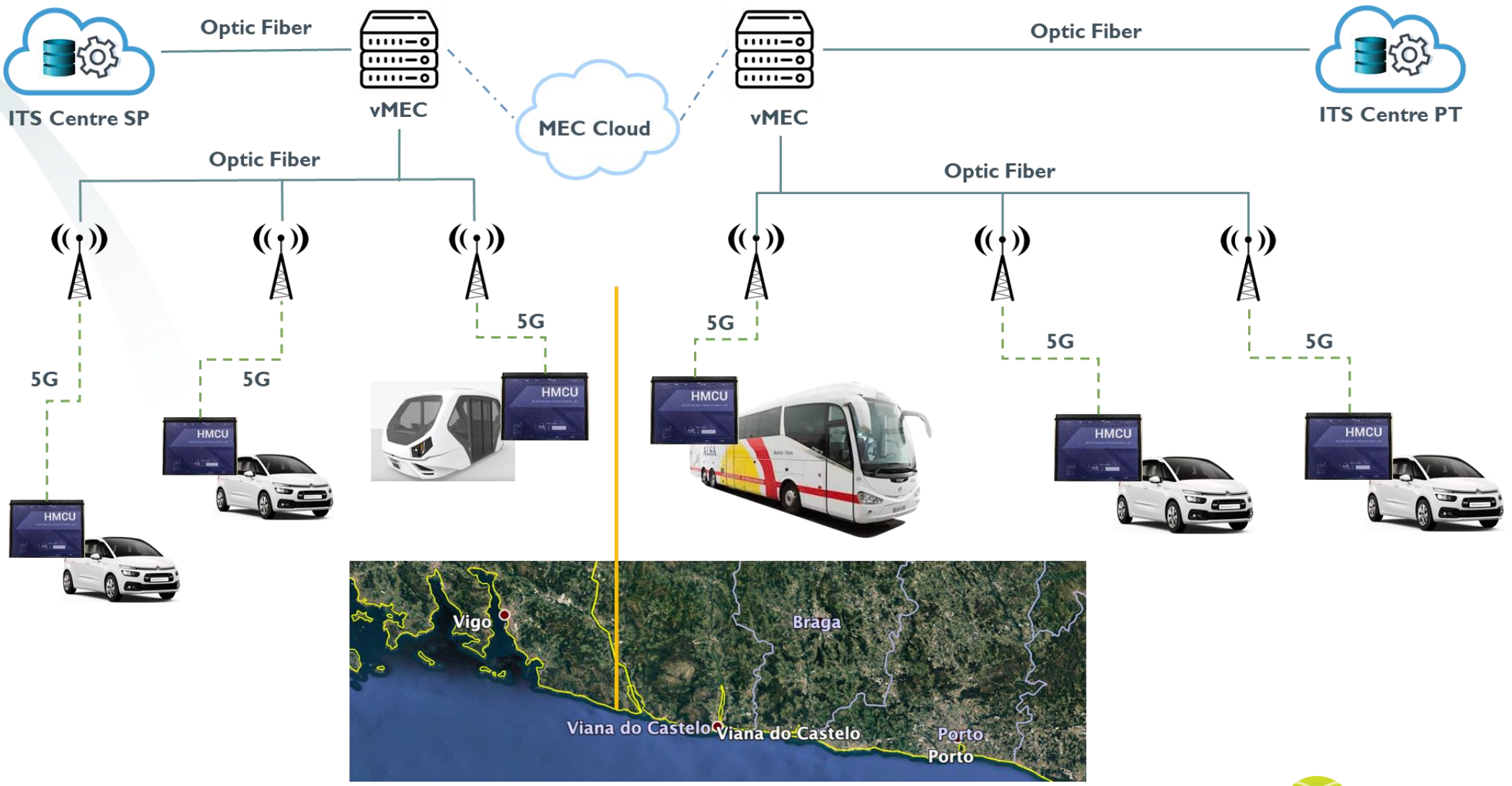
- **CTAG Shuttle EV Bus:**
  - SAE L4.
  - Real-time remote driving.
  - Communications unit developed by CTAG.
  - Sensors: LIDARs 2D and 3D, cameras, Map Unit, DGPS+IMU.

- **C4-Picasso (Automated Car):**
  - 3 Citroën C4 Picasso, SAE L4 / Automated driving functions.
  - Communications unit developed by CTAG.
  - Sensors: LIDARs 2D and 3D, cameras, Radars, Map Unit, DGPS+IMU.

