



5th Generation End-to-end Network, Experimentation,
System Integration, and Showcasing

A Large-Scale Facility for 5G Experimentation

5GENESIS HANDBOOK FOR ICT-19-2019 PROPOSERS



5Genesis



The research conducted under the 5GENESIS project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 815178.

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OUR VISION

5GENESIS aims at offering to the research community, the industry, the SMEs and especially the 5G verticals a Facility and an open set of tools to facilitate 5G and beyond experimentations. New 5G use cases and services could be used, new algorithms and novel technologies could be used in the Facility to assess the capability of the European-based R&D innovation to reach and exceed the 5G KPIs. This will be achieved by integrating highly diverse results and technologies from EU, global as well as internal (corporate) R&D projects, to “glue together” the 5G picture and unveil the potential of a truly full-stack, end-to-end 5G Facility, which can leverage the functionalities of five Platforms (see overleaf).



In order to achieve a smooth evolution and a concurrent validation of the Facility, its development is organized into three main integration cycles, each one lasting for 6 months. The scope of each integration cycle is to upgrade each of the five experimentation Platforms with the latest technical achievements and results from all relevant R&D activities as well as to align it with the most current edition of the 5G standards. Each integration cycle will be followed by a 3-month testing phase.

OUR ROAD MAP

OUR TEAM

The 5GENESIS consortium was swiftly crafted in order to contain all the different expertise and experiences needed to make the 5G Facility a reality. Our consortium is built around the need for bringing together heterogeneous players, with the required expertise and background in 5G technologies and in the target testbeds and vertical sectors. The consortium brings together 29 partners from 12 countries, (Germany, France, UK, Spain, Italy, Ireland, Israel, Greece, Cyprus, Norway, Sweden and Portugal)



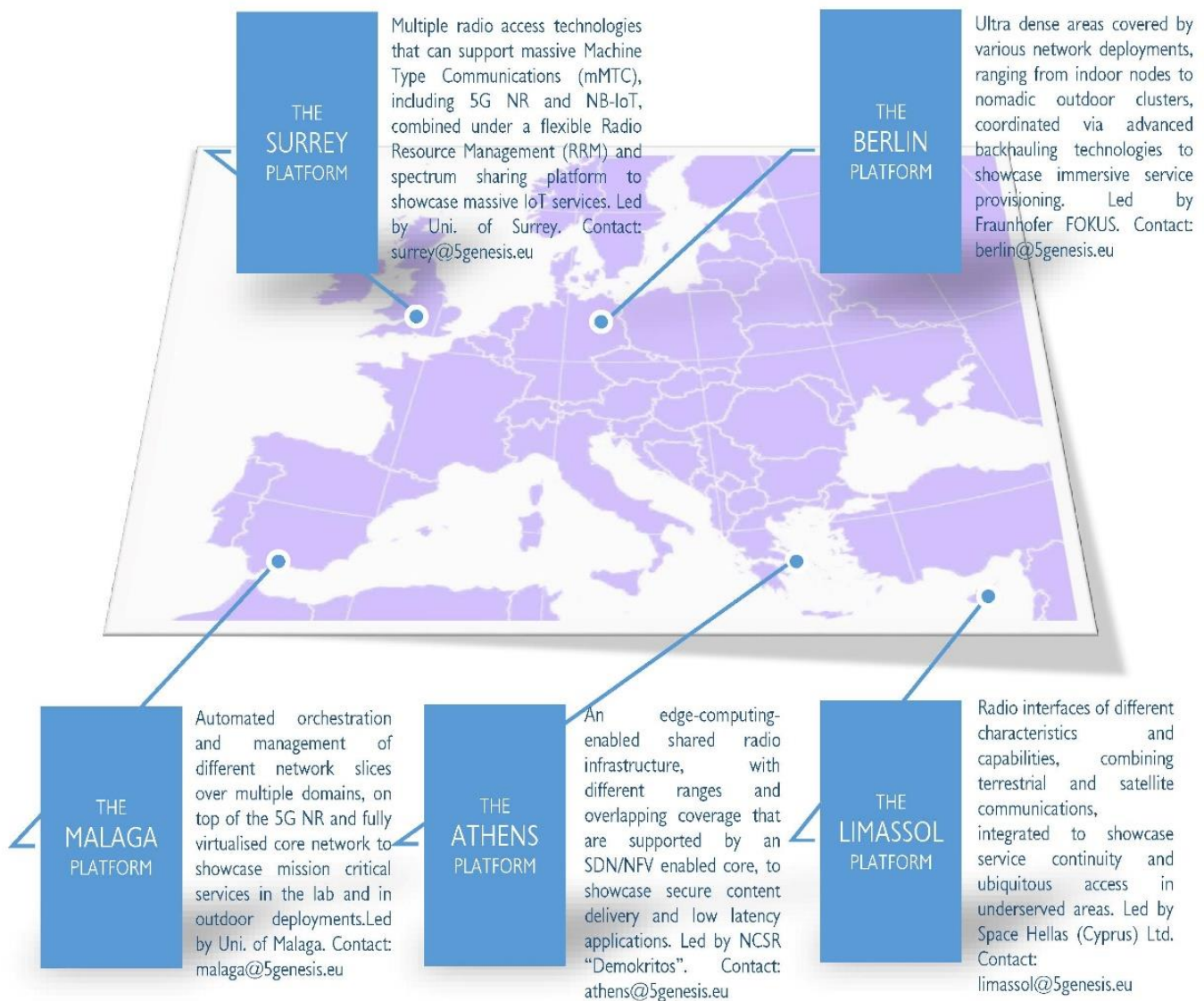
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A Large-Scale Facility for 5G Experimentation

