Deploying an Open 5G infrastructure to support verticals

The 5G-VINNI & 5GinFIRE Experience

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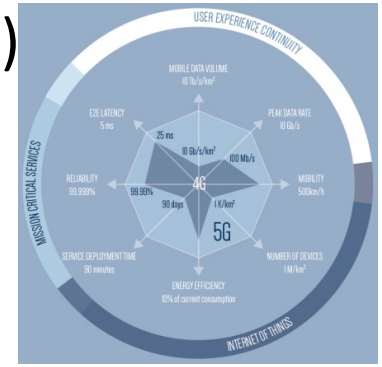
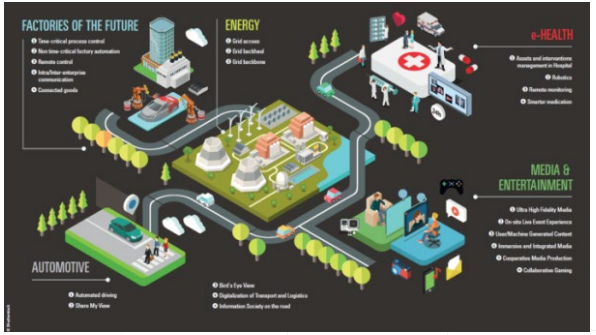
Overview

- Deploying an open 5G infrastructure
  - The 5G-VINNI Project
- Deploying verticals & services
  - The 5GinFIRE

5G-VINNI (**5G V**erticals **INN**ovation **I**nfrastructure)



- Build an open large scale 5G End-to-End facility that can
  - demonstrate that key 5G network KPIs can be met
  - be validated, accessed and used by vertical industries (e.g. in ICT-19 projects) to test use cases and validate 5G KPIs.
- Duration: 3 years, budget: 19,998 M€
- Consortium: 23 partners (operators, vendors, academics, SMEs)
- External Stakeholder Board: Vertical industry
- A 5G-PPP project
- https://www.5g-vinni.eu/



telenor BT SAMSUNG ERICSSON CISCO INTRACOM TELECOM KEYSIGHT TECHNOLOGIES altice labs simula uc3m Universidad Carlos III de Madrid EURESCOM

Telefónica SES NOKIA HUAWEI SRS SOFTWARE RADIO SYSTEMS Lime microsystems EANTC EUROPEAN ADVANCED NETWORKING TEST CENTER ENGINEERING ATHENS UNIVERSITY OF ECONOMICS AND BUSINESS ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΑΤΡΩΝ Fraunhofer FOKUS

5G-VINNI

5G-VINNI Facility Sites

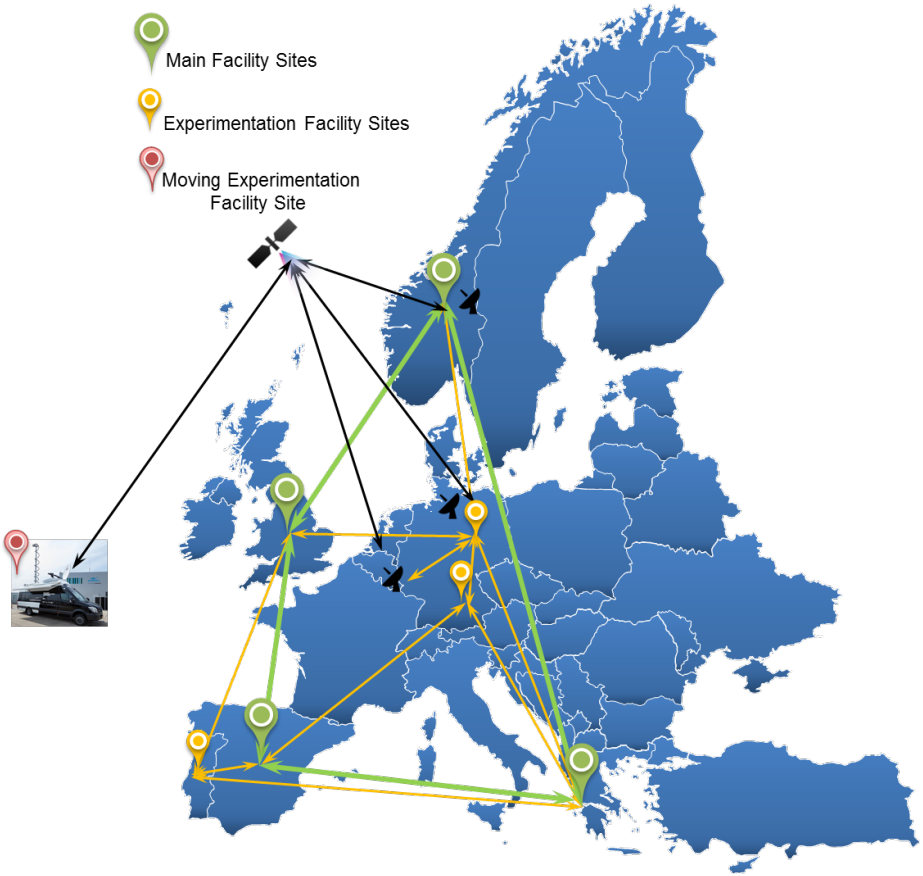
Main Facility sites: E2E 5G-VINNI facility that offers services to ICT-18-19-22 projects with well-defined Service Level Agreements.

- Norway (Oslo, Kongsberg)
- UK (Martlesham)
- Spain (Madrid)
- Greece (Patras)

