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Sustainable 5G deployment model for Future mobility in the Mediterranean Cross-Border Corridor

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SIS 11: Towards realising seamless automated cross-border mobility

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Project Overview

- Innovation Action funded by H2020 Research and Innovation programme (H2020-ICT-53-2020)

- **Main goal:** Evaluate capabilities of 5G technologies (3GPP Rel.16) to meet the requirements of advanced CAM (automotive) and FRMCS (railway) use cases in cross-border scenarios

1. Design a cross-border 5G network architecture that can be replicated along European corridors

2. Deploy two 5G SA networks (France, Spain) along 65 km of the Mediterranean cross-border corridor between Figueres (Spain) and Perpignan (France)
    - E-15 highway
    - High-speed rail track (incl. 8 km cross-border tunnel)

3. Deploy and demonstrate 4 CAM and FRMCS use cases

Use Cases (I)

- UC1: Remote driving
  - Teleoperation of autonomous vehicle that finds complex traffic situation
  - Transmission of video images, sensors data, and teleoperation commands
  - Requirements: Very low latency, high data-rate, high reliability, very short interruption time

- UC2: Road Infrastructure Digitalization
  - Vehicles and roadside sensors detect hazards and abnormal traffic situations
  - Traffic Management Center disseminates warnings and traffic recommendations
  - Requirements: Low latency, very high reliability, short interruption time

Use Cases (II)

- UC3: Future Railway Mobile Communications
  - Monitoring of sensors on-board the train and detection of obstacles on rail tracks
  - Provide high-performance wireless connectivity to passengers
  - Requirements: Low latency, very high data rates, short interruption times

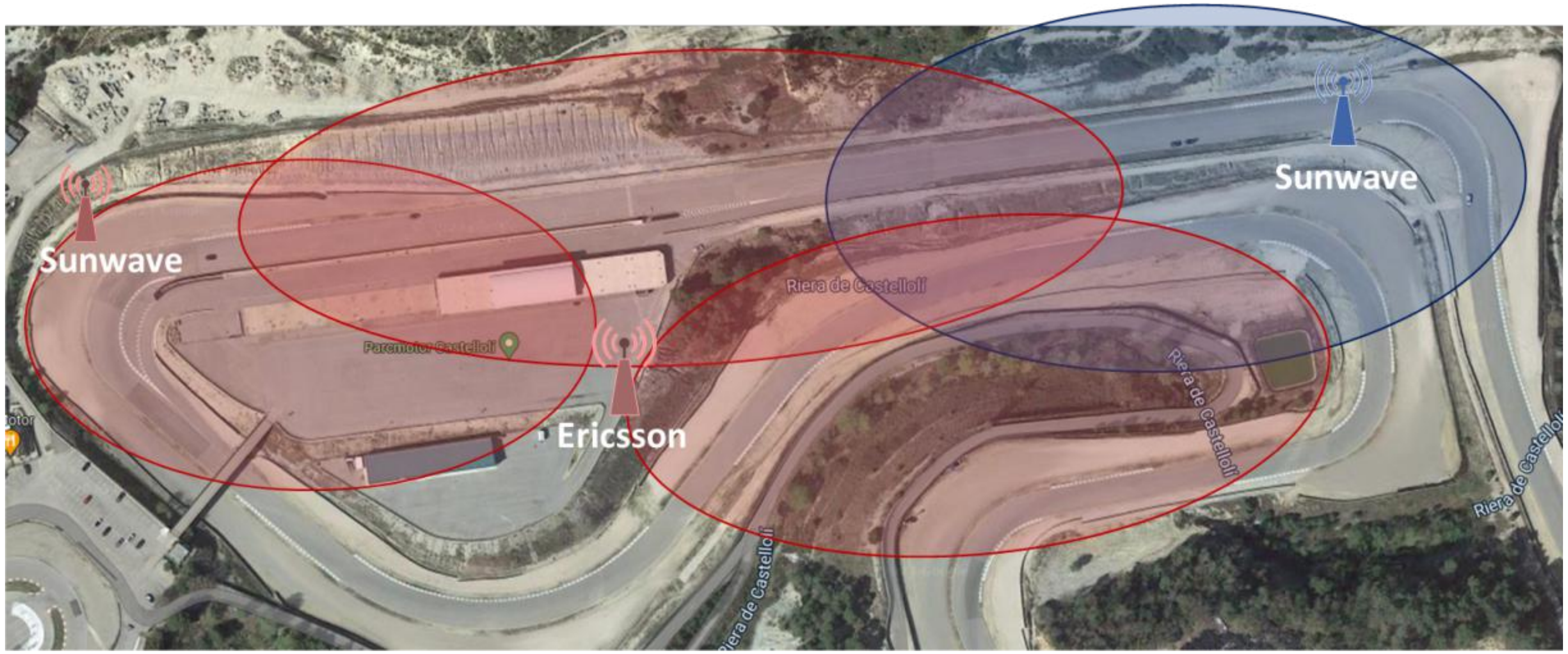
- UC4: Follow-Me Infotainment
  - Distribution of high-quality media content to passengers
  - Media services deployed on edge nodes and follow movements of UEs
  - Requirements: Low latency, high data rates, low jitter, short interruption times