The 5GENESIS Facility is based on five end-to-end experimental Platforms, distributed across Europe, having complementary features, yet all implementing the full 5G stack. Each one of the five Platforms is associated to one consortium partner, which leads and steers the operations of the Platform, and acts as the main point of contact for verticals and entities external to 5GENESIS that would like to submit a request for experimentation.



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5GENESIS Project



[@5genesis_h2020](https://twitter.com/5genesis_h2020)



info@5genesis.eu

Engagement Process of Vertical Industries in ICT-19-2019

Especially concerning the commercial exploitation model of the overall 5GENESIS facility upon the completion of the project, this is based on the plan that the facility be provided as an experimental asset to the potential vertical industries that are interested to test the performance of their services in 5G.

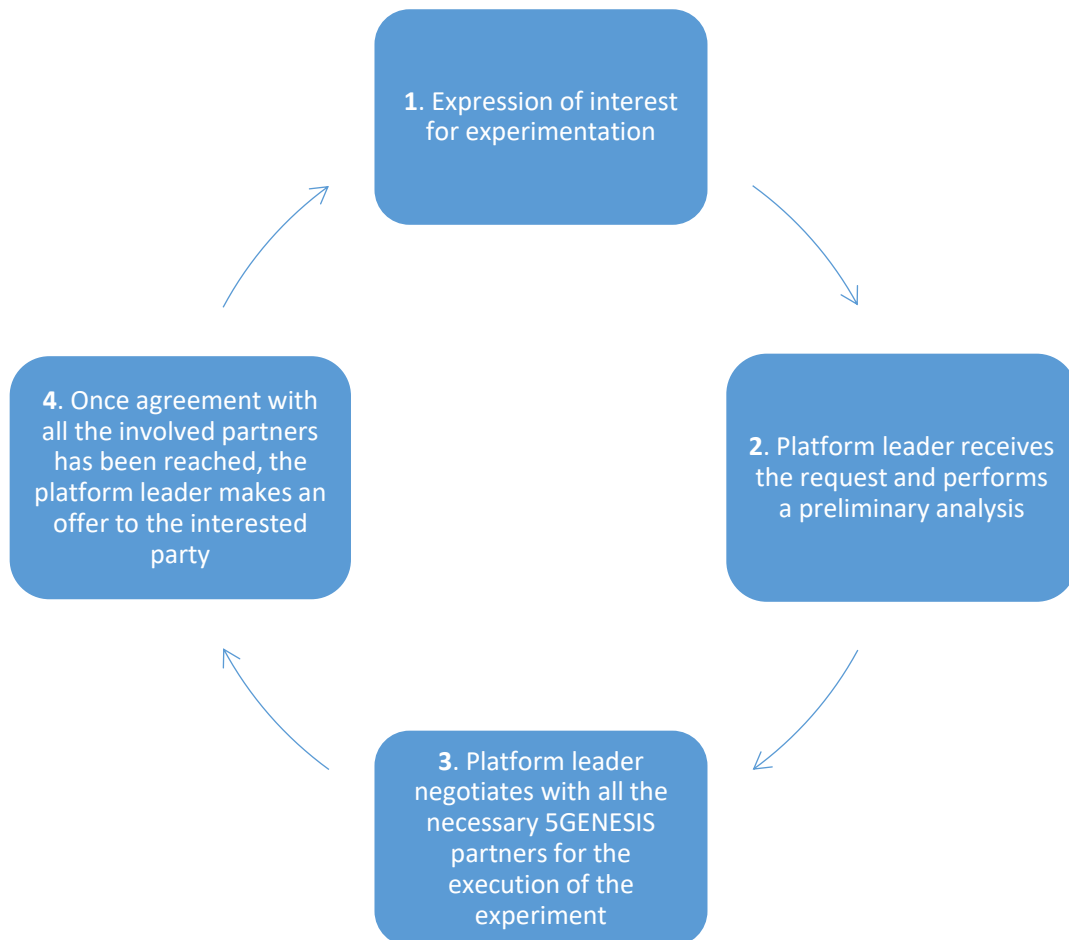


Figure 1. Process diagram of 5GENESIS facility exploitation by a vertical industry