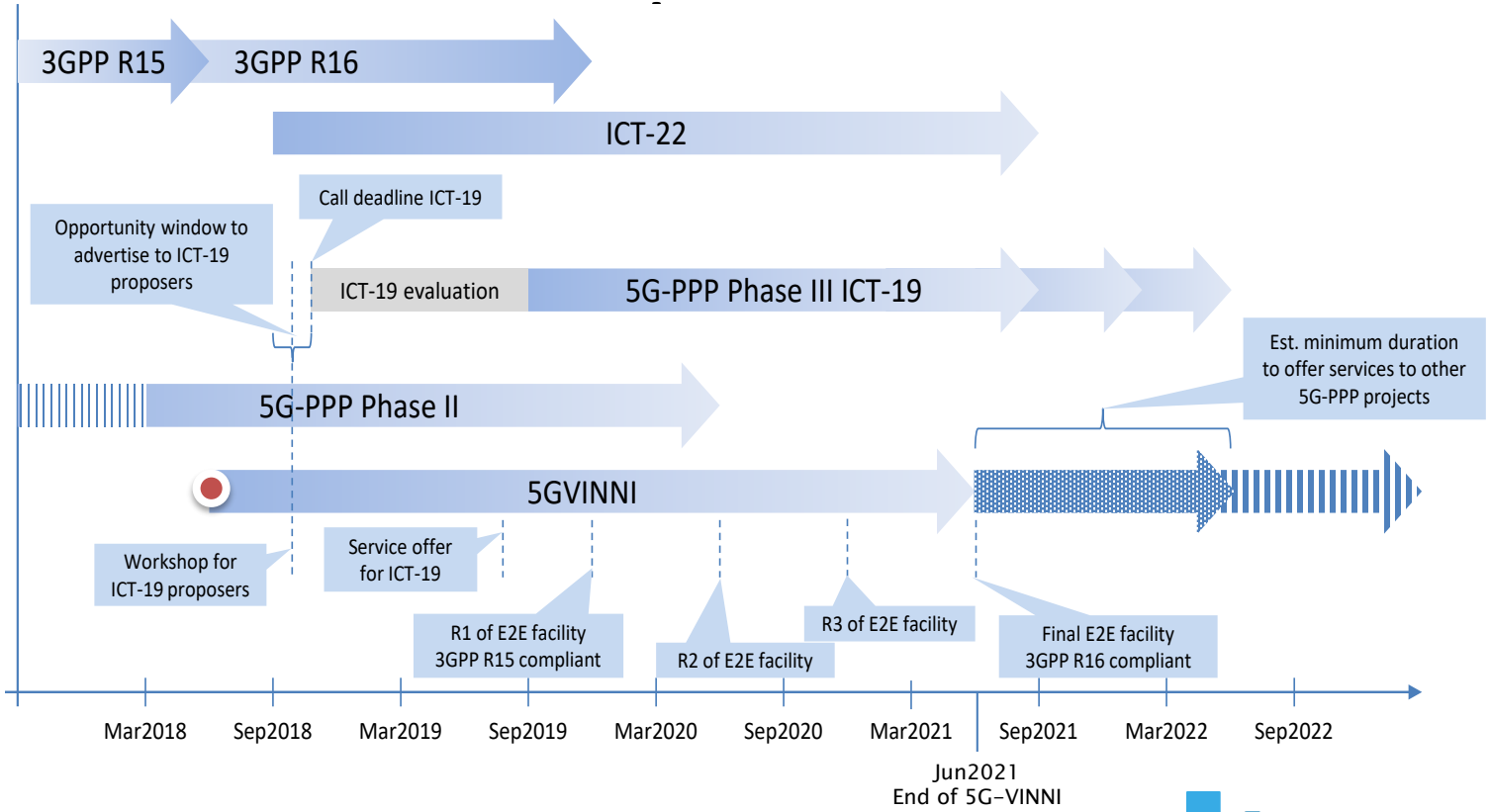
Experimentation Facility sites: provide environments for advanced focused experimentation and testing possibilities on elements and combinations of elements of the E2E model.

- Portugal (Aveiro)
- Germany (Berlin)
- Germany (Munich)

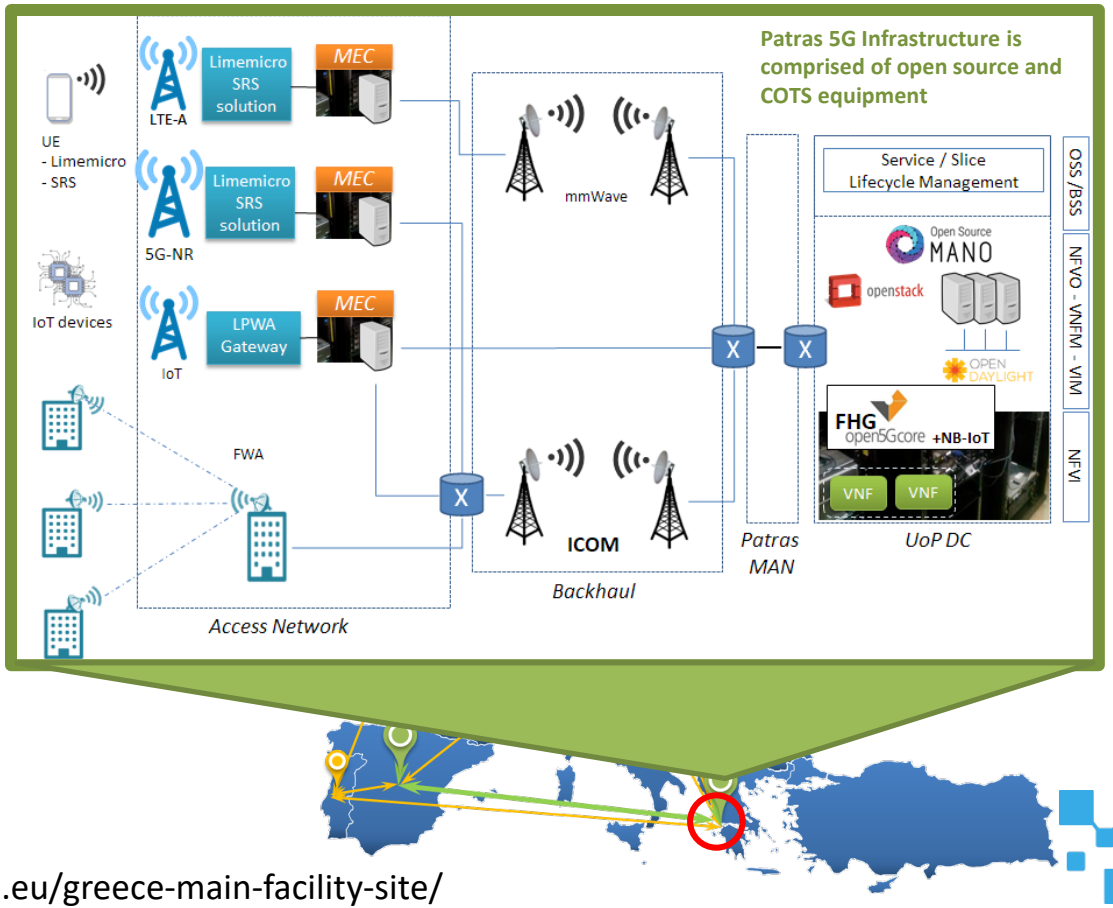
Moving Experimentation Facility site: satellite connected vehicle.



