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Abstract

The deliverable provides a test plan for the 5G-DRIVE V2X trials at the Espoo and JRC Ispra trials sites. The deliverable provides details about the pilot site infrastructure, the use cases, the intended test scenarios and methodology for evaluation

[End of abstract]

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[1] http://creativecommons.org/licenses/by-nc-nd/3.0/deed.en_US

Executive Summary

5G-DRIVE objectives include developing 5G technologies at pre-commercial testbeds V2X service, and then demonstrating Internet-of-Vehicle (IoV) services using Vehicle-to-Network (V2N) and Vehicle-to-Vehicle (V2V) communications. Evaluating 5G benefits on V2X will result from Trial scenarios to be carried out on two main pilot sites in EU, namely Espoo in Finland and JRC at Ispra in Italy.

The objectives of the trials are to test 5G network capabilities to deliver ultra-reliable lower-latency communication (URLLC) for self-driving scenarios and to validate 5G KPIs in terms of bandwidth, latency and communication coverage in different scenarios and pilot sites as well evaluating V2V and V2N communications resilience against cyber/RF attacks and interference under real-life conditions.

This deliverable aims at specifying the plans for the required V2X deployment, as well as the methodology to execute the trials on the two sites, Espoo in Finland and JRC at Ispra in Italy.

Following a short introduction of the deliverable in Section 1, Section 2 provides a description of a generic methodology for defining the deployment plans to execute the trials. The methodology aims at providing a consistent description of the two pilot sites as well as an approach to execute the trials and evaluate the results.

The section 3 provides a detailed description of the plans for deployment, testing and validation for the two pilot sites. The section is split into two sub-sections corresponding to each pilot site. Espoo and Ispra trial sites have different trial objectives:

- Trials at Espoo aim to demonstrate 5G benefits for automated driving use cases.
- Ispra trials are focusing on evaluating the co-existence of ITS-G5 and LTE-V2X.

The two sub-sections in Section 3 are providing different types of deployment and trial plans, but both following the taxonomy provided in Section 2.

Espoo trials will execute trials with self-driving vehicles on public roads with real driving environments. The 5G and infrastructure deployments will also be part of real infrastructure components, supported by 5G network equipment vendors and local Mobile Operators.

Ispra trials will be carried out at the JRC laboratories, and thus be executed in a “controlled” environment, being radio measurement labs and anechoic chambers. The test methodology is part of harmonised standards relating to Radio-communications equipment operating in the 5.855 MHz to 5.925 MHz frequency band.

The Trials plans are therefore combining two main types of testing with vehicles driving in a real environment, thus needing more “natural” testing scenarios together with testing scenarios in a “controlled” environment, based on harmonised standards. This combination intends to provide the required diversity of test for evaluating the suitability and benefit of 5G for V2X scenarios.

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Abbreviations

C-V2X	Cellular V2X referring to all forms of cellular V2X communications, i.e. LTE-V2X and 5G-V2X
DENM	Decentralized Environmental Notification Basic Service as specified in ETSI EN 302 637
EC	European Commission
ECU	Embedded Control Unit
FESTA	Field opErational teSt supporT Action (see [1])
GLOSA	Green Light Optimized Speed Advisory
IoV	Internet-of-Vehicle
ITS-G5	Acronym defined in EN 302 663 (ITS access layer specification) and standing for the Physical and Data layers for the ITS ad hoc network, as defined in ETSI EN 302 665 (ITS communication architecture)
JRC	Joint Research Centre in Ispra (see: https://ec.europa.eu/jrc/en/about/jrc-site/ispra)
KPI	Key Performance Indicators
LTE	Long Term Evolution as standardised by 3GPP from release 8 onwards (see: http://www.3gpp.org/technologies/keywords-acronyms/98-lte)
LTE-V2X	LTE-V2X is a specific utilisation of LTE for vehicle to "everything" communications, including V2V, V2I, V2N, introduced first in 3GPP Release 14 (see: ETSI TR 121 914 V14.0.0 section 7)
OBU	On-Board Unit
RSU	Road Side Unit
URLLC	Ultra-Reliable Low-Latency Communication
V2I	Vehicle to Infrastructure
V2N	Vehicle to Network
V2V	Vehicle to Vehicle communication

1 Introduction

One of 5G-DRIVE objectives is to develop key 5G technologies at pre-commercial testbeds V2X services and then demonstrate IoV services using Vehicle-to-Network (V2N) and Vehicle-to-Vehicle (V2V) communications.

To evaluate those benefits of 5G on V2X scenarios, trial scenarios will be carried out on two main pilot sites in EU, namely Espoo in Finland and JRC at Ispra in Italy. The objectives of the relating tasks include:

- Defining and demonstrating 5G-based IoV scenarios
- Ensuring the interoperability between Chinese and European IoV technologies
- Testing 5G network capabilities to deliver Ultra Reliable Low Latency Communication (URLLC) for self-driving scenarios
- Validating 5G KPIs in terms of bandwidth, latency and communication ranges in different scenarios and pilot sites;
- Evaluating V2V and V2N communications resilience against cyber/RF attacks and interference under real-life conditions.

This deliverable aims at specifying the plans for the required V2X deployment, as well as trial methodology on the two trial sites, Espoo in Finland and JRC at Ispra in Italy.

Section 2 provides a description of a generic methodology to ensure the provision of a consistent description of the two pilot sites.

Section 3 provides a complete description of the plans for deployment, testing and validation for the two pilot sites.

2 Pilot Site Infrastructure and Trial Methodology

The V2X trials will be carried out in 3 main phases:

- Phase 1 - Trial setup and preparation
- Phase 2 - Trials execution
- Phase 3 – Evaluation

This section provides a generic plan to be applied by the V2X trial sites, namely Espoo in Finland and JRC at Ispra, Italy. This plan actually corresponds to the results of the first phase: Trial setup, including the deployment of the trial site infrastructure and the pilot preparation.