Please send your requests at the 5GENESIS platform leaders:

5GENESIS Athens Facility: athens@5genesis.eu

5GENESIS Malaga Facility: malaga@5genesis.eu

5GENESIS Limassol Facility: limassol@5genesis.eu

5GENESIS Berlin Facility: berlin@5genesis.eu

5GENESIS Surrey Facility: surrey@5genesis.eu

For each of the five platforms that realises the 5GENESIS facility, the responsible platform leaders from the 5GENESIS consortium will act a point of contact, where the interested parties/verticals will get in touch in order to express their interest and submit their request for experimentation. The platform leader upon performing a requirements analysis of the requested experiment will contact all the involved



www.5genesis.eu

partners which are needed for the execution of the experiment and will eventually submit to the interested party a business offer and pricing for the execution of the experiment. Figure 1 provides a sequence diagram of the steps that should be followed by a vertical industry in order to use 5GENESIS facility for experimentation purposes.

The Consortium Partners with their diverse and complementary Research and Business contexts and capabilities provide all potential exploitation modalities and routes to attract all interested vertical industries.

5GENESIS Athens platform

Contact Info

Please send you vertical industry inquiry concerning ICT-19-2019 collaboration to Dr. Harilaos Koumaras (NCSR "Demokritos") at the following e-mail address **athens@5genesis.eu**

Country/Countries

Greece

Platform objectives

The Athens platform will be implemented on the Athens.5Glink (www.athens5glink.eu) testbed. Athens.5Glink is an open 5G testbed being built, set up in the city of Athens. The testbed is going to be extended so to offer the telecommunication ecosystem an E2E experimental 5G platform, showcasing features of next generation networks, with particular focus on software network technologies (NFV/SDN) and edge computing for small cell infrastructures.

Short description

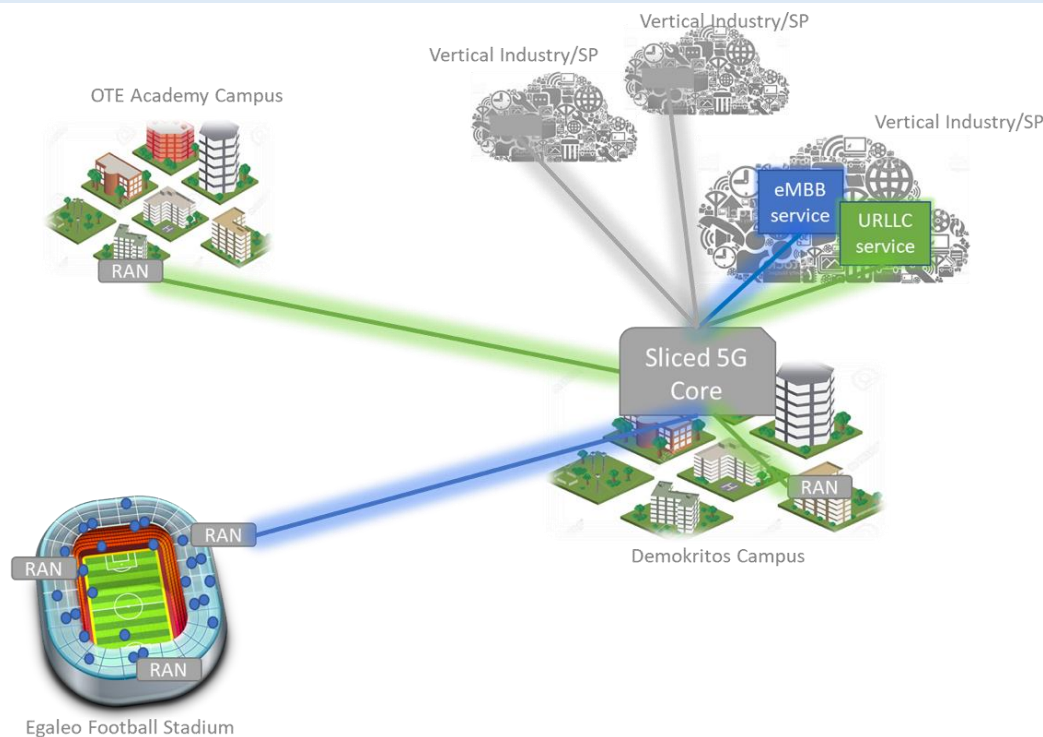


Figure 2. Overview of the 5GENESIS Athens platform

Athens.5Glink consists of three different site deployments:

- The campus of NCSR "Demokritos", in north-east Athens, is a 150-acre area, combining indoor and outdoor environments, covered by five software-driven 5G wireless nodes and supported by an optical backbone.
- The stadium of Egaleo, in west Athens, is going to be an actual "field" testbed, supporting a wide variety of real-life scenarios, ranging from massive MTC to flash crowd events.

