# Deployment of 5G Experiments on Underserved Areas using the Open5GENESIS Suite


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***Abstract*—This demo shows how the Open5GENESIS suite can be used for executing 5G experiments at rural and underserved areas, integrating technologies such as edge computing and satellite backhaul. The use case considered is a smart farming application for weed detection, realized by means of Virtualized Network Functions (VNFs) and tailored functions. The 5GENESIS experimentation methodology will be presented, showing its flexibility for orchestrating, managing and retrieving metrics of this particular experiment.**



***Keywords—5G experimentation, satellite/5G integration, experimentation methodology, edge computing***


## I. Overview

The fifth generation of mobile networks, 5G, comes with great advantages compared to its predecessor, not just with higher bandwidth and lower latencies but also increasing spectral efficiency, connection density, coverage, etc. All these, combined with SDN/NFV paradigm, the concept of slicing and the combination with edge computing equipment unlocks novel use cases in a great number of scenarios. However, as with most novel technologies, 5G arrives much later to rural and underserved areas, delaying the deployment of novel uses cases and the embracement of new business models. The Limassol Platform [1], one of the 5G experimental platforms of the H2020 5GENESIS project [2], integrates satellite backhauling and shows how it can extend 5G coverage to these areas.

Using a satellite link to connect gNB (5G radio) to 5GC (5G core) brings increased latencies and reduced bandwidths, which cut out many of the advantages of 5G. These problems can be minimized with local break-out (LBO) configurations, that is, deploying data plane functions of 5GC at the satellite edge so application traffic does not have to reach central/cloud facilities. In this manner, 5G applications can be deployed at the edge, closer to the gNB, without needing a dedicated terrestrial backhauling for serving a rural area. The network setup for the demo is composed of the following key elements:

- The core data center, at Primetel's premises (Limassol, Cyprus) which hosts the Open5GENESIS suite, the managing and orchestration elements (see [3]) and the 5GC functions (Open5GS v2.2.6, Standalone).
- The portable "5G Hotspot", with the satellite terminal (also at Primetel's), the edge computing server (with Intel Neural Compute Stick 2 for ML acceleration) and integrated gNB (Amari Callbox Classic, with NR configuration: 50 MHz, 2x2 MIMO, band 78).
- Satellite link, over Avanti Hylas 2 geostationary satellite (Ka-band, with 15Mbps DL/5 Mbps UL).
- Raspberry Pi 4 with Waveshare 5G Hat as UE.

Besides, the Limassol platform is ready for supporting other setups making use of Virtualized Network Functions (VNFs), such as IoT (with INTER-IoT vGateway) and link aggregation capabilities for aggregating satellite and terrestrial backhaul networks, via Intelligent Network Gateway (ING, at core data center) and Intelligent User Gateway (IUG, at edge location).

The use case to be shown is framed in the sector of smart farming, being a weed detection application. These applications are being slowly adopted in the agriculture sector since they allow reducing the quantity of herbicide that has to be applied in the field to remove unwanted weeds. There are two types: (a) drone based with 5G UE and camera attached to detect spots with accumulation of weed, or (b) autonomous


Fig. 1. Core data center (left), portable "5G Hotspot" deployed at the satellite edge (center), satellite link (right)

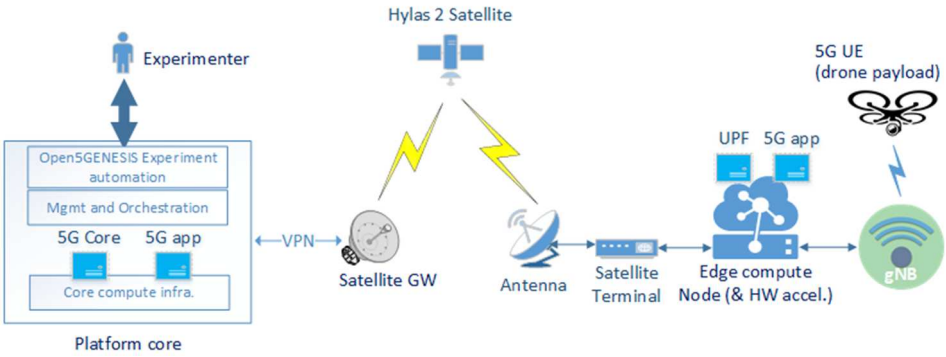


Fig. 2. Demo setup topology

robot based with 5G UE and cameras attached, that travels through the field and applies herbicide where is needed, hence also avoiding the need of manual labor.