This first section provides a description of the overall trial methodology according to the specified three phases. The next section consists of the actual V2X test plan, corresponding to the first phase of the V2X trials, namely the setup and preparation, resulting in the trial plans for each of the two trial sites.

As the trials are not intending to assess driving or vehicle function, the evaluation methodology is not likely to follow thoroughly the Field opErational teSt supporT Action (FESTA) methodology (see:[1]). However, some methods and definition of the FESTA methodology are recommended to be used as a reference to ensure using a consistent definition of the different activities of the trials.

The two trial sites, Espoo and Ispra have different objectives for the trials. Trials at Espoo aim to demonstrate 5G benefits for automated driving use cases. Ispra trials are focusing on evaluating the co-existence of ITS-G5 and LTE-V2X.

2.1 Trial setup and preparation

The trial setup and preparation is the initial phase of the trial plan. This phase is used to prepare the trials and, in particular, to define and specify the trial environment as well as the actual trial scenarios and the evaluation methodology. The trial site setup will also include a description of the V2X developments as part of the trial site description.

The information relating to the trials setup and preparation is specific to each trial site so that in Section 3, individual trial plans for each trial site will be provided.

The trial setup and preparation phase enables to specify the following information concerning the trial environment and conditions for each trial site, which forms a generic trial plan:

- Trial site description
    - Trial site environment
        - Location with map
        - Main activities in the surrounding related to the trial use cases ...
    - Use cases to be utilised in the trials
    - Road infrastructure utilised by the use cases
        - Road type and usage (commuting, logistic …)
        - Physical Road infrastructure required for the use case (tunnels, crossing …)
        - IT road infrastructure (traffic lights, Cooperative ITS, traffic management …)
    - Connectivity infrastructure
        - ITS-G5
        - LTE-V2X, 5G-V2X (planned releases)
        - 5G core network
        - MEC relating to the use cases
        - Cooperative ITS protocols (Geo-networking, BTP, CAM, DENM…)

  - Vehicles
    - Types and Self Driving level
    - Details on inboard technologies: Radar/Lidar, HD cam, IoT gateways …
    - Users involved in the use cases: driver, passengers, pedestrian, cyclist …
  - Trial site organisation
    - Leader(s)
    - Actors
    - Legal (protection of privacy and risks …)
    - Other contracted or 3rd party partners: authorities, insurances, experts, road operators, connectivity providers, and MNOs
- Trial site test scenarios
  - Scenario description
    - Number and role of vehicles
    - Naturalistic driving or controlled testing
    - Interaction with the trial site environment
    - Note: the descriptions are likely to differ between the use cases
  - Test planning
    - The intended duration of the different types of test
    - Iteration and planning of the tests during the execution phase
  - Tools and methods for coordinating the scenarios
- Evaluation methodology
  - Evaluation objectives
  - Required data
  - Data management
  - Methods for the treatment of the evaluated data to generate evaluation results

2.2 Trial test scenarios

This section is intended for the Trial site to provide a description of the methodology to be applied to carry out and coordinate the execution of the trial. The methodology may also refer to existing standards for testing.

The methodology also includes a description of the different phases for the execution of the trials and the type of driving scenarios as well as the interaction with the infrastructure.

The type of description for the trial execution methodology depends on the use cases but needs to ensure the provision of the suitable data for the evaluation.

2.3 Evaluation

This section is intended for the Trial site to provide a description of the methodology for evaluating the results of the trials and deliver conclusions about benefits and challenges of using 5G in the context of V2X scenarios.

The evaluation methodology describes the objectives of the trials and the way to be used for providing an assessment of the objectives across the different scenarios.

3 Trial Plan

3.1 Espoo trial site plan

3.1.1 Trial site description

The 5G-DRIVE V2X main trial site is located in Espoo, Finland (e.g. Karaportti Nokia site; see Figure 1). Espoo area is equipped with 3.5 GHz base-stations. The length of the roads available in Karaportti site is about 2.6 km including intersections and parking areas. The site is equipped with a mobile traffic light and a base-station.