- The COSMOTE building (OTE Academy), to the north of the city, is a multi-functional complex, combining various indoor and outdoor usage scenarios.

The 5GENESIS Athens platform includes the following features:

- Fully software-driven, multi-tenant and virtualisation-capable infrastructure
- Micro servers integrated in each Small Cell, according to the SESAME and 5G-ESSENCE architectures for mobile edge services
- SDN/NFV-based Management and Orchestration (MANO)
- Extensive IT capacity (180 CPU cores, 1.5TB RAM)
- Existing VNFs: vDPI, Security Appliances (Firewall, IDS), Network Monitor
- Edge services: Transcoder, Video analysis (object recognition)
- Radio front-end based on SDR platforms, fully reconfigurable
- High-speed Internet connectivity (via GRNET/GEANT)
- Fully configurable remote access (IPSec or SSL VPNs)
- Measurement/test tools including oscilloscopes, signal/spectrum analysers, traffic monitoring tools (ntop, Prometheus, Apache Spot) and visualisation tools (Grafana)

Use cases

Use Case 1: Big event Use case

- Content creation - demonstrate adaptive upstream content transmission
- Low-latency AR applications - edge computing infrastructure will be used to host part of the AR application and serve the associated content

Use Case 2: UAV Use Case – “Eye in the sky” applications

- Control the drone over a low-latency 5G slice and transmit HD and 4K real-time video to the ground control station

Use Case 3: Security-as-a-Service (SecaaS) at the edge

- Deployment and automated configuration of security VNFs for the identification and mitigation of security incidents

Technologies available

SDN/NFV-based Management and Orchestration (MANO) with supported NFV MANO platforms: OSM, OpenBaton and TeNOR, End-to-End Network Slicing with predictable performance isolation, Network Functions Virtualization (NFV) of 5G Networks, NFVI based on OpenStack (supporting VMs or Containers) and OpenDaylight, 5G (core + NR + UEs) Networks across multiple administrative network domains

Support of Verticals

Business model

The coordinating organization (NCSR) acts as the single point of contact for the vertical user/experimenter, negotiating the terms of use/SLA as well as the compensation for the human and technical resources, which will be employed for the support of the experiment.

Connectivity/Usage requirements

Vertical users can deploy their own services in the platform or can connect their remote services to the platform. The platform offers the common 5GENESIS Experimenter Interface to describe services and experiments to be executed in the

platform. The platform may also expose some internal interfaces to connect vertical services and devices.

Other info

Extensions: The platform is fully modular and may be extended with further functionalities depending on the vertical requirements and needs (e.g. VNFs, edge services, 5G-NR hardware, etc.)

Projects using your platform: 5GENESIS, 5GESSENCE

Vendors/Manufacturers/Providers providing support for the platform: Eurecom, Athonet

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5GENESIS Malaga platform

Contact Info

Please send you vertical industry inquiry concerning ICT-19-2019 collaboration to Prof. Pedro Merino (University of Malaga) at the following e-mail address **malaga@5genesis.eu**

Country/Countries

Spain

Platform objectives

5GENESIS Malaga platform aims the validation of selected 5G KPIs in indoor and outdoor 5G scenarios. Technologies in the platform are focussed on integrating 5G with other access technologies (4G, WiFi, fiber, ..) with great automation capabilities to execute experiments both unattended and with real users. The initial plan, in the context of the project funded in ICT-17 call (5GENESIS), considers KPIs related to capacity, speed, latency, reliability, density of users, location accuracy, service creation time and network management (CAPEX/OPEX). The use cases to validate the KPIs are related to Mission Critical Services. Once the platform has been validated as a 5G environment, it will support other use cases and KPIs, coming from ICT-19 or from other projects. Expected use cases should require features related to eMBB and/or URLLC.

Short description



Figure 3. Overview of the 5GENESIS Malaga platform

The physical infrastructure is mainly hosted and operated by University of Malaga (UMA), Malaga city (Police Department) and Telefonica. It is composed by 4 big areas:

- indoor fully automated UMA lab for initial testing of technologies and services and for identification of baseline values for KPIs
- outdoor UMA deployment for first testing of use cases in a controlled environment with and without real users

- outdoor Malaga city center deployment for testing with real users, including the possibility of large scale events
- edge computing platform at Telefonica premises in Malaga city (close to the access nodes deployed at the city center) to demonstrate the advantages of MEC capabilities

What can be supported:

- Lab indoor/building outdoor/large area in campus and city
- Extensible to cover vertical premises in the area
- 4-5 cells at UMA and 15-20 cells at Malaga city center
- 1-2 users (UE) in the lab, large community of users outdoor
- Different mobility scenarios: static, pedestrian and vehicular in outdoor deployments, static, pedestrian, vehicular and high speed emulated in lab
- Experimental and commercial UE and gNB (as far as they become available)

Use cases

- Automotive and road transport
- Transport
- Public Safety
- Media and Entertainment
- eHealth
- Factory of the Future / Industry 4.0
- Smart Cities
- Energy
- FinTech
- Smart Buildings

Technologies available

Fully software-automated, 5G NR, LTE-A, NB-IoT, LTE-WiFi aggregation, GPS emulation, Slice Manager, NFV (Openstack, OpenNebula, MANO orchestrator,) and SDN in transport and core, edge computing for low latency services.