Global timing alignment with 3GPP

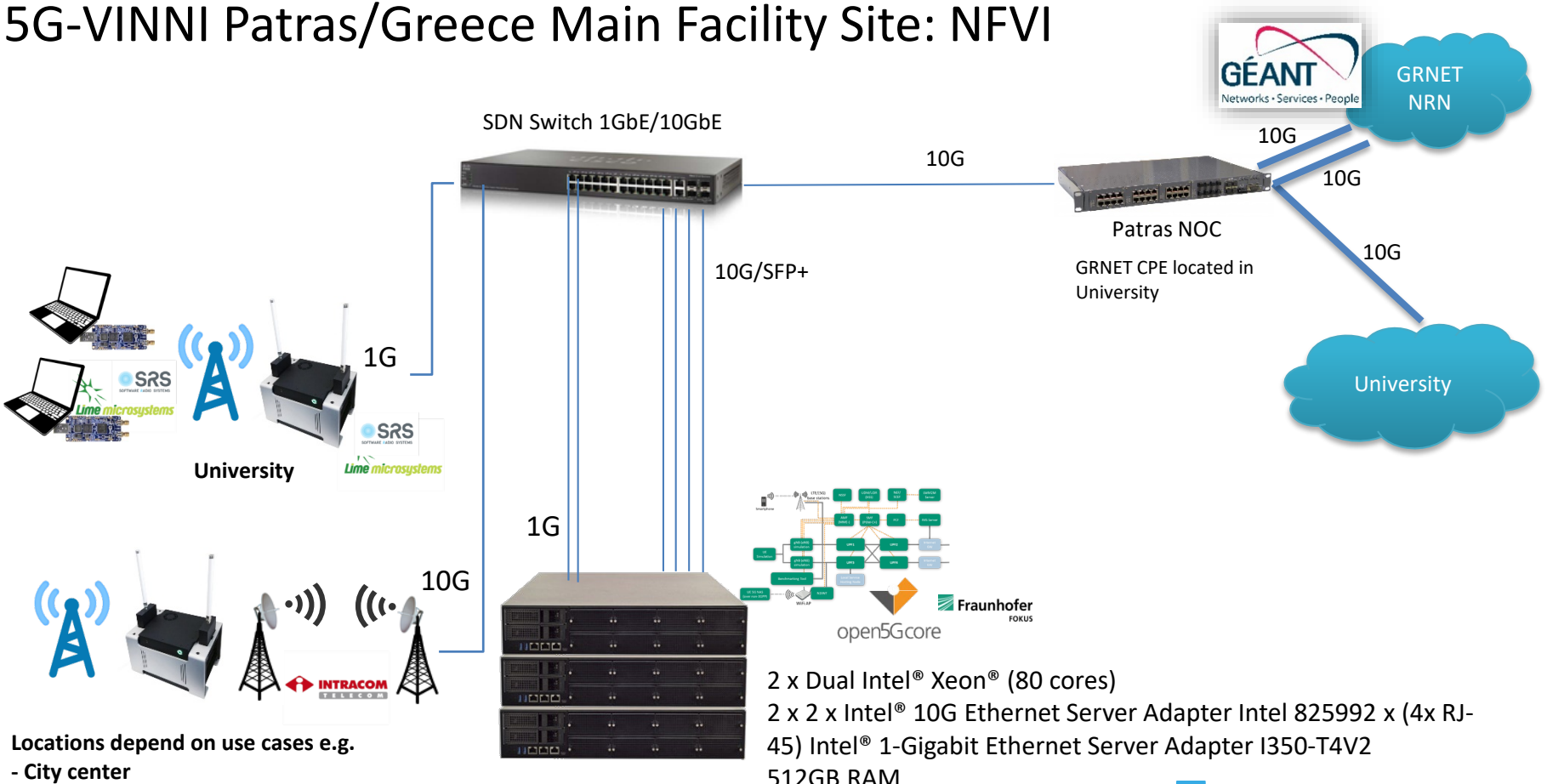


5G-VINNI Patras/Greece Main Facility Site



https://www.5g-vinni.eu/greece-main-facility-site/

5G-VINNI Patras/Greece Main Facility Site: NFVI

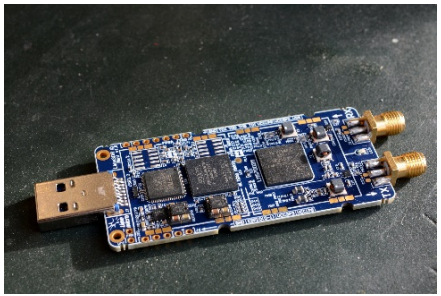


Locations depend on use cases e.g.
- City center
- Train Stations

2 x Dual Intel® Xeon® (80 cores)
2 x 2 x Intel® 10G Ethernet Server Adapter Intel 825992 x (4x RJ-45) Intel® 1-Gigabit Ethernet Server Adapter I350-T4V2
512GB RAM
DPDK, SR-IOV, EPA

5G-VINNI

5G-VINNI Patras/Greece Main Facility Site: NFVI (RAN)



LimeSDR, LimeSDR Mini
UE on Laptops

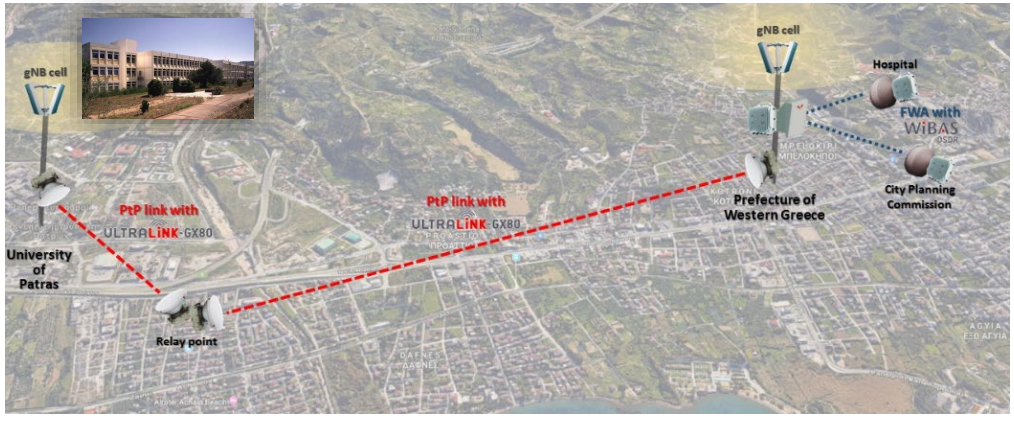
NBIoT

SODAQ SARA Small Form Factor

LimeNET Mini
For Indoor Base Station test
as “crowdcell”
and as UE

LimeNET Base Station
Deployed outdoor

5G-VINNI Patras/Greece Main Facility Site: NFVI (Transport network)