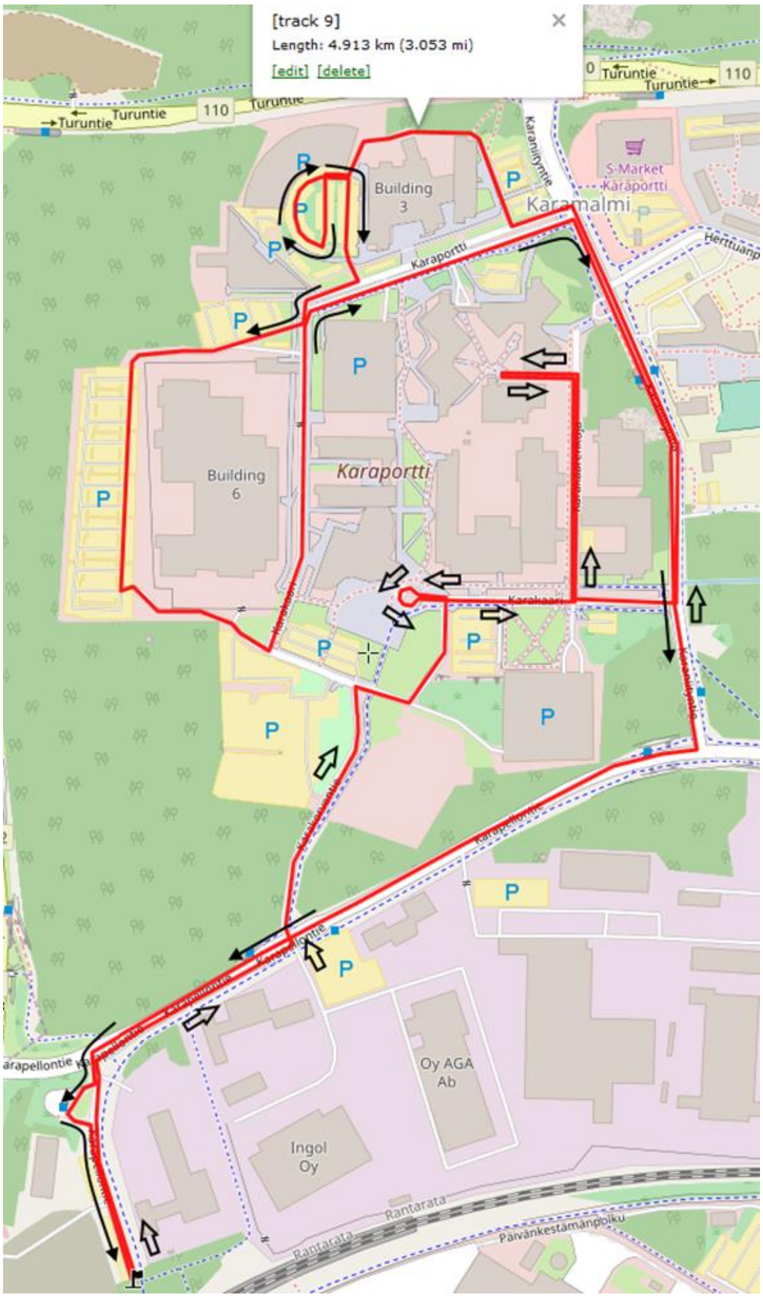

Figure 1: The V2X test site trial area in Espoo

The trial use cases in the test site are:

- Green Light Optimal Speed Advisory (GLOSA) V2I - The automated vehicle communicates with the infrastructure sub-system. The traffic light status is communicated via hybrid LTE/5G and ITS-G5 channels in intersection areas. The messages are C-ITS compatible using the latest version of SAE J2735 (2016).
- Intersection safety V2I – This use case emulates a pedestrian crossing an uncontrolled intersection with a conflicting path to an approaching vehicle. The infrastructure sends out a DENM (Decentralized Environmental Notification Message) via hybrid 5G and ITS-G5 channels. The use case is very time critical due to the safety aspect. Therefore, detections are emulated not to put real pedestrians at risk.

The roads are covered with asphalt with visible lane markings on site. The area is located in an industrial campus which is supervised by the company. Security controls are in place to enter the area.
This use case features a traffic light that is connected to the local mobile edge computing (MEC) server. Both use case scenarios are related to intersection driving. Traffic light is a mobile version which is configured to the local infrastructure restrictions (see Figure 2). The Dynniq RSU can easily be connected to the pole and only requires a Power over Ethernet (PoE) connection to the MEC server for communications. The Dynniq back office that provides an Message Queuing Telemetry Transport (MQTT) interface for exchanging messages. This back office will be the source of information for eMBB type communication, while the RSU is used for V2X-type communication.
A Real-Time Kinematic (RTK) base-station provides error correction to the GNSS signal. The base-station provides even 20-30 cm accuracy for positioning depending on the used receiver type.

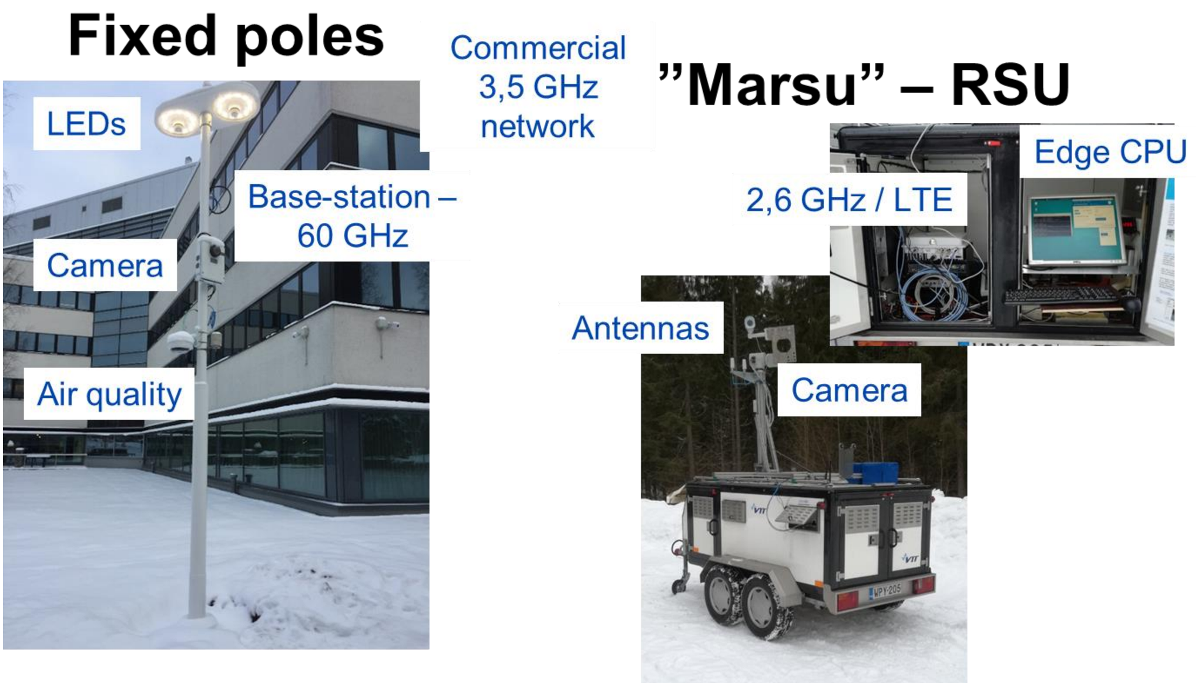

Figure 2: The smart lamps and MEC server available in the test area

The test site and the scenarios support hybrid 5G and ITS-G5 connectivity between vehicles. The cellular network is LTE-based but will be upgraded during Spring 2020. The scenarios are based on V2X support using 3GPP release 14 and later on also Rel.15/16 depending on the availability of communication modules. The interfacing is LTE Uu based and later PC5 if the communication modules become available.
The VTT's instrumented demo vehicle called 'Marilyn' is available for the scenario trials (see Figure 3to Figure 6). The car contains multiple sensors and communication devices like:

- 3 different 905 nm LiDARs for long range sensing

- 24 GHz radar for detecting metallic objects in front
- Stereo camera for 3D object detection in front of the vehicle
- Inertia unit for acquiring accelerations and heading of the vehicle
- GNSS receiver
- Sierra Wireless LTE communication unit (2,6 GHz band) which will be updated to 3,5 GHz
- Dynniq ITS-G5 communication module

Figure 3: Instrumented and automated Marilyn demo vehicle with on-board sensors

Figure 4: IMU, GNSS and antennas in the vehicles

Figure 5: The Embedded Control Units (ECU) and communication units (Sierra Wireless LTE and ITS G5) are in the trunk of the car

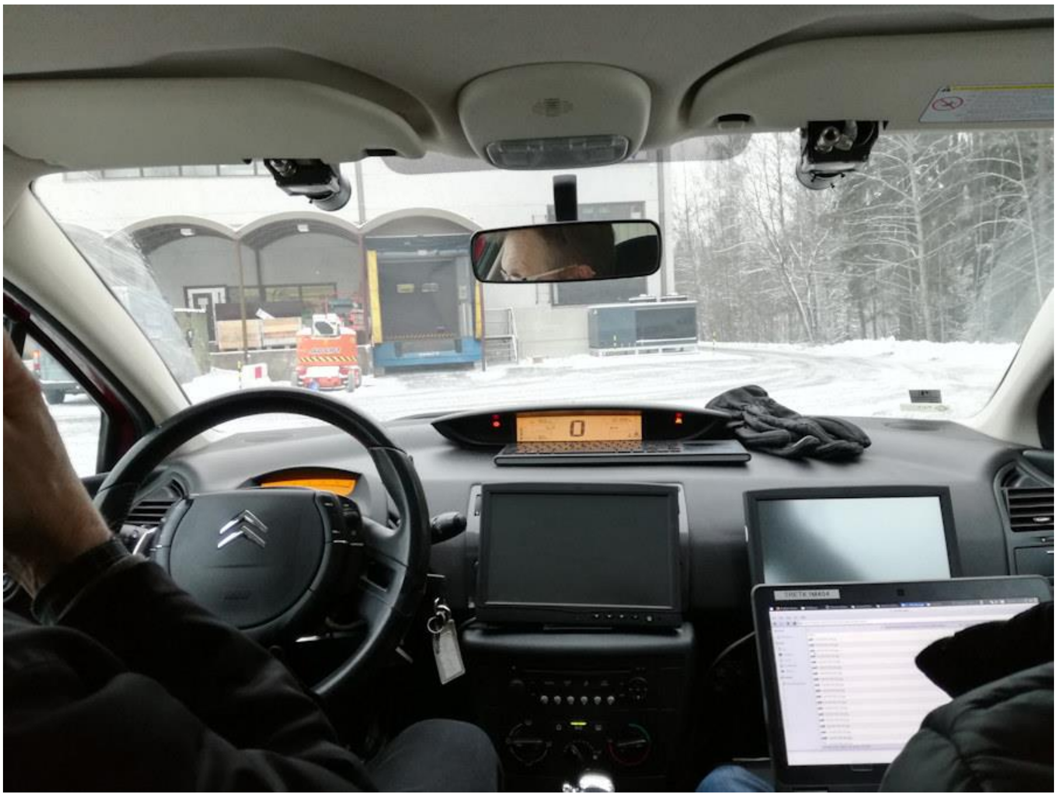

Figure 6: The measurement units inside the cabin

VTT is the leader and main contact of the test site activities. The trial site is owned by Nokia and they take care of access to the test site area. Nokia also supports the installation and implementation of

equipment to the test site. The Nokia competitors have restricted access to the trial site.
The demo vehicle 'Marilyn' is owned by VTT and insurances for vehicle or instrumentation damages exist. Operating the car is limited to the people in VTT, who have been nominated to be authorised driver and supervise the robot-car fleet.

3.1.2 Trial site test scenarios

The test site contains only one automated vehicle. In addition, there are other manual-driven cars equipped with compatible communication devices. Marilyn is able to test the automated driving scenarios and is fully compatible with infrastructure side equipment. The manual-driven vehicle is used for sending messages to the road infrastructure.
The automated car is communicating with a manual-driven car via hybrid C-V2X devices and ITS-G5 communication unit. The intersection, which is equipped with MEC capable base-station, is able to send traffic light status and also camera view from the intersection area. The cars and digital road infrastructure are connected to the cloud based ITS service via MQTT interface.
The tests will be carried out iteratively through project execution. At least three phases are expected:

I. Setup the V2I devices (LTE and ITS-G5) to the cars and drive baseline data for identifying latencies and bandwidth capacity.
II. Implement C-V2X devices (LTE Uu, release 14) to two different cars operating in 2,6 GHz and 5,9 GHz band
III. Implement C-V2X devices (LTE, release 15/16) which are operating in 5,9 GHz, depending on the availability of communication modules
IV. If possible to test slicing for optimising data channels between cars and infrastructure

The aim is to understand eMBB, URLCC and also slicing feature opportunities when proceeding forward with real 5G networks.
VTT will take care of implementing the necessary measurement tools in the car. Furthermore, the server will be setup for having a shared ITS database. The database includes HD map of the area with the landmarks in the area.