Support of Verticals

Business model

- Business model restrictions (With agreement for use)

Connectivity/Usage requirements

Vertical can deploy their own services in the platform or can connect their remote services to the platform

The platform offers the common 5GENESIS Experimenter Interface to describe services and experiments to be executed in the platforms

The platform also expose some internal interfaces to connect vertical services and devices (most of them are 3GPP interfaces)

Other info

Projects using your platform

The starting point for 5GENESIS Malaga platform is the instance of TRIANGLE testbed hosted at UMA. This platform is (was) already used in the projects FLEX, Fed4FIRE, Fed4Fire+, Q4Health and TRIANGLE.

Vendors/Manufacturers/Providers supporting your platform

The platform (including TRIANGLE and new contributions by 5GENESIS partners) will integrate equipment and software coming from Keysight Technologies, Polaris Networks, Nokia, ATOS, Runel, Athonet, Eurecom, Airbus, Nemergent, Fogus Innovations & Services.

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5GENESIS Limassol platform

Contact Info

Please send you vertical industry inquiry concerning ICT-19-2019 collaboration to Dr. Georgios Gardikis (Space Hellas Cyprus Ltd) at the following e-mail address **limassol@5genesis.eu**

Country/Countries

Cyprus

Platform objectives

The Limassol 5G platform will integrate several infrastructures in the city of Limassol, Cyprus, in order to form an interoperable multi-radio facility, combining terrestrial and satellite communications with the ultimate aim of efficiently extending 5G coverage to underserved areas. To that end, the Limassol 5G platform will employ NFV-/SDN-enabled satellite communications as well as tight integration of different access and backhaul technologies, in order to achieve the following innovative features: i) ubiquitous coverage with reduced latency, ii) support for multi-radio slicing, iii) 5G throughput enhancement via air interface aggregation, where necessary and iv) dynamic spectrum allocation between satellite and terrestrial.

Short description

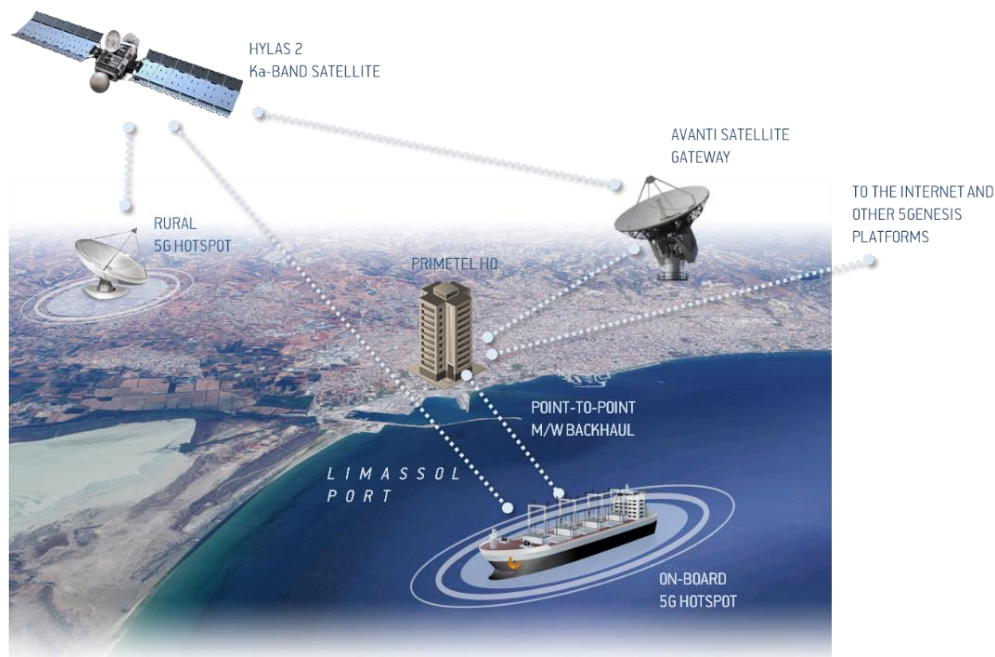


Figure 4. Overview of the 5GENESIS Limassol platform

The key infrastructures on which the platform will be built is the Avanti Satellite Gateway in Cyprus, providing connectivity to the Hylas2 satellite, and of Primetel testbed in the company's central building, near the Limassol port. The implementation of the platform is coordinated by Space Hellas (Cyprus) Ltd, which is integrating the various assets and is also offering the management and coordination components. In

5GENESIS, the platform focuses on two use cases: maritime communications and capacity-on-demand in rural/underserved areas.