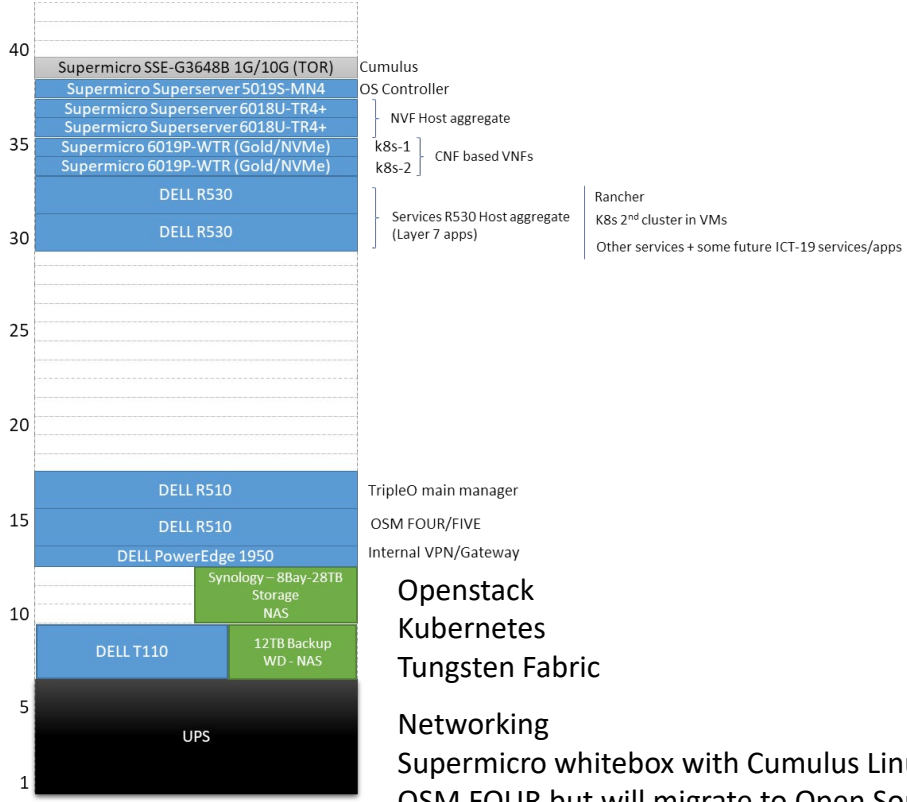


FWA and Backhaul Networks at Patras Facility Site

Location #1: University of Patras, Electrical and Engineering Department Building
Location #2: City of Patras, Prefecture of Patras
Location #3: To be defined

Illustration from Radio Planning for FWA Network at Patras Facility Site (access to a hospital, school, City Directorate-General for Development Planning, and a park to perform some of the use cases)

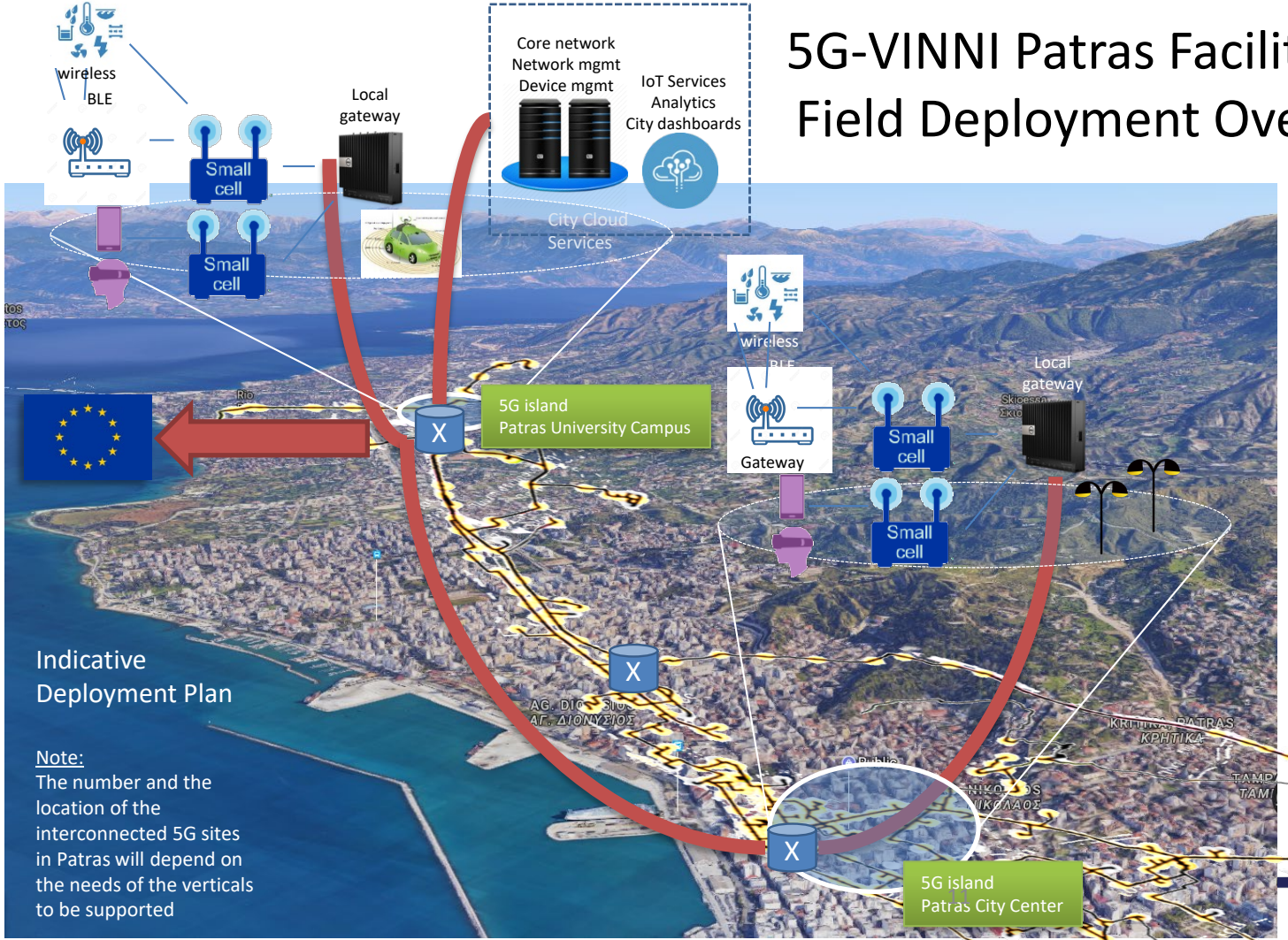
5G-VINNI Patras/Greece Main Facility Site: NFVI (Cloud)



Openstack
Kubernetes
Tungsten Fabric

Networking
Supermicro whitebox with Cumulus Linux
OSM FOUR but will migrate to Open Source MANO version FIVE