3.1.3 Evaluation methodology

The trial scenarios are outlined in Table 1. The objective is the evaluation of 5G benefits for latency times and communication with the MEC server.

	Trial Scenarios	Objective	Expected outcome
1	Uplink bandwidth capacity / eMMB	Exchange raw sensor data between vehicles and digital local infrastructure (MEC) connected via LTE/5G. Focus especially uplink capacity	Raw sensor data delivery rates (Mbits/sec) vs. the automated driving data sharing requirements
2	Inter-operability between different mobile network band frequencies	Switching between different frequency bands (2,6; 3,5; 60 GHz)	Switching latency between different frequency bands - overhead/latency increase
3	Mobile-edge computing	Data transmission and receiving from local edge-computing sites.	5G-MEC server routed connectivy to the car terminals. C-ITS message exchange between MEC and vehicle
4	Message formats	C-ITS vs. Chinese message	Feasibility of e.g. the

		formats. Compare service quality levels. Take into account e.g. SENSORIS work group proposals	SENSORIS compatible message formats
5	Latency times / uRLLC	V2V, V2I latency times with using low payload ping-messages	Latency time comparison in milliseconds.
6	E2E Uu-based V2X service validation and performance evaluation	To experimentally validate the functionality and performance of an E2E V2X service over e.g. the 3.5GHz Uu interface	Two vehicle-embedded UEs send/receive V2X messages over the Uu interface (i.e., via e.g. the 3.5GHz base station).
7	E2E PC5-based V2X service validation and performance evaluation	To experimentally validate the functionality and performance of an E2E V2V service over the 5.9GHz PC5 interface	Two vehicle-embedded UEs send/receive V2V messages over the PC5 interface (i.e., direct link without eNB involvement)

Table 1: The measurement units inside the cabin

The data is collected to the servers while driving and executing the test scenarios. The data in the collection database is synchronised with GPS. The latency times are drawn to the geographical map for estimating coverage of the network in the area. Therefore, the collected data is also stamped with WGS-84 coordinates. The data will not include any personal data sets, which are restricted by GPDR regulations.

3.2 JRC Ispra trial site plan

3.2.1 Trial site description

The JRC Ispra site is a fully-fenced research campus equipped with high-level safety and security features – a 167-hectare controlled environment for hands-on experimentation, testing and demonstration purposes. It features 36 km of internal roads under real-life driving conditions, as well as 9 Vehicle Emissions Laboratories (VELA 1-9) for calibration and electromagnetic compatibility and interference testing, amongst other. In the context of WP4, the JRC Ispra site will focus on the experimental evaluation of V2X scenarios both at the laboratory and field test levels.

Figure 7: Map of the JRC Ispra site

The JRC Ispra campus has been mapped at very high resolution using drones and LIDAR, with digital maps available in various formats. Maps can be used for network planning (i.e., radio propagation and network coverage simulations), as well as accurate vehicle localisation and intelligent routing. As to the communications infrastructure, the JRC owns various LTE eNodeBs of both commercial and experimental grade, as well as commercial ITS-G5 Road-Side Units (RSUs) and On-Board Units (OBUs) for LTE-V2X/ITS-G5 coexistence testing. This communications infrastructure will be expanded in the upcoming months with the addition of both commercial and experimental-grade LTE-V2X RSUs and OBUs. In addition, the JRC is also deploying a software-defined Evolved Packet Core (EPC) to support essential network services for internal test users (e.g., mobility, session management, user authentication, etc.).

Both the radio access and core network infrastructure will be complemented with Mobile Edge Computing (MEC) hosts distributed throughout the Ispra campus. MEC systems will take the form of small-form factor PCs co-located with cellular base stations and V2X RSUs, and their aim will be to reduce end-to-end latency by offloading time-critical computing workloads from the core network to the RAN.

Table 2 depicts some examples of hardware devices and software platforms used in the JRC Ispra V2X testbed.

	Product Name	Summary of Technical Specifications
	Nokia FlexiZone Micro BTS - FWND model	Outdoor LTE TDD base station Band 40 (2.3 GHz) 2x20 MHz 2x2 MIMO 250mW to 5W per TX path Size: 247mm (H) x 327mm (W) x 120mm (D) Volume: 7.2 litres / mass: 6.2 kg
	Nokia FlexiZone Pico BTS – FWNA model	Indoor LTE TDD base station Band 40 (2.3 GHz) 2x20 MHz 2x2 MIMO 50mW to 250mW per TX path Size: 255mm (H) x 252mm (W) x 54mm (D) Volume: 2.8 litres / mass 2.2 kg
	LimeNET Mini	Indoor LTE FDD/TDD Network-in-a-Box Small-form factor LTE eNodeB and EPC Configurable TX/RX bands Configurable BW, 2x2 MIMO Size: 52mm (H) x 112mm (W) x 120mm (D) (excluding antennas) (May also be deployed outdoors with ruggedised case)
	USRP-based base stations	LTE FDD/TDD BTS (experimental) Indoor/outdoor (with ruggedised case) Intel NUC mini-PC connected to USRP Configurable TX/RX bands Configurable BW and MIMO Size: 100mm (H) x 150mm (W) x 200mm (D)