- **Volkswagen Golf (Automated Car):**
  - Volkswagen Golf, SAE L4.
  - Communications unit developed by CTAG.
  - Sensors: LIDARs 2D and 3D, cameras, Radars, Map Unit, DGPS,+IMU.

5GMOBIX

Communications Architecture



5GMOBIX

Infrastructure Specifications

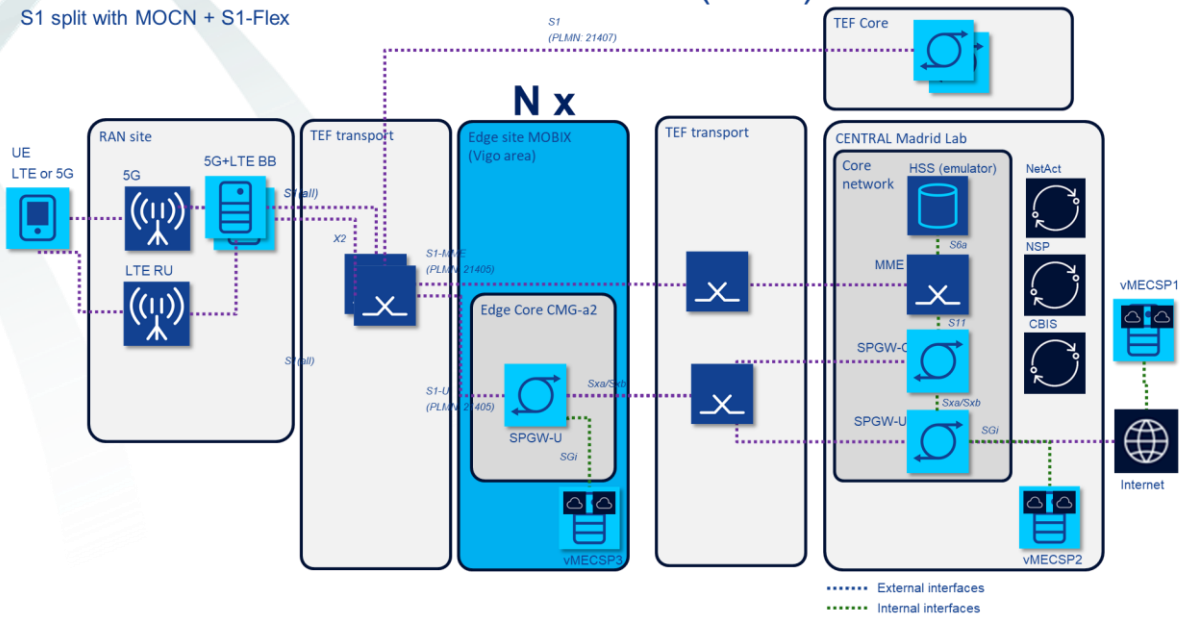
- **MEC nodes** with additional capabilities for interconnection with MEC nodes from another operator.
- A number of macro / small cells, initially based on **4G LTE but eventually upgradeable to 5G NR**, to reinforce the coverage in either a high band (e.g. 3.5 GHz) or a low band (e.g. 800 or 700 MHz).
- A **network slicing framework** for proper isolation between V2X and eMBB services, based on either SDN/NFV technologies or more traditional means (like e.g. local breakout and QoS differentiation).
- A number of **SIM cards** properly registered in Telefónica's provisioning systems for access to V2X services.
- **IP/MPLS** fixed network.
- Fibre optic network access points with energy power supply.

