5G-STREAM: Sustainable Surveillance for Smart Cities

By Diamantis Group

Booklet

Part of: H2020 5G-IANA Open Call Winners' Booklet Series

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101016427

INTRODUCTION

✓ *Overview of 5G-STREAM*

In today's rapidly evolving smart city landscape, **5G-STREAM** introduces an innovative surveillance service designed to meet the needs of **urban mobility and public transportation**. This next-generation solution harnesses the power of **5G connectivity**, enhanced by **edge/cloud computing** and **advanced video analytics**, to deliver (near) real-time video processing and data-driven insights for city environments.

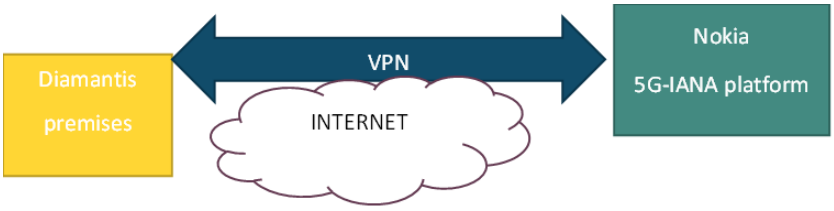
A Dual-Component Architecture: The 5G-STREAM system is built around two core components:

- **Cloud Service Platform**: A network application (nApp) equipped with AI-driven video analytics capabilities for **object detection, classification, and tracking**.
- **Client-Side Application**: Developed in-house, the client application is deployed on a **prototype Solar-powered Battery-equipped Camera (SB-CAM)**, featuring built-in 5G connectivity. These self-sustaining units require no external power, allowing for **easy installation** on various urban infrastructures.

Sustainable by Design: The SB-CAM prototype is designed for **minimal environmental impact** and can be seamlessly mounted on public assets such as **bus stations, lighting poles, bicycle stations, and smart waste bins**. By capturing real-time streaming data, it enables cities to implement efficient, low-maintenance surveillance and monitoring systems. Initially focused on **people detection at bus station shelters**, the 5G-STREAM module is planned for broader integration across our full smart city product line—and even as a security solution for **photovoltaic (PV) parks**.

Real-World Testing with NOKIA

To validate its performance, the 5G-STREAM service is hosted on the **NOKIA testbed**, which offers an advanced **5G Standalone (SA) core**, 5G modems, servers, and 5G-IANA components. This infrastructure allows us to experiment with various setups, including **processing at the edge vs in the cloud**, to assess performance and flexibility. Importantly, **NOKIA has shown particular interest** in the **energy efficiency** aspect of 5G-STREAM, especially given the high-power demands of 5G user equipment. Our ongoing collaboration aims to explore innovative ways to **minimize energy consumption** without compromising functionality, an essential step toward greener, more sustainable 5G solutions.



Connection directly to IANA back-end platform (netapps)

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✓ Objectives

High level objectives

- Develop **innovative connected surveillance** solutions for smart cities.
- Evaluate the **5G as an enabler for standalone deployments via cloud computing offloading**.
- **Enhance public transportation efficiency** by integrating our solution to bus stops.

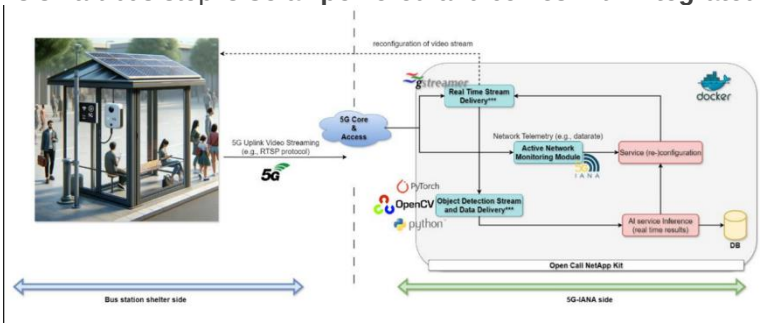
Technical objectives

- Develop a **Solar-powered Battery-equipped camera** module with a 5G interface.
- Develop a **containerized AI and video analytics service** for advanced object detection.
- **Evaluate** the **performance** of the **5G-STREAM** solution and its energy requirements.

Testing Setup & Results

✓ Testing & Qualitative Evaluation

Our envisioned scenario centers around **people counting at a 5G-enabled, self-sufficient bus stop**, requiring **no external power sources**. This smart bus stop is **solar-powered** and comes with **integrated surveillance capabilities**, enabling deployment even in off-grid locations. As illustrated in the accompanying figure, the video processing and inference tasks are offloaded to the **5G-IANA platform**, showing the platform's cloud-based processing capabilities.



Key Innovation: Cross-Border Deployment. A notable aspect of our setup is its **cross-border architecture**: the **end-point is located in Greece**, while the **NOKIA testbed**—which hosts the 5G-IANA platform—is located in another country. As the 5G-STREAM use case is **not latency-sensitive**, this geographical separation has **no negative impact on performance evaluation**.

End-Point Hardware and AI Capabilities. The deployed **end-point module** is a compact, energy-efficient unit composed of:

- A **RasbPi 5** processing unit
- A **10W solar panel**
- A **10Ah battery**

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We developed a **containerized AI service for human presence detection**, based on **YOLOv8**, which supports flexible execution either **at the edge or in the cloud**.

Baseline vs Offloaded Execution. For benchmarking, we evaluated two scenarios:

- A **baseline** where the Raspberry Pi 5 hosts the full 5G-STREAM AI service locally.
- A **cloud-offloading** mode where only video frames are captured at the edge, and all AI processing is performed remotely at the 5G-IANA platform.