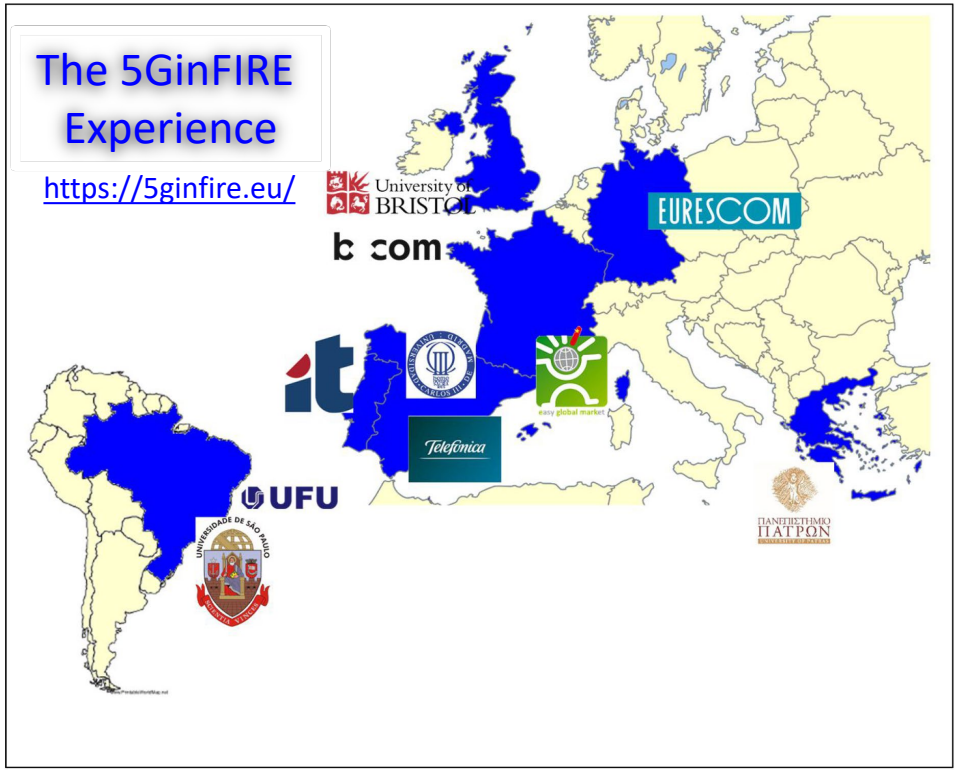
5G-VINNI Patras Facility Site: Field Deployment Overview



Patras Area as a playground for Vertical Industries

Patras Area as a playground for Vertical Industries

Deploying Verticals & Services



Entry point: The 5GinFIRE portal

Supporting Processes and Maintaining Artifacts

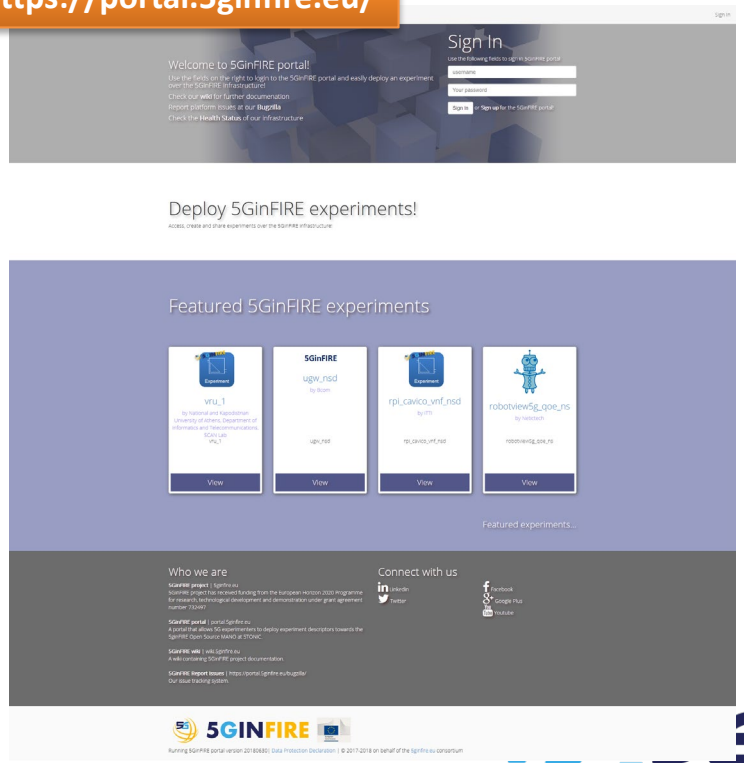
Supporting Processes

- VxF Lifecycle
- NSD/Experiment Lifecycle
- Deployment Requests

Managing artifacts

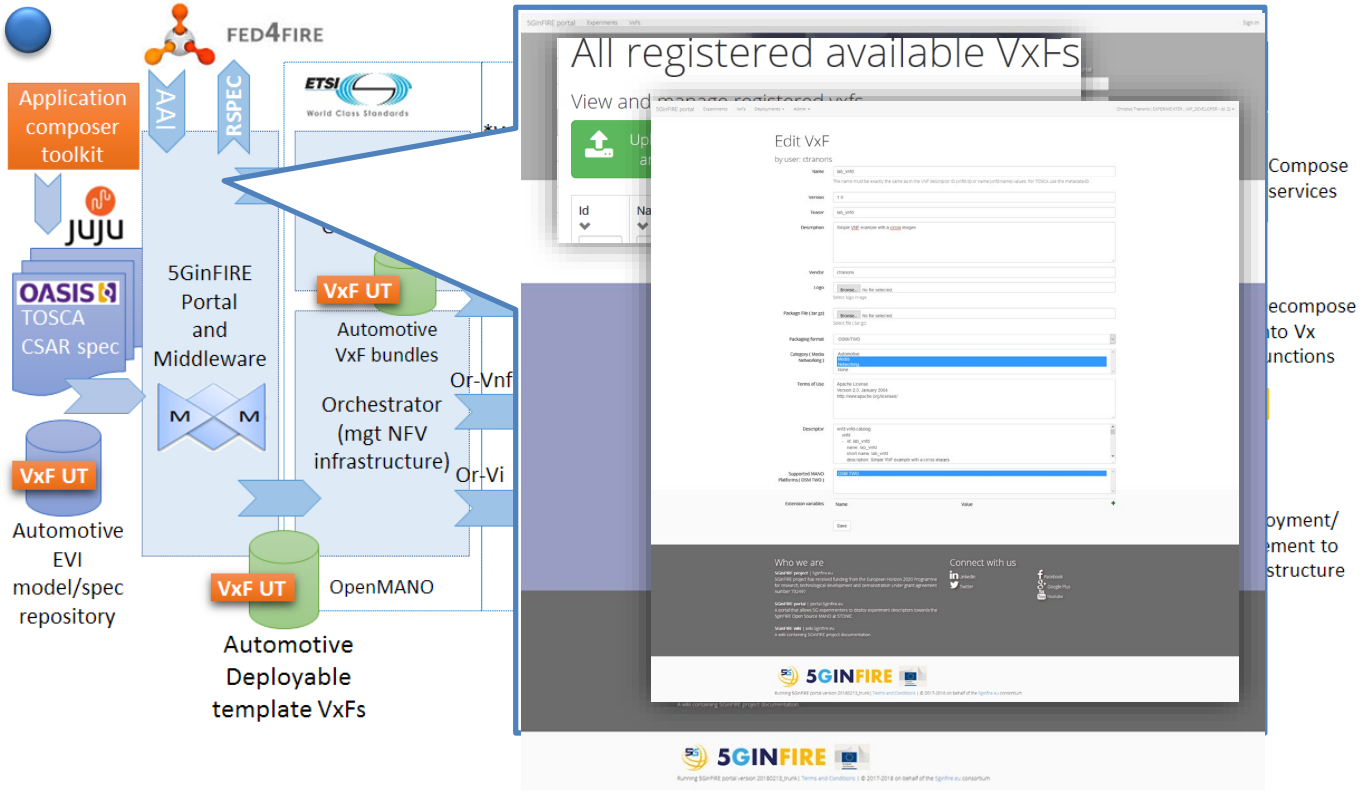
- Users
- VNFs/NSDs and VNF Images
- MANO endpoint
- Deployment requests