5GMOBIX

Communications Architecture – detailed view

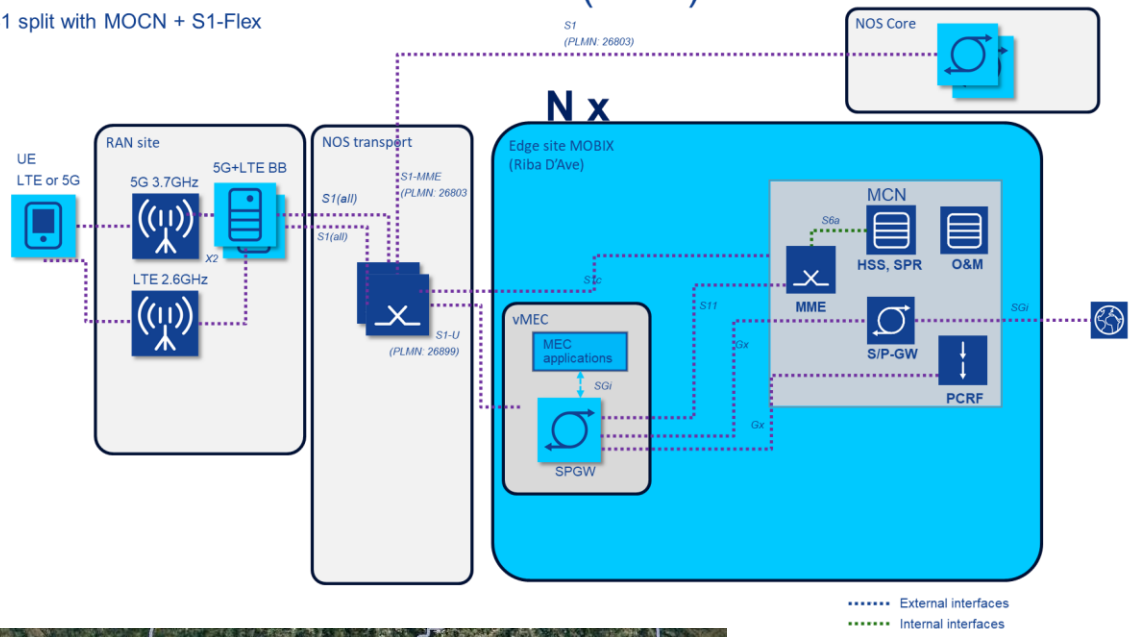
Telefonica - Trials architecture vMEC (2019) 2 PLMN IDs

S1 split with MOCN + S1-Flex



NOS - Trials architecture vMEC (2019) 2 PLMN IDs

S1 split with MOCN + S1-Flex



5GMOBIX

Evaluation KPIs

TECHNICAL

- Area traffic capacity.
- Availability.
- Bandwidth.
- Connection density.
- Control plane latency.
- Coverage area probability.
- End-to-end latency.
- Packet error rate.
- Transmission rate.
- Positioning & timing accuracy.
- Information age.
- Message payload.
- …

IMPACT

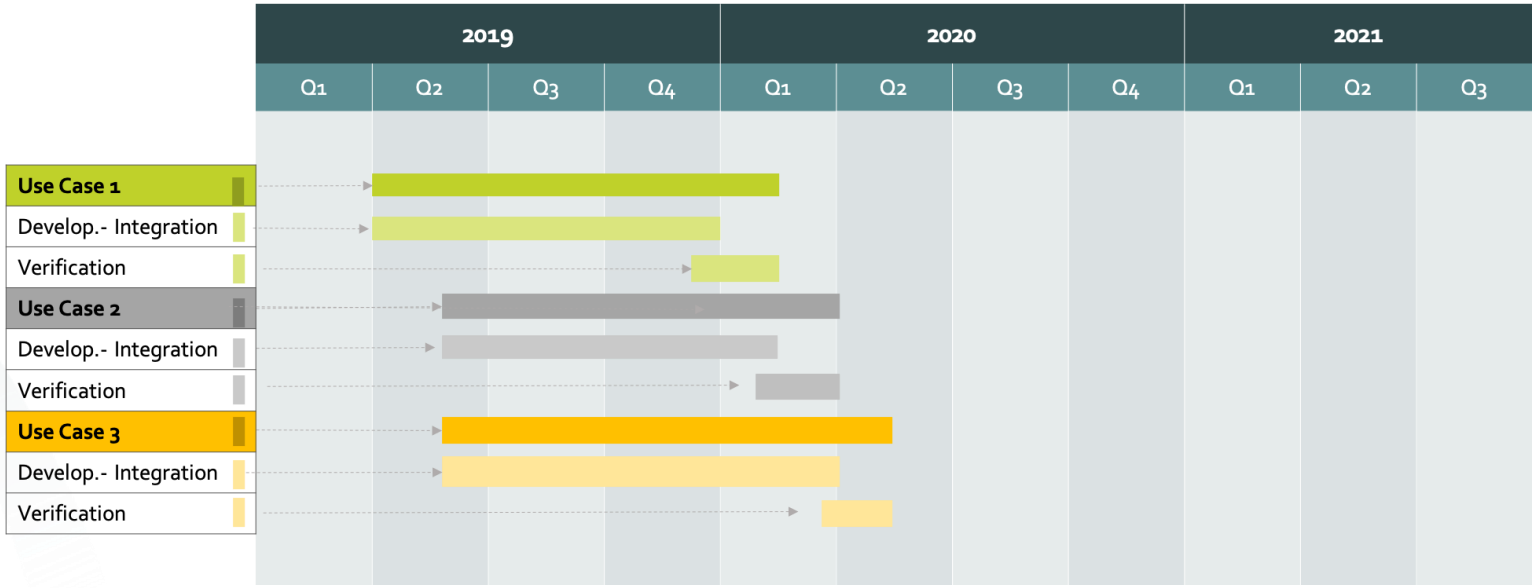
- Number of journeys.
- Length of journeys in distance.
- Proportion of use of each transport mode for journeys.
- Travel time per distance of journeys.
- Route of journeys.
- Route choice.
- Acceleration / deceleration.
- Emissions (Nox, PM, HC) / fuel consumption per 100 km.
- Speed (mean).
- …