Main Challenges

- Existing Home Routed Roaming (HRR) mechanism introduces long interruption times (+ 1 min.) → unfeasible for seamless service continuity → We need roaming optimization techniques
- HRR induces high latency because user data are routed to the home UPF when the UE is in a visited network → We need Local Break-Out (LBO) roaming
- To guarantee service continuity across the border → we need cross-border interfaces between…
  - Orchestrators of different MNOs (to orchestrate slicing and deployment of services)
  - MECs of different MNOs (to exchange data of services deployed in MEC)
- Irregular orography and dense vegetation in cross-border area → we need complementary radio technologies to cover 5G NR holes (70 GHz & satellite in remote/isolated areas, C-V2X)

Achievements: Castellolí small-scale test site (I)

- Small-scale test site representing the cross-border scenario (1 Spanish MNO, 1 French MNO)
- Multi-vendor 5G RAN: 1 gNodeB (Ericsson), 2 small cells (SunWave)
- 2 Instances of 5G SA Druid Core



Achievements: Castellolí small-scale test site (II)

- HRR in idle mode with **equivalent PLMN and N14 interface*** → Interruption time is less than 1 sec
  - ePLMN eliminates the need for blind attachments attempts
  - N14 interface between AMFs of both MNOs
    - Reduces registration time: the AMF of visited network gets the UE context from the source AMF
    - Reduces user plane re-establishment time: the visited network is informed of used UPF and UE IP address

Time	Longitude	Latitude	PLMN-id	Tech.	RSRP	Speed	Altitude
2023.02.01_10.04.52	1.6924354	41.592380	999_99	5G	-107	25	388
2023.02.01_10.04.54	1.6924824	41.592272	999_99	5G	-107	22	387
2023.02.01_10.04.56	1.6924362	41.592173	999_99	5G	-104	20	387
2023.02.01_10.04.58	1.6922947	41.592125	999_99	5G	-107	23	387
2023.02.01_10.05.00	1.6921072	41.592150	999_99	5G	-107	30	386
2023.02.01_10.05.01	1.6921072	41.592150	001_01	5G	-101	30	386
2023.02.01_10.05.02	1.6918982	41.592216	001_01	5G	-101	31	386
2023.02.01_10.05.04	1.6916944	41.592236	001_01	5G	-103	30	386
2023.02.01_10.05.06	1.6914850	41.592197	001_01	5G	-95	32	385
2023.02.01_10.05.08	1.6912986	41.592089	001_01	5G	-96	34	383

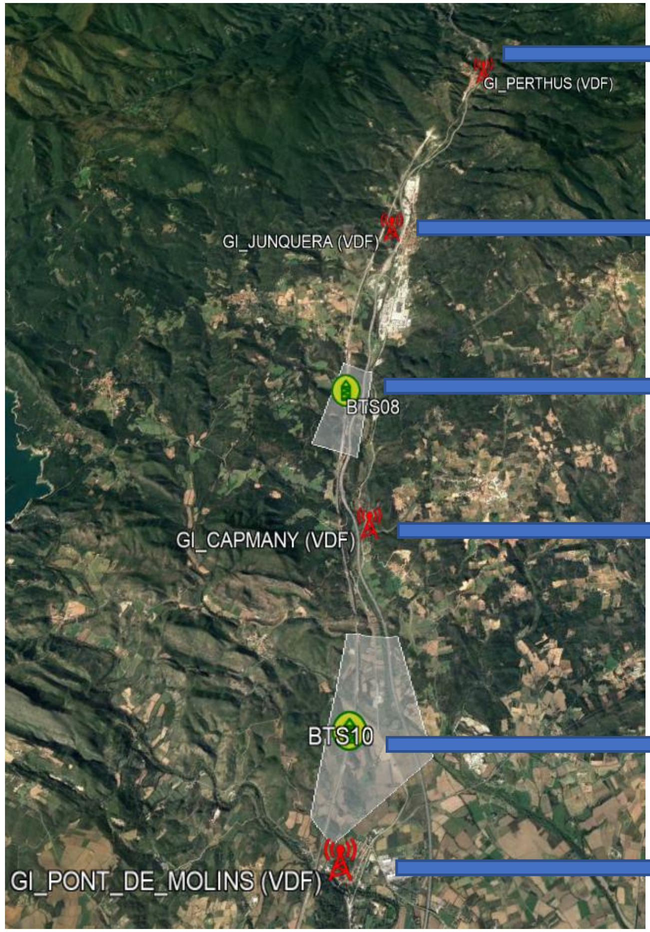
Interruption time < 1 sec.