The 5GENESIS Limassol platform includes the following features:

- Next-generation satellite communications, supported by the Avanti HYLAS2 and HYLAS4 satellites, featuring NFV/SDN enablers and seamless integration into 5G.
- NG Core and 5G NR, focusing on ad-hoc, remotely-deployed 5G hotspots (in underserved areas, long-range transportation media etc.)
- Support for dynamic deployment and management of network services at the satellite edge (satcom MEC), including local session handling (LBO) and IoT interoperability.
- WAN optimization and multi-link aggregation, for satellite/terrestrial radio coupling.
- Dynamic Spectrum Allocation (DSA) between satellite and terrestrial
- Security Analytics framework, based on Big Data and Machine Learning technologies for the dynamic identification and classification

Use cases

- Long-haul transport (supported by MARAN UK shipping company)
- Underserved areas
- Sensor networks
- Public Safety (disaster relief)
- Media and Entertainment (caching, multicast distribution etc.)
- eHealth
- Factory of the Future (focus on factory ships)

Technologies available

Satellite backhauling, NFV/SDN-enabled satcom, 5G core, 5G NR, Network Slicing, SDN in transport and core, edge computing for low latency services at the satellite edge, ML-based security analytics, dynamic spectrum management

Support of Verticals

Business model

The coordinating organization (Space Hellas Cyprus Ltd.) acts as the single point of contact for the vertical user/experimenter, negotiating the terms of use/SLA as well as the compensation for the human and technical resources, which will be employed for the support of the experiment.

Connectivity/Usage requirements

Vertical users can deploy their own services in the platform or can connect their remote services to the platform. The platform offers the common 5GENESIS Experimenter Interface to describe services and experiments to be executed in the platform. The platform may also expose some internal interfaces to connect vertical services and devices.

Other info

Extensions: The platform is fully modular and may be extended with further functionalities depending on the vertical requirements and needs (e.g. VNFs, edge services etc.).

Projects using your platform: 5Genesis, SaT5G, commercial industry projects.

Vendors/Manufacturers/Providers providing support for the platform: Avanti, PrimeTel, iDirect, Eurecom, Athonet

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5GENESIS Berlin platform

Contact Info

Please send you vertical industry inquiry concerning ICT-19-2019 collaboration to Dr. M. Emmelmann (Fraunhofer FOKUS) at the following e-mail address **berlin@5genesis.eu**

Country/Countries

Germany

Platform objectives

5GENESIS Berlin platform aims at providing a flexible and scalable end-to-end integration of 5G technologies including 5G Core, transport network, and mmWave backhauling. The Berlin platform is directly connected via dense wavelength division multiplexing (DWDM) to a German-wide, 100-Gbps fiber backbone allowing experiments representing connectivity over long-haul operator backbones; in addition, the platform allows for satellite-based backhauling and for a local, nomadic instantiation of platform components. The platform provides multi-vendor, commercial 5G NR upon availability and supports network slicing, function virtualization, and mobile edge compute. It supports stand-alone and non-standalone network configurations, utilizing indoor- and outdoor coverage based on commercial LTE & 5GNR operating in 700, 2600, and 3700 MHz bands. For 5G KPI evaluations, the platform facilitates means for GDPR-conformant anonymization of measurement data. The initial plan, in the context of the project 5GENESIS, considers the evaluation of KPIs related to speed, reliability, density of users, and service creation. Use cases employed to validate the KPIs include media and video distribution in a dense urban environment. Once fully validated, the platform will support additional use cases including industrial IoT / URLLC, intelligent transportation, and eMBB.