System Architecture and Reproducibility. To enable this setup, the following components and steps were implemented:

- **WireGuard VPN** installed on the Pi 5 to access the remote container running the AI service.
- **GStreamer server** setup on the Raspberry Pi to read frames from a wide-angle camera and create an **RTP stream**.
- RTP video stream transmitted over **5G** to a **remote server** hosting the 5G-STREAM AI service.
- At the server side, the AI service includes a **GStreamer client** listening for RTP/TCP traffic, forwarding the frames for **real-time inference**.

Deployment Details: The 5G-STREAM service has been **containerized using Docker**, built on **Ubuntu 22.04**. Configuration files for both **Docker Compose** and **Maestro Compose** have been prepared. The final service image is approximately **7 GB compressed**. While the container supports **CPU and GPU execution**, our evaluations on the 5G-IANA platform were conducted using **CPU-only processing**.

Demonstration & qualitative analysis

To assess the efficiency of our solution, we carried out a comparative evaluation using a consistent setup: a 25-second video processed at up to 2 frames per second. For the cloud-based configuration, we used a high-accuracy AI model, while a lightweight version was employed on the edge device to support real-time processing. In the **baseline architecture**, all processing is performed locally on a 5G-enabled edge device, without any cloud involvement. This independent setup results in an average power consumption of approximately 7 watts. To ensure continuous operation, it requires a 100W solar panel and a 10Ah battery, making it relatively demanding in terms of energy and hardware.

In contrast, the **5G-STREAM configuration** leverages the 5G-IANA platform for remote AI inference. The edge device is limited to video capture and streaming, with all processing handled in the cloud. This significantly reduces power usage to less than 0.7 watts on average. As a result, the hardware requirements are minimal—only a sub-10W solar panel and a 1Ah battery are needed. Overall, **this setup demonstrates** that the 5G-STREAM architecture is **up to ten times more energy-efficient** while simplifying hardware demands and offering improved scalability.

Key Outcomes

- **Energy Efficiency**: The cloud-offloading solution is **10x more power-efficient** than the standalone alternative.
- **Hardware Simplification**: It enables the use of **lighter, more cost-effective equipment**, reducing installation and maintenance complexity.

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- **Improved Accuracy**: By utilizing advanced models in the cloud, the 5G-STREAM architecture **achieves higher detection accuracy**.

✓ Results

Updated business plan. 5G-IANA enabled us to assess the potential of the 5G-STREAM solution. In the next year the plan is to optimize the overall performance of our solution and transform our device into a fully integrated product. The performance optimization includes both the capabilities of the end device but also the detection accuracy of the service. According to the revised business plan, the service will be provided as an once off payment incorporated in the cost of acquiring the necessary equipment. The cloud service will be executed on a public cloud. Regarding the smart bus stations through the integration with a Traffic Management Center solution, 5G-STREAM is set to significantly enhance public transportation efficiency, while also making meaningful contributions to societal well-being and sustainability.

Challenges faced. Due to significant delays in the announcement of the Open Call results (mid May), there was less than 6 months time left for the execution of the project. Given also the summer break, the timely execution of the project became particularly challenging. Despite the challenging setup, the consortium has been always responsive and willing to help with any technical issues that came up. Besides, the advanced capabilities of the 5G-IANA platform and the inherent support of cloud services made integration easy.

Key Conclusions & Future Plans

The **5G-STREAM project** has marked a significant milestone for the **Diamantis Group**, representing a valuable opportunity to enhance our smart city solutions portfolio. From the moment we discovered the initiative via the **5G-IANA platform**, our team developed a clear and focused implementation roadmap to integrate 5G-STREAM into our product catalog.

Enabling Adaptive Public Transport: Our **smart bus stations**, now powered by the 5G-STREAM solution, bring intelligence to public transportation by detecting **real-time passenger presence** at each station. This data allows for the **dynamic adjustment of bus routes and frequencies**, making public transport more **efficient, responsive, and user-centric**.Looking ahead, we plan to integrate this solution with **commercial Traffic Management Centers**, enabling real-time decision-making for route planning.

Expanding Opportunities in the Smart City Market: A **market analysis** conducted in collaboration with the **5G-IANA consortium** has highlighted numerous growth opportunities for 5G-STREAM in the broader smart city domain. With **global investments in smart city infrastructure on the rise**, largely driven by **governmental incentives**, the potential applications of our solution extend far beyond public transport. The 5G-STREAM technology can be adapted to support:

- **Waste management optimization**

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- **Public safety and surveillance**
- **Renewable energy infrastructure monitoring**

According to industry forecasts, the **global Smart Cities market** is projected to grow from **USD 600 billion in 2023 to over USD 2.5 trillion by 2032**, offering a substantial opportunity for innovation and commercial deployment.

Vision for the Future: Smart, Connected Urban Solutions

Over the next **1 to 3 years**, we anticipate equipping the **majority of our product range** with smart modules to transform them into **connected IoT-enabled assets**. For use cases with lower data and performance demands, we will also explore **alternative communication technologies**, such as (i) **LPWAN (Low-Power Wide-Area Networks)** and **(ii) Ambient IoT.** By embracing 5G and emerging IoT technologies, Diamantis Group is committed to shaping the future of **intelligent urban infrastructure**.

Online & Multimedia Material

Video content, including a recorded live demonstration and explanation, is available on the 5G-IANA YouTube channel. Scan the QR code on the right to watch:

SCAN ME

Discover more about Diamantis' and other success stories available on the 5G-IANA website by scanning the QR code on the right:

SCAN ME

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