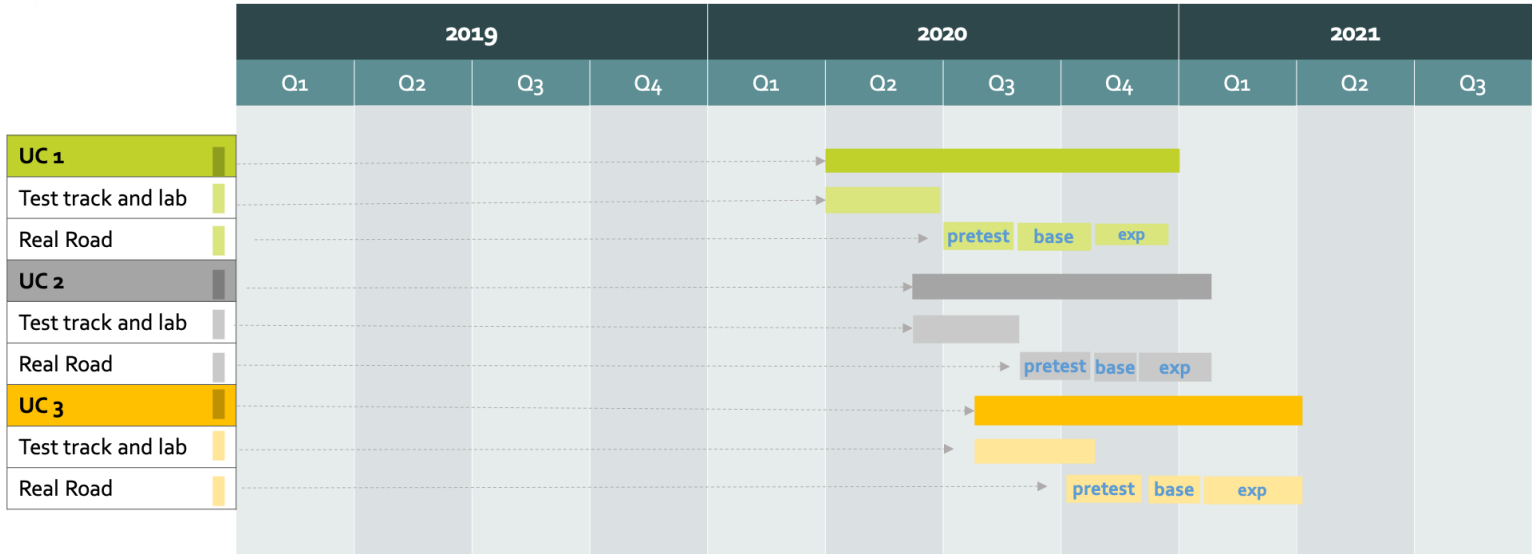
USER ACCEPTANCE

- Percentage of goals achieved.
- Percentage of users successfully completing task.
- Time to complete task.
- Tasks completed per unit of time.
- Monetary cost of performing the task.
- Mental Workload.
- Rating scale for satisfaction
- Frequency of discretionary use.
- …

5GMOBIX

Corridor planning





5GMOBIX

Thank you

5GMOBIX

www.5g-mobix.com

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 825496