https://portal.5ginfire.eu/



5GinFIRE Experimentation Workflow

Technologies, Infrastructures and Verticals



5GinFIRE Ex

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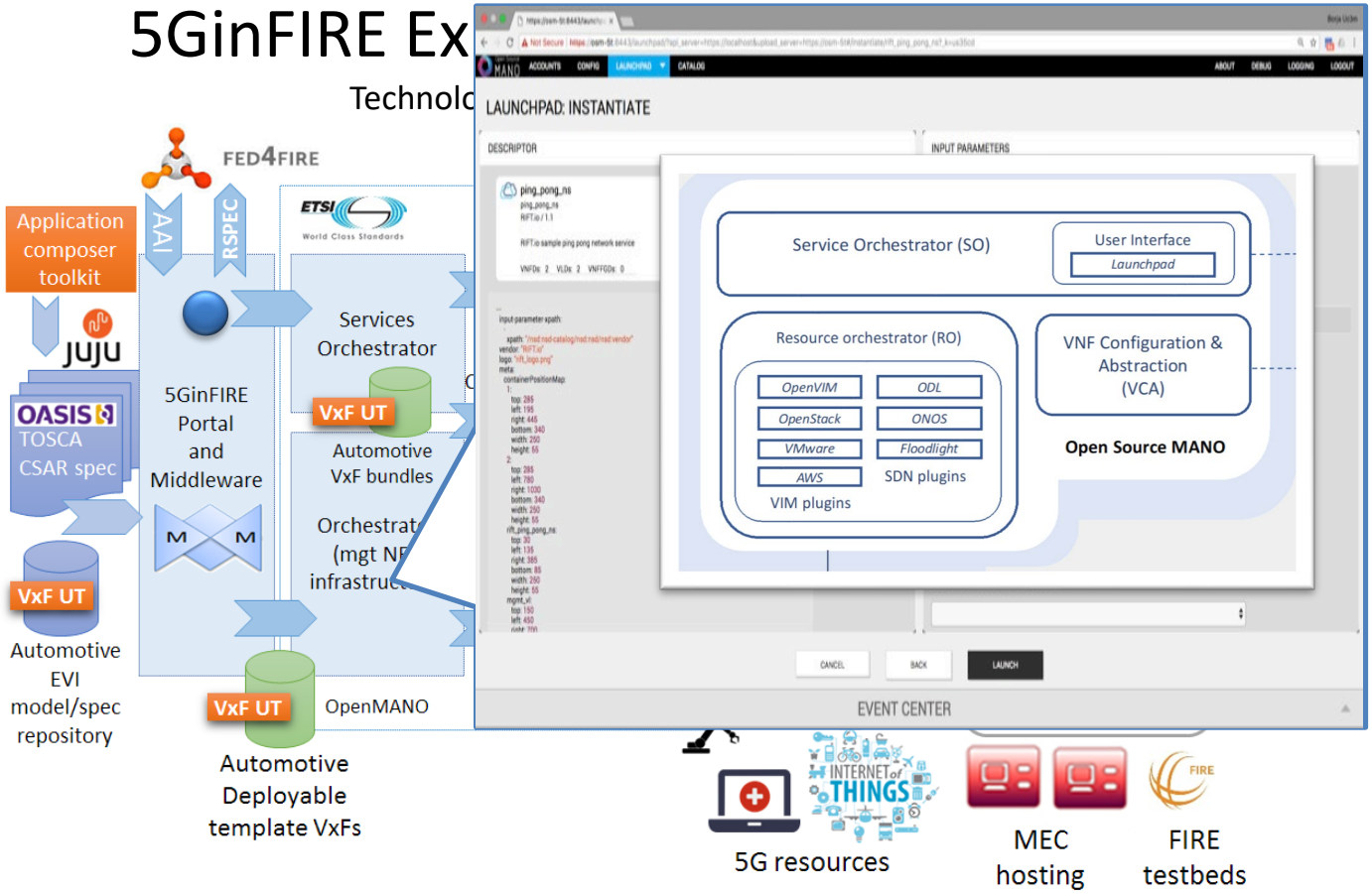