Our use case demonstrates the first type. While scanning a field, the drone sends crop images to the edge where they are processed leveraging hardware acceleration capabilities and Deep Learning models, making use of Tensorflow and OpenCV, among other libraries. 5G brings higher bandwidths and lower latencies than its predecessor, enabling both the use of higher image resolutions and lower processing times, hence allowing sweeping the field for unwanted weed much faster while also reducing the carbon footprint.

The use case setup is presented in Fig. 2. As previously mentioned, the Open5GENESIS suite is used for orchestrating, managing and monitoring the use case as well as for retrieving Key Performance Indicators (KPIs). From the central site, the Open5GENESIS experimentation framework (see [3]) can retrieve metrics from a measurement agent deployed at the UE, that in turn collects application-level metrics from the application. This demo will have the following structure and will include these features:

- Overview of the network setup and the use case considered.
- Live presentation of the **Open5GENESIS Portal**, **via PC**. A guided tour through its different interfaces will be given, summarizing the methodology that has to be followed prior to the experiment's execution (more information can be seen in [4]):
    - Test case template and definition. Monitoring agents/probes preparation.
    - Scenario and slice templates and definitions (slice not used for this use case).
    - Experiment template and definition.
- Experiment execution. The demo equipment will be at Space Hellas Ltd. facilities, Greece, **remotely** accessible from the Portal. The demo will be shown with a **monitor via video streaming and records.**
- Live presentation of the experiment results and analysis of KPIs. Two types of KPIs will be gathered:
    - Application response time, from the submission of the captured image by the UE to the reception of the response (weed present or not). Two experiments: with and without LBO (i.e., application of the use case at Limassol's core data center).
    - Inference time, average and metrics of the time needed by the edge to process a frame.

## II. Innovation

This demo shows the flexibility of the Open5GENESIS suite from H2020 5GENESIS project to exploit automation capabilities in 5G-related experiments. The use case considered leverages on different technologies and tools (satellite backhaul, edge computing, novel 5G equipment, etc.) to test and validate a smart farming application, targeting underserved areas. In particular, it considers a weed detection application which requires higher bandwidths and lower latencies than current available ones to enable faster field sweeps and higher accuracy while lowering energy consumption. In any case, the suite can be integrated in different kinds of facilitates, so 5G experiments can be carried out in other verticals such as automotive, city management, energy and manufacturing, among many others.

## III. Relevance and Interest

This demo is relevant specifically for the tracks related to *5G for Industrial Applications* and *Next Generation Networks*. Although the use case presented is not directly related to industry, the Open5GENESIS suite can be utilized in this and any other sector that deploys uses cases with 5G. The audience can be interested in this demo for different reasons, such as learning how Open5GENESIS can be leveraged for executing 5G experiments, how all the involved technologies have been integrated and which other possibilities are available, or which is the importance of supporting not only this smart farming application but 5G and IoT use cases in general in underserved areas.

## Acknowledgment

The work described in this paper has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815178.

## References

[1] H2020 5GENESIS project, 5th Generation End-to-end Network, Experimentation, System Integration, and Showcasing, https://5genesis.eu/

[2] Gardikis, Georgios, et al. "The 5GENESIS testing facility as an enabler for integrated satellite/terrestrial 5G experimentation." 2019 IEEE Wireless Communications and Networking Conference Workshop (WCNCW). p. 1-6., 2019.

[3] H2020 5GENESIS project, D2.4 - Final report on facility design and experimentation planning, https://5genesis.eu/deliverables/

[4] A. Díaz Zayas, G. Caso, Ö. Alay, P. Merino, A. Brunstrom, D. Tsolkas, and H. Koumaras, "A Modular Experimentation Methodology for 5G Deployments: The 5GENESIS Approach," Sensors, vol. 20, no. 22, p. 6652, Nov. 2020.