Short description

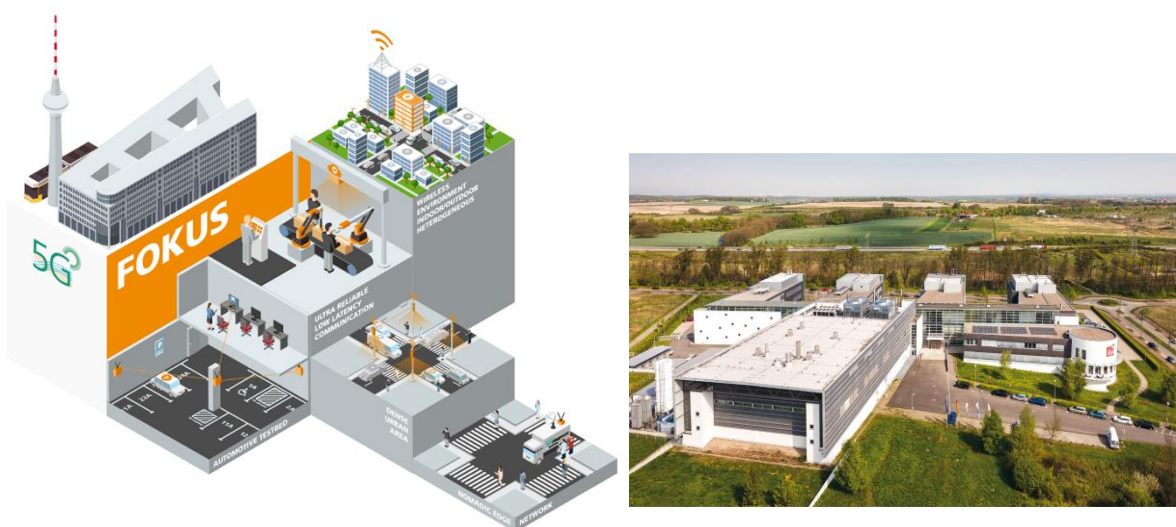


Figure 5. Overview of the 5GENESIS Berlin platform

The physical infrastructure is facilitated via the *Fraunhofer FOKUS* 5G Playground Berlin interconnected with the *IHP – Leibniz-Institut für innovative Mikroelektronik*, Frankfurt (Oder). The platform may connect via GEANT or satellite links to additional customer premises.

The 5Genesis Berlin platform integrates advanced measurement schemes as derived from the MONROE platform. The Berlin platform allows for:

- Indoor and outdoor, automated initial testing of technologies and services and for identification of baseline values for KPIs
- Instantiating nomadic remote deployments, e.g. in the Berlin city center or other locations across Europe to conduct experiments involving a large number of users in dense urban environments, or e.g. providing 5G-based coverage in “white spots” at remote locations.

The 5Genesis Berlin platform provides and supports:

- Simultaneous use of heterogeneous access technologies, including LTE, 5G NR¹, mmWAVE backhaul links, WiFi, and LoRa WAN.
- Experimental and commercial UEs and gNBs²
- Stand-alone and non-standalone 5G core network
- Attachment of customer equipment e.g. for edge computing
- Underground parking deck fully covered via commercial 5G NR
- Enablers for GDPR-conformant anonymization of measurement data

Use cases

- Smart Cities
- Automotive and road transport³
- Public Safety
- Media and Entertainment
- eHealth
- Factory of the Future / Industry 4.0

Technologies available

5G core, 5G NR, LTE-A, WiFi, LoRa-WAN, Network Slicing, SDN in transport and core, edge computing for low latency services, mmWAVE and satellite backhauling, operator-graded DWDM access to German wide fiber backbone.

Support of Verticals

Business model

- Business model restrictions (legal agreement and compensation scheme)

Connectivity/Usage requirements

Vertical can deploy their own services in the platform or can connect their remote services to the platform. The platform offers the common 5GENESIS Experimenter Interface to describe services and experiments to be executed in the platform. The

¹ Upon availability of commercial equipment expected in Q1/2-2019.

² Upon availability of commercial equipment expected in Q1/2-2019.

³ Parking deck and surrounding Fraunhofer FOKUS premises.

platform may also expose some internal interfaces to connect vertical services and devices.

Other info

Extensions: The platform may be extended with further functionality depending on the vertical requirements and needs.

Projects using your platform: 5Genesis, 5G-Enhance, 5G!Pagoda, 5G-XHaul, 5G Berlin, 5G-VINNI, commercial industry projects.

Vendors/Manufacturers/Providers providing support for the platform: Nokia (t.b.c), Huawei (t.b.c), Telefonica, Vodafone, NetApp, Runel, Acceleran

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5GENESIS Surrey platform

Contact Info

Please send you vertical industry inquiry concerning ICT-19-2019 collaboration to Dr. Klaus Moessner (University of Surrey) at the following e-mail address surrey@5genesis.eu

Country/Countries

United Kingdom

Platform objectives

In 5GENESIS, the Surrey platform is used to demonstrate the capability of 5G networks to use and exploit multiple radio access technologies that can support massive Machine Type Communications (mMTC) services. The platform supports commercial 4G and 5G NR and features such as network slicing, function virtualization, SDN control and mobile edge computing. Both stand-alone and non-standalone network configurations are supported, providing coverage based on commercial Lte & 5G NR operating in 700, 2600, and 3500 MHz bands. The platform also supports mmWave PtP/PtMP and satellite backhauling. The set-up of the platform is foreseen to provide support for NB-IoT and LoRa air interfaces, combined under a flexible Radio Resource Management (RRM) to showcase massive IoT use-case scenarios. The initial plan, in the context of the ICT-17 call (5GENESIS) considers KPIs related to capacity, latency, scalability and reliability. The platform provides experimentation facilities to verticals and is also able to support eMBB and URLLC related use-cases, coming from ICT-19 or from other projects.