5GinFIRE Experimentation Workflow

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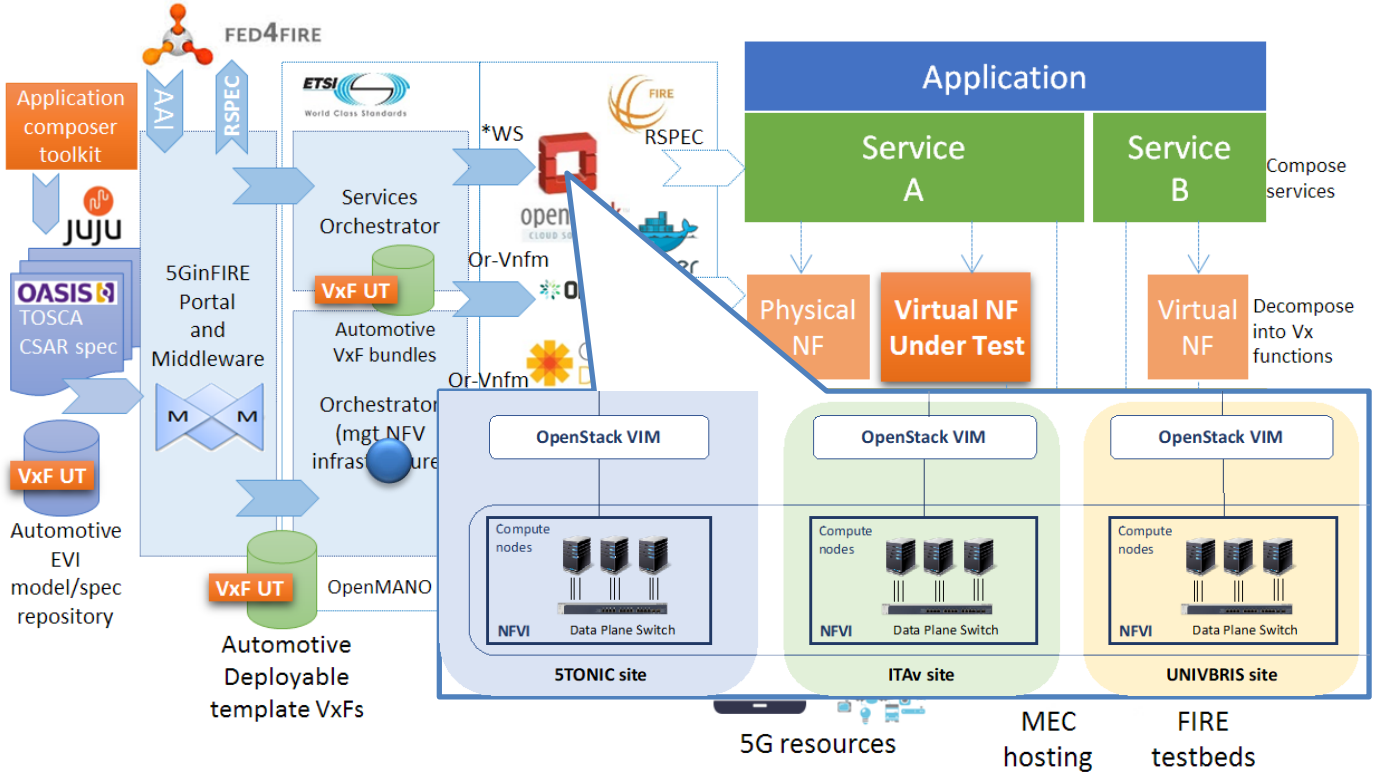
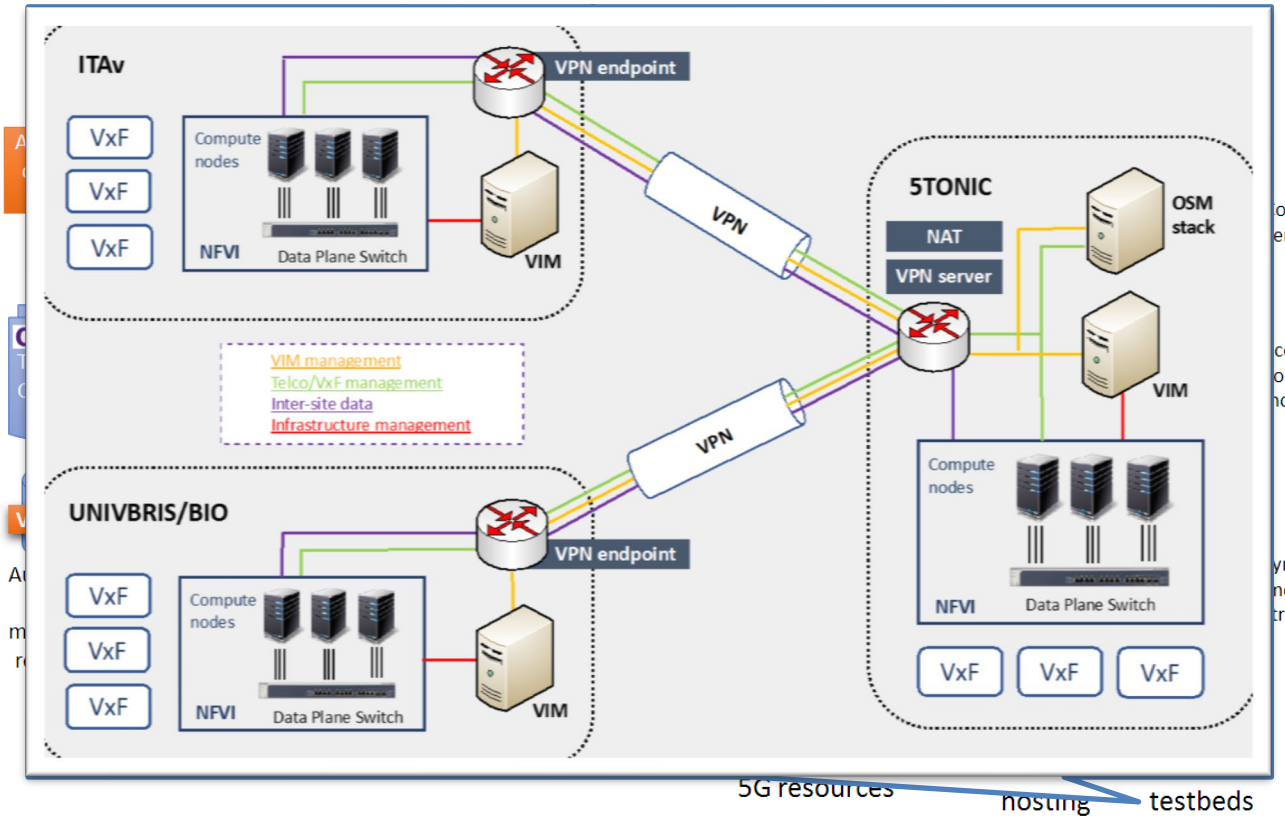
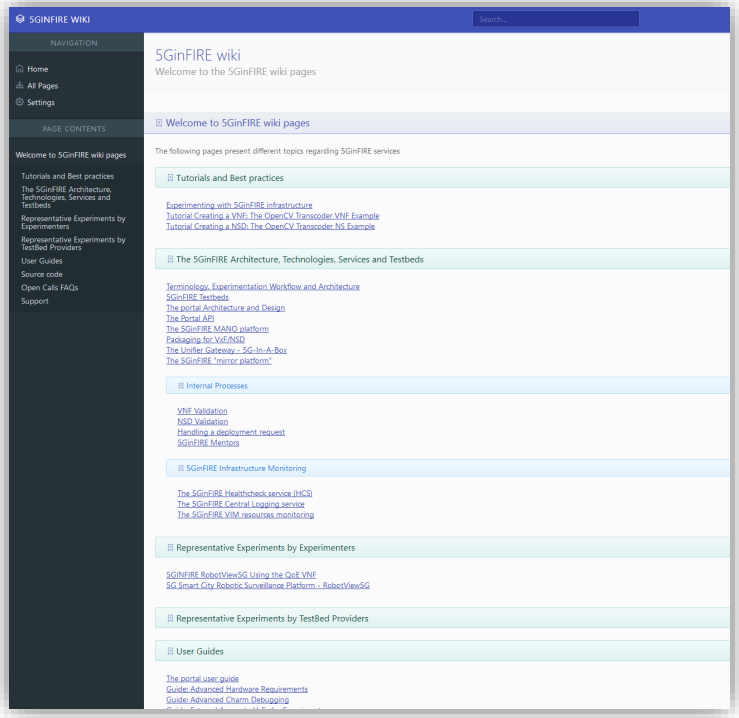


5GinFIRE Experimentation Workflow



Support (http://wiki.5ginfire.eu/)

- Tutorials and Best practices
- Examples
  - From Experimenters
  - From Testbed Owners
- User guides
- Architecture and Terminology
- Processes
- APIs Services
- Testbed descriptions and access
- FAQs



5G & Verticals

- ICT19 projects are round the corner
  - 5G-VICTORI
  - 5G-SOLUTIONS
- 5G-VINNI will be used and extended
  - Support for eMBB, mMTC and URLLC
- Timeframe at least 4 years
- The investment and research impact will be high

5G-SOLUTIONS

5G-VICTORI

<u>Use Case: Factories of the Future - Digital Utilities</u>

IoT for Infrastructure Real Time Protection

<u>Use Case: Transportation</u>

Enhanced Mobile broadband under high speed mobility in Rail environments

Challenges & Next Steps

- Host Verticals as network slices across the city/region facilities
- Experiment with new business models
  - Enabled by 5G and Open technologies
- Synergies with national operators
- Expand collaboration with local stakeholders (private or public)
  - Adding technologies
  - Engage in bilateral research & innovation activities
- **Blocking Factors**
  - Provisions of spectrum for a) Private Networks and b) for Research
  - See the Citizens Broadband Radio Service (3.55-3.7 GHz, 150 MHz band) in USA