- **On-going**: tests of roaming including **radio handover between cross-border gNodeBs*** → interruption time < 100 ms

* Network Reselection Improvements recommended by 5GAA

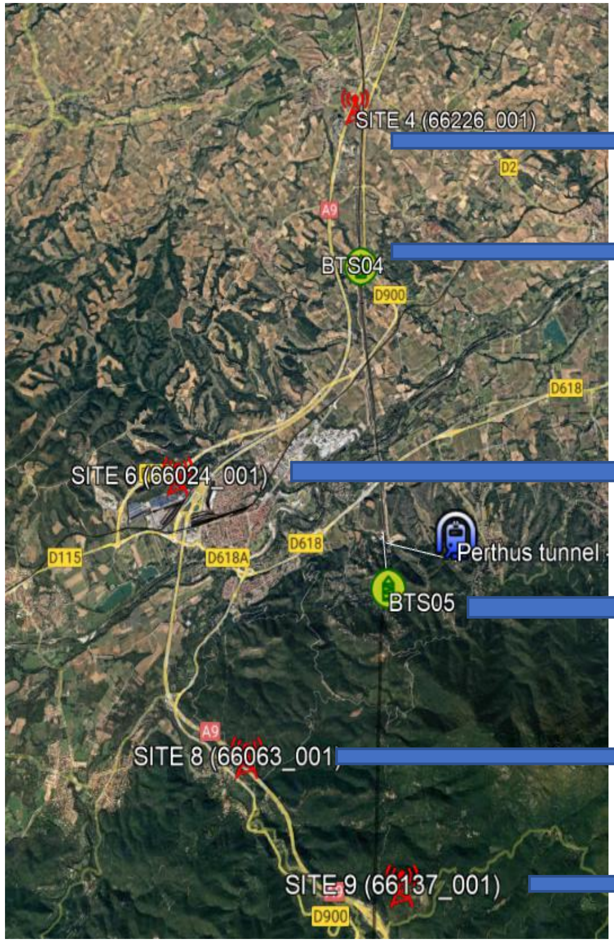
Achievements: Cross-border test site

SPAIN



- GI_PERTHUS (VDF) → ON AIR
- GI_JUNQUERA (VDF) → ON AIR
- BTS08 → 30.07.2023
- GI_CAPMANY (VDF) → ON AIR
- BTS10 → ON AIR
- GI_PONT_DE_MOLINS (VDF) → ON AIR

FRANCE



- SITE 4 (66226_001) → 30.06.2023
- BTS04 → 30.06.2023
- SITE 6 (66024_001) → 17.05.2023
- BTS05 → 31.08.2023
- SITE 8 (66063_001) → 31.08.2023
- SITE 9 (66137_001) → ON AIR

Business models within the value chain

- Neutral host operator (Cellnex) installs 5G RAN infrastructure along the corridor
- The 5G RAN infrastructure is shared by different MNOs (VDF, Free Mobile)

- Lease model
  - Neutral Host leases the 5G infrastructure for a fee
  - Fees depend on amount of data used, number of customers, and includes service level agreements (SLAs)

- Revenue sharing model
  - Neutral Host and MNOs share revenue generated by 5G infrastructure based on the usage of network by MNO customers
  - Revenue sharing agreement based on % of revenue generated by MNO or a flat fee per customer

- Managed service model
  - Neutral Host provides managed services for the 5G infrastructure (site acquisition, construction, equipment procurement, installation, and maintenance)
  - MNOs pay fixed fee for the managed services based on SLAs or other performance metrics

Lessons learned when deploying the solutions

- Commercial equipment not fully-compliant with 3GPP Release 16 features
  - Most smartphones do not support “testing” (non-commercial) PLMN IDs
  - Limited numbers of UEs support slicing. Those supporting can only be active with 1 slice
  - 5G RAN slicing still not supported by some RAN vendors (e.g., Sunwave)
  - Handover between gNodeBs of different RAN vendors fails due to incompatibility issues

- Roaming mechanisms/optimizations not implemented in most 5G Cores (commercial, open-source)
  - Need to align project timeline and 5G Core manufacturers roadmap (N14 interface, LBO roaming)

- Deployment of orchestrated (dynamic) network slicing in RAN side is still far from being realistic
  - Commercial RAN equipment allows communication with an orchestrator through OSS, but it is expensive, or it is not possible due to cybersecurity issues
  - Most O-RAN equipment that allow direct communication with orchestrators are still unstable

- Irregular orography in corridor requires complex transport networks (multi-hop microwave links)

Recommendations

- Long time to get permits for trials and demo in highway → Simplify procedures with road authorities

- Drive long distances and need permits for tests in cross-border corridor → Use small-scale test sites for fast deployment and validation (lessons learned can be directly applied in corridor)

- Limited number of tools for measurements of 5G network metrics → Develop platforms for KPI collection, storage, and real-time visualization

- Non available datasets including "5G network metrics and road traffic data" in cross-border scenarios (to train AI for network optimization) → Motivate generation of open-source datasets

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Thank you!

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