	*ITS-G5 On-Board Units (OBU)*	*Dual ITS-G5/DSRC radio* *GPS to deliver lane-level accuracy* *Integrated security* *Hardware acceleration* *Tamper-proof key storage* *Supports ITS-G5, DSRC and Wi-Fi (802.11abgn)*
	ITS-G5 Road-Side Unit (RSU)	Dual ITS-G5/DSRC radio GPS to deliver lane-level accuracy Integrated security Hardware acceleration Tamper-proof key storage Supports ITS-G5, DSRC and Wi-Fi (802.11abgn)
	OpenAirInterface software protocol stack (eNodeB)	Standard-compliant implementation of a 3GPP Rel.10 LTE eNodeB Software protocol stack runs on standard Linux-based platform (x86/ARM)
	Amarisoft software protocol stack (eNodeB)	3GPP LTE release 14 compliant eNodeB Support for FDD and TDD BW: 1.4, 3, 5, 10, 15 and 20 MHz TX modes: 1 (SISO) and 2-10 (MIMO 4×2) Carrier Aggregation support with cross carrier scheduling (up to 5 DL channels) 256QAM DL support for PDSCH and MBMS

Table 2: Examples of hardware devices and software platforms in the JRC Ispra V2X testbed

In addition to network infrastructure, security is also a critical component in Cooperative Intelligent Transportation Systems (C-ITS). The JRC features a production-level Public Key Infrastructure (PKI) to manage the creation, issuance and revocation of the end user digital certificates needed in V2X communications. This PKI has already been extensively used in the road transportation sector, concretely by playing the role of the European Root Certification Authority for the EU Digital Tachograph (ERCA-DT). In the context of 5G-DRIVE, this PKI will be used to generate 'dummy' certificates for the OBUs/RSUs used in the V2X experiments.

At the laboratory level, the JRC hosts the European Microwave Signature Laboratory (EMSL), being a large (20-meter diameter) anechoic chamber used to perform RF characterisation and performance tests. The EMSL anechoic chamber is large enough to host a commercial vehicle in its interior — a feature that will be exploited in 5G-DRIVE to characterise the RF performance of on-board LTE-

V2X/ITS-G5 devices in vehicles, as well as to conduct coexistence testing between both technologies in the 5.9GHz band. In addition to the large anechoic chamber, the EMSL also features a smaller shielded anechoic chamber, where ad-hoc testing of standalone communications devices (i.e., not mounted on vehicles) can also be conducted in a clean channel environment. Finally, ITS-G5 and LTE-V2X devices will also be tested in conducted mode, i.e., replacing the antenna elements with direct connections to the RF measurement equipment.

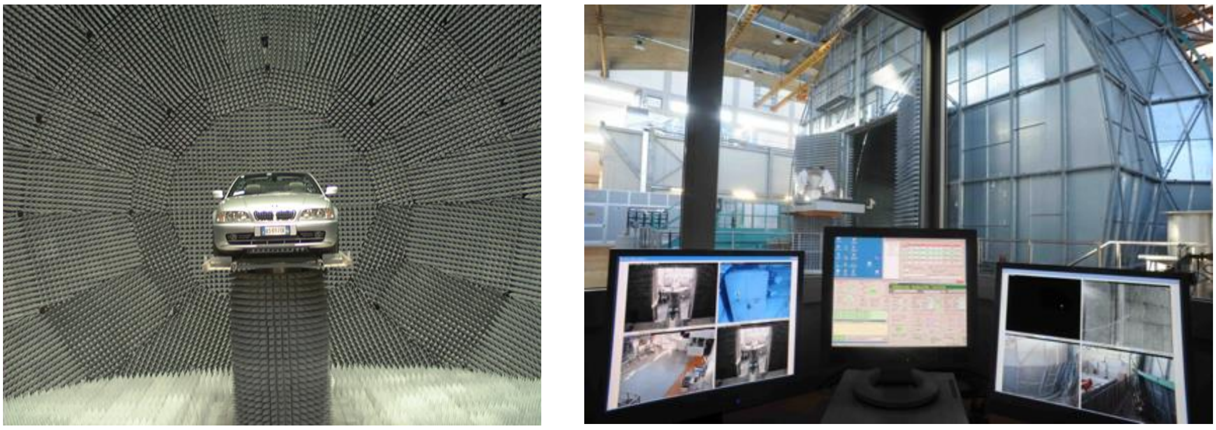

Figure 8: The large anechoic chamber at the Joint Research Centre Ispra

Figure 9: The small shielded anechoic chamber at the Joint Research Centre Ispra

3.2.2 Trial site test scenarios

V2X testing at the JRC Ispra site comprises two main scenarios, namely on-the-field C-ITS service demonstration and LTE-V2X/ITS-G5 coexistence in the 5.9GHz band. These scenarios are described below:

3.2.2.1 On-the-field C-ITS service demonstration

- Scenario description:
  - The aim of this test scenario is to demonstrate a selected day-1 C-ITS service (e.g., GLOSA, road works warning) using ITS-G5 and LTE-V2X equipment. By using both V2X communication technologies (not simultaneously) in the same scenario, the JRC aims to experimentally benchmark LTE-V2X and ITS-G5 in a single user service setup.