Short description

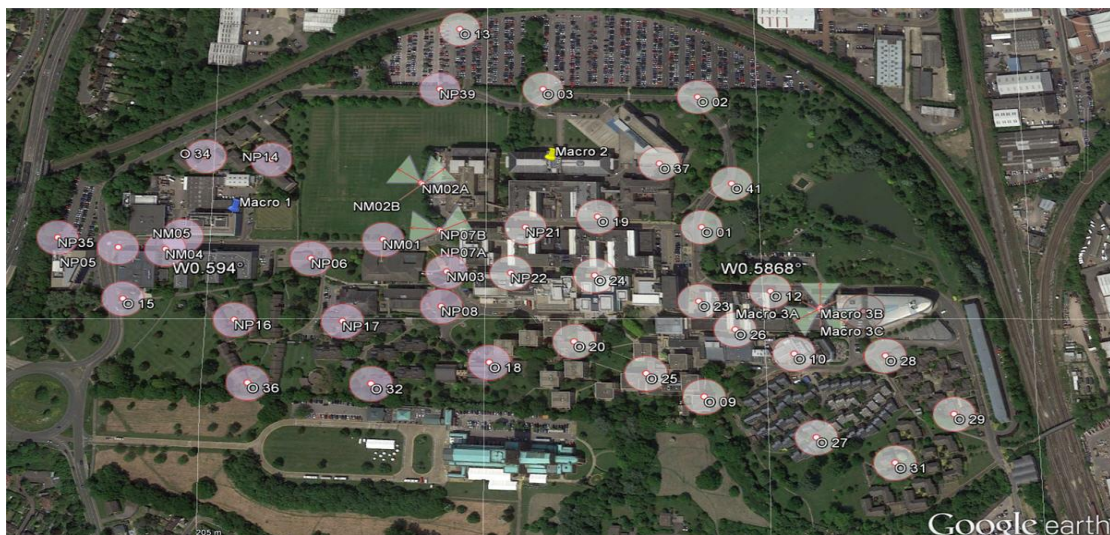


Figure 6. Overview of the 5GENESIS Surrey platform

The testbed consists of separately managed 4G and 5G RAN and core-network segments. The 5G segment has been designed to employ the best of evolving NFV and SDN implementations and features. This architecture is able to inter-connect with and support different RAN configurations, C-RAN, D-RAN etc., according to available

transmission options. The testbed currently covers the whole of the main campus of the University of Surrey, which spans an area of around 4km². The RAN segment of the testbed is illustrated below.

The Outdoor deployment, consists of 4G ultra-dense C-RAN comprising 3 macro cells (Lte-A TDD, tri-sector), plus 39 Lte-A TDD small-cell sites, all operating at 2.6 GHz (BW = 2x 20 MHz ; 4x4 MIMO) as well as 1x 4G FDD site operating at 700 MHz ; (BW = 10/20 MHz ; 2x2 MIMO), and 8x 5G NR TDD sites, operating at 3.5 GHz (BW = 100 MHz; 64x64 MIMO). Additionally, 28 GHz (PtP), 60GHz (PtMP) mmWave and satellite backhauling are also supported. **The Indoor deployment** (Lte-A based C-RAN) consists of 6x TDD and 6x FDD cells over 2 floors, and Wi-Fi APs. **The Core Network** supports separate 4G and 5G core segments. The 4G segment is based on Rel-14 EPC 'CUPS'. The 5G segment supports virtualised core functions and Rel-15 features such as Context Awareness and simplified control plane. The testbed also supports edge computing to demonstrate MEC (co-located with the access nodes deployed at the campus) capabilities.

Use cases

- eMBB, URLLC and massive MTC
- Connected & Autonomous Transport
- Public Safety
- Media and Entertainment
- eHealth
- Factory of the Future / Industry 4.0
- Smart Cities
- Satellite Backhauling

Technologies available

Lte-A, WiFi, 5G NR, 5G UEs, NB-IoT, In-house developed slicing, orchestration and virtualization managers, SDN in transport and core, MEC, centralised storage for VNFs (repository), mmWave and satellite backhauling.

Support of Verticals

Business model

The coordinating organization (5GIC) acts as the single point of contact for the vertical user/experimenter, negotiating the terms of use/SLA.

Connectivity/Usage requirements

Verticals can deploy own services in the platform or can remote connect to the platform (via secure PtP VPN connection using the JANET network). The platform offers the common 5GENESIS Experimenter Interface used to describe services and experiments to be executed on the platform.

Other info

Extensions: The platform can be extended with further functionality depending on the vertical requirements and needs.

Projects using the platform: 5Genesis, Clear5G, Sat5G, SoftFIRE/SoftFIRE+, commercial industry projects.

Vendors/Manufacturers/Providers providing support for the platform: Huawei, Quortus, Aruba, MYCOM, Vodafone, FoN, RunEL, INFOLYSIS, Ericsson.

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