5G-Platform 5G-VINNI Energy: Energy Metering for HV and LV

- Energy: Energy Metering for HV and LV
- Stakeholders ADMIE, TRA, UOP, IASA, ORO, AIM, EUR, UTH, UHA, UNIVBRIS
- KPIs Addressed: mMTC for LV: high density distribution (e.g. 10k sensor /10sqkm), uRLLC for HV: Real time low latency (e.g. less than 8 ms, Round trip latency less than 100 ms),
- Reliability: high availability Packet loss rate: as low as 1e-04
- 5G-Platform 5G-VINNI (HV scenario) / 5G-EVE (LV scenario)

5G-Platform 5G-VINNI Energy: Energy Metering for HV and LV

- The HV trial will take place at Thriasio where ADMIE feeds a range of primary substations. One of these ,primary substations (150kV/25kV), at Loutropyrgos, is used for TRA suburban trains traction (TPSS). A 5G base station (access) will be installed at the Substation connected to a local data center (virtual machine). Access antennas will be installed at 3-4 adjacent train stations to accommodate the coverage.
- The objective of the trial is gathering of energy consumption and load data (recovery of energy fed back during braking) in the RMS and EMS platforms. The former aims to assist infrastructure managers and railway operators to select optimal strategies and resources in a cost-effective and energy-efficient manner (i.e by synchronizing decelerating and accelerating rolling stock) and the latter aims to assist substation operators to perform smart energy techniques such as demand-respond , peak management, substation stress avoidance, load balancing, efficient HV grid interaction and cost savings in the EMS platform.

5G-Platform 5G-VINNI Energy: Energy Metering for HV and LV

- 5G-VICTORI will demonstrate the operation of a dynamically re-configurable ICT infrastructure to facilitate the smart energy operation at the HV (150kV/20kV) primary substations of ADMIE (fault detection and preventive maintenance), taking advantage of the low latency signal exchange between the substations and the control Center.
- Focus on regenerative braking energy (RBE). RBE in trains can lead to substantial energy savings (thus and CO2 emission reductions), especially at very dense suburban network trains (~ 30%). During braking, AC and DC powered trains (AC in this trial) electro motors generate electricity to be returned to the power distribution system. The motivation of the trial is the potential for substantial economic payoffs if the regenerated energy is better harvested and reused.

5G-Platform 5G-VINNI Energy: Energy Metering for HV and LV

- The **regenerative braking energy** is primarily used to compensate energy consumption of adjacent trains which are at the acceleration mode. This **energy balancing**, otherwise the RBE utilization, is dependent to factors such as train speed, equivalent inertia, time of braking, train characteristics, power profiles, network configuration, rolling stock, line voltage and topology of track between others. Part of the regenerated energy contributes to primarily supplying the train's auxiliary loads and equipment, e.g. the onboard air conditioning system, which does not result in considerable energy savings. The rest and most significant **part of the RBE is fed back to the railway Traction Power Supply Substation (TPSS).**
- Trains typically take between ~15-20 seconds to brake from their nominal speed to a complete stop, the regenerative energy is sent back to the distribution system in very short time intervals (in burst mode) so the **handling of this two way energy transaction becomes challenging both for the Railway System Operator (Trainose – in terms of rolling stock scheduling and energy savings) and the supplying TSO (ADMIE- in terms of energy balancing and TPSS health related to voltage stress and load variances).**
- The trial aims to address how the infrastructure advancement (low latency 5G signaling) can contribute to tackle the dynamic characteristics of this fast energy transaction which requires transient analysis instead of static steady-state models for energy exchange. **Since the TPSS and the railway system act equivalently as a classical TSO-DSO energy system where the RBE represents DER (Distributed Energy Resources) at the edge of the DSO network**
- **The motivation for the trial is the ability to apply smart energy techniques to accommodate energy efficiencies and power balancing beneficial to both TSO and RSO (Combining the 5G low latency with smart on board metering/sensing and TPSS sensing and actuation**).

5G-Platform 5G-VINNI Energy: Energy Metering for HV and LV

- 5G-VICTORI will demonstrate the operation of a dynamically re-configurable ICT infrastructure combining: i) the smart energy operation of a HV (150kV/20kV) primary substation (TPSS) and ii) the rolling stock load of TRAINOSE suburban railway along with the braking smart energy recovery – acting as a generator (TRAINOSE acts as a DSO with distributed generation) in order to facilitate the smart energy cross operation of the overall infrastructure**. Regenerative braking is based on the ability of an electric motor to act as a generator during deceleration, whereby the kinetic energy stored in the rotor as mechanical inertia becomes a prime mover, sending electric power back to the power supply when the train decelerates**. Even if the energy provided by regenerative braking is not completely utilized, it is favorable over traditional frictional braking, as it does not generate wear and tear, dust, smell, heat or sound [Vuchic, 2007].
- Electricity powered **trains also act as power generations during the phase of speed lowering**. This leads to momentarily reduced energy consumption, as measured in the High Voltage substation demarcation points. In cases of dense train traffic, the train operators can use this feature as a combined means of **uniform power flow**. Through the optimization of combined train mobility, the speed lowering of the active trains can be coordinated in time and provide minimal fluctuation of power flow through the demarcation HV substations that feed the rail network.
- **The real time information of power fluctuation can be extremely useful, not only for the train operators, but also for the Transmission System Operator, since it can provide useful forecast information about power demarcation in the affected HV substations**. Furthermore, the uniformity of power consumption in time can be a potential subject of future, secondary, markets. **5G plays (by fulfilling specific objectives) a catalytic role in the creation of the canvas upon which technology solutions can be applied to transform the railway system into a smart energy ecosystem making full utilization of RBE resource and securing the safety of the energy supply infrastructure.**

5G-Platform 5G-VINNI Energy: Energy Metering for HV and LV

- **Requirements**
- -Installation of sensing and monitoring devices for the rolling stock, the stations and the substations.
- -Physical network connectivity.
- -Resilient, instantaneous connectivity, which drives the need for URLLC.
- - 4G/5G OAI extension capabilities to the sites.
- - ONAP capabilities extension and integration into the environment.
- - End-to-End Cluster integration and adaptation, prepared for different verticals and use cases.
- **Challenges**
- - Dynamic reconfiguration of the communication network taking into account railway (rolling stock
- mobility, the very diverse track nature spanning from surface to in-tunnel operation and urban to rural)
- and power system's operational needs (moving power loads and possible imbalances).
- - Limited battery lifetime of the sensing devices.
- - System level data synchronization.
- - Handling large amounts of data and an increasing number of devices/nodes being connected.

ΕΥΧΑΡΙΣΤΩ!

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