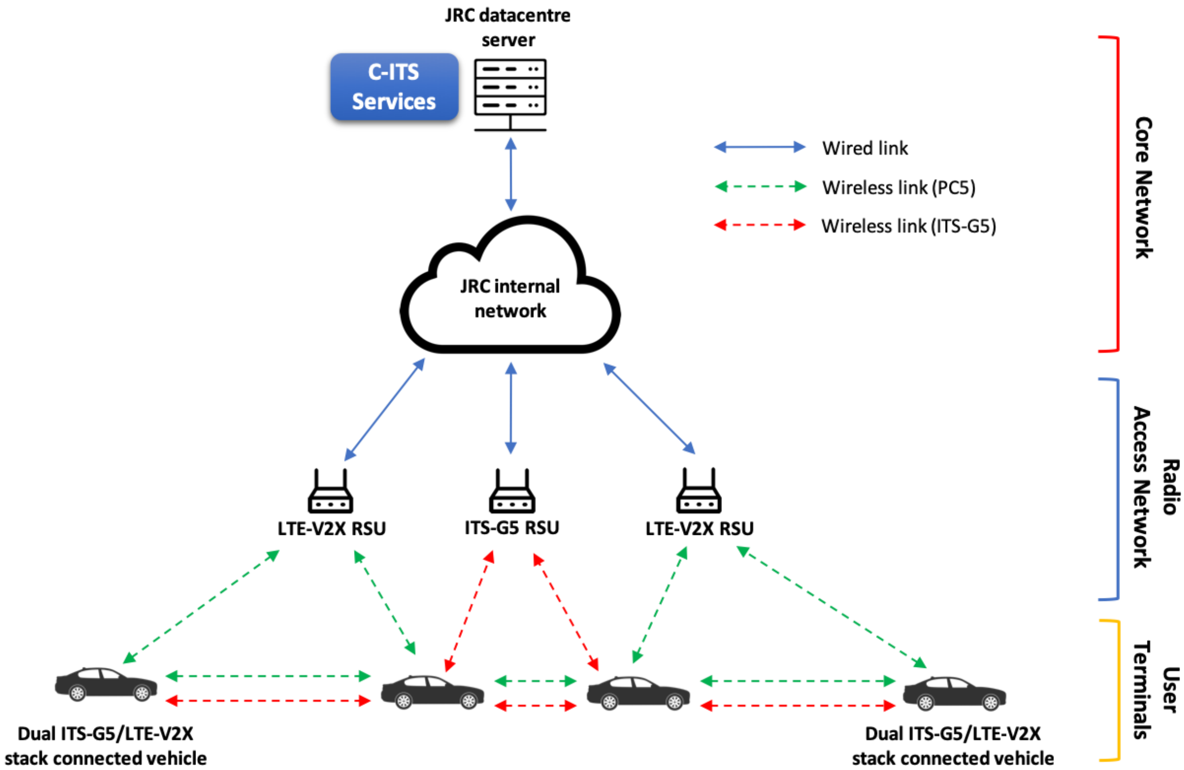

Figure 10: On-the-field C-ITS service demonstration scenario

- The test will involve at least one non-automated vehicle from the JRC's service vehicle fleet, as well as two RSUs (one LTE-V2X, one ITS-G5) and two OBUs (one for each V2X technology). The test will be conducted on the field over the JRC's internal road network.
- Regardless of the specific day-1 C-ITS service (see: https://ec.europa.eu/transport/themes/its/c-its_en) , under demonstration, the test setup will require the RSU to send Decentralised Environmental Notification Messages (DENM) in a broadcast fashion. OBUs will receive these messages and display appropriate context information to drivers via a standard user interface (UI) (e.g., a laptop connected to the LTE-V2X or ITS-G5 OBU). Since the purpose of this scenario is to benchmark the performance of both V2X technologies on the field, the focus is actually not on the UI, but instead on capturing and post-processing network data (e.g., V2X frames) to extract relevant KPIs such as latency, network coverage, spectral efficiency, packet error rate, etc.

- Test planning:
  - The tests are expected to last five months, including an initial test setup phase (installation of LTE-V2X/ITS-G5 RSUs and OBUs in a JRC site location and on-board the vehicles), a system infrastructure and service testing phase, a drive tests campaign, as well as a data collection, post-processing and reporting final phase.
- Hardware and software tools:
  - 1x ITS-G5 RSU, 1x LTE-V2X RSU capable of running day-1 C-ITS services
  - At least 1x ITS-G5 OBU, 1x LTE-V2X OBU capable of running day-1 C-ITS services (depending on the specific test scenario)
  - At least 1x JRC service vehicle (depending on the specific test scenario)
  - 1 laptop connected to the ITS-G5/LTE-V2X OBUs
  - 1 server PC connected to the ITS-G5/LTE-V2X RSU
  - Wireshark/tcpdump protocol analysers for data capturing and network

troubleshooting
  - A suite of in-house Matlab and Python scripts for post-processing and analysing experiments data

3.2.2.2 LTE-V2X/ITS-G5 coexistence in the 5.9GHz band

- Scenario description:
  - The goal of this test scenario is to evaluate the 'out-of-the-box' coexistence of commercial off-the-shelf ITS-G5 and LTE-V2X devices. Prior to evaluating concrete coexistence solutions (which, at the time of writing, are being discussed in the ETSI ERM TG37 group), 5G-DRIVE will conduct an initial evaluation of the co-channel interference between these two V2X technologies. The outcome of this experimental work will be a quantitative analysis of the impact of ITS-G5 transmissions on the performance of LTE-V2X devices, and vice-versa. These results will illustrate the state of play of both technologies prior to the development of any co-channel coexistence solutions and will help frame the technical discussions undertaken in ETSI ERM TG37.
  - This test scenario will comprise two main activities. First, the JRC will conduct a subset of the RF compliance tests described in the ETSI Harmonised Standard for radio-communications equipment operating in the 5855 MHz to 5925 MHz frequency band [2] on standalone ITS-G5 and LTE-V2X devices. Secondly, the JRC will characterise the co-channel interference of each technology over the other by evaluating the same RF metrics in a joint ITS-G5/LTE-V2X deployment. Initial tests will be conducted both in conducted mode and in the small shielded anechoic chamber of the JRC's Radio Spectrum Laboratory. At a later stage, should there be a need to evaluate the performance of on-board ITS-G5/LTE-V2X equipment in a real-life setup (i.e., mounted on a commercial vehicle), additional experiments will also be conducted in the large anechoic chamber.

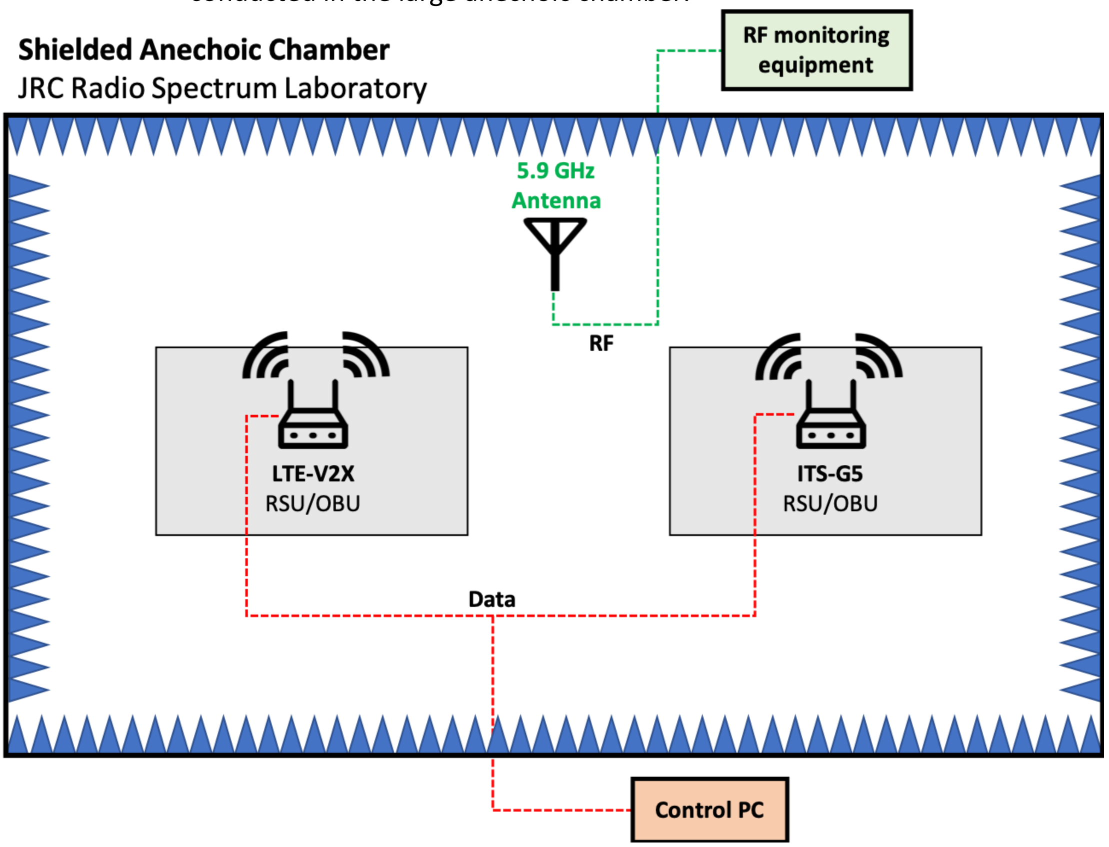

Figure 11: LTE-V2X/ITS-G5 coexistence testing scenario

    - As previously mentioned, the JRC plans to contribute to the ongoing discussions on ITS-G5/LTE-V2X co-channel coexistence testing in ETSI ERM TG37 by submitting experimental results to the group.

- Test planning:
    - The coexistence tests are expected to last five months, including the initial setup phase (deployment of LTE-V2X/ITS-G5 RSUs and OBUs in the JRC's laboratories and anechoic chambers), the setup of the RF measurement and protocol analysis equipment, the measurements campaign phase, and the post-processing, analysis and reporting of all experimental data.
- Hardware and software tools:
    - 1x ITS-G5 RSU, 1x LTE-V2X RSU capable of running day-1 C-ITS services
    - 1x ITS-G5 OBU, 1x LTE-V2X OBU capable of running day-1 C-ITS services
    - 1x JRC service vehicle (for on-board testing in the large anechoic chamber)
    - RF testing and measurement equipment (directional antennas, filters, spectrum analyser, RF power detector, etc.)
    - Wireshark/tcpdump protocol analysers for data capturing and network troubleshooting
    - A suite of in-house Matlab and Python scripts for post-processing and analysing experiments data

3.2.3 Evaluation methodology

The evaluation methodology for the above tests will follow the procedures described in chapter 5 of the ETSI Harmonised Standard for radio-communications equipment operating in the 5855 MHz to 5925 MHz frequency band [2].

4 Conclusions

The Trials plans provided by the two trials sites for the V2X scenarios, namely Espoo in Finland and Ispra/JRC in Italy, combine two main types of testing. At the Espoo trial sites, vehicles will drive in a real environment, thus needing more “natural” testing scenarios for evaluating 5G benefits, in particular with URLLC. At Ispra, testing scenarios are provided in a “controlled” environment, based on harmonised standards. This combination intends to provide the required diversity of test for evaluating the suitability and benefit of 5G for V2X scenarios.

The deliverable provides the plans for 5G, vehicles, and infrastructure deployments as well as testing and evaluation processes as part of the trial site activities. The description of the deployment, testing and evaluation is provided according to a methodology to ensure consistency of plans from the two different trial sites. This consistency is not only important for efficient coordination of the trial site activities but also to ensure the provision of consistent evaluation results.

References

[1] FESTA Handbook - http://fot-net.eu/Documents/festa-handbook-version-7

[2] ETSI EN 302 571 V2.1.1 (2017-02) - Intelligent Transport Systems (ITS); Radio-communications equipment operating in the 5 855 MHz to 5 925 MHz frequency band; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU (see: https://www.etsi.org/deliver/etsi_en/302500_302599/302571/02.01.01_60/en_302571v020101p.pdf)

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