Surface Anomaly Detection System

By FERON Technologies

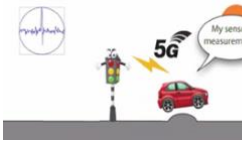
Booklet

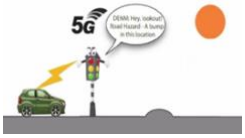
Part of: H2020 5G-IANA Open Call Winners' Booklet Series

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

INTRODUCTION

✓ *Overview of Surface Anomaly Detection System* as a Network Application





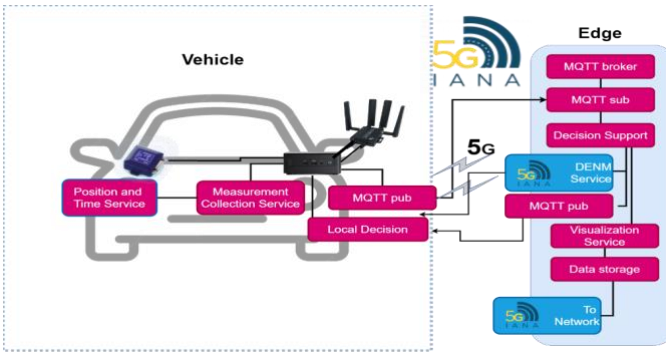
This innovative Network Application focuses on **real-time road condition monitoring and anomaly detection** by identifying **bumps and potholes**. It enhances **urban infrastructure management** and **road safety**, making it highly relevant for **smart mobility applications**. The system integrates an **On-Board Unit (OBU)** equipped with:

- A **vehicle motion sensor** (*LPMS-UTTL2 accelerometer, gyroscope, and magnetometer*) detecting **vibrations and abrupt movements** for potential anomalies.
- A **GNSS module** for **high-precision location tracking**, ensuring accurate road conditions mapping.

A **5G modem** to **transmit real-time data** to the **network edge**, where it is stored, visualized, and analyzed for proactive decision-making.

Integration with 5G-IANA

This Network Application leverages **5G-IANA's Open Experimentation Platform**, utilizing **low-latency, high-speed 5G** for **seamless data transmission and real-time processing**. 5G-IANA's capabilities allow to enhance **performance, scalability, and innovation**, providing **transportation authorities and smart city planners** with an efficient **road maintenance and safety solution**.



System Architecture

To validate performance, **Nokia's 5G testbed in Ulm, Germany**, was selected for its:

- **Advanced 5G**: *moderate-speed, low-latency* transmission for **real-time IoT applications**.
- **Realistic Urban Testing & accurate anomaly detection validation**: Real-world conditions using a test vehicle.
- **Industry Expertise**: Expert collaboration and **cutting-edge facilities** enhancing system credibility

✓ Objectives

The goal is to develop a **real-time road condition monitoring system using IoT and 5G** to improve road safety and urban infrastructure management that detects potholes and bumps, hence reducing accidents and vehicle damage. 5G integration provides low-latency data transmission for immediate alerts and rapid decision-making, highlighting 5G's key role in smart cities, supporting intelligent transportation systems. Its scalable design adapts easily to different urban settings, promoting smart mobility.

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The system **utilizes edge computing** and machine learning for real-time anomaly detection and road irregularity classification. **Sensor and GNSS data**, collected at 100Hz and 5Hz respectively, undergo **event-triggered filtering** to optimize 5G bandwidth usage. The **MEC**'s containerized architecture includes an **MQTT broker, Telegraf for data ingestion, Influx for time-series storage, and Grafana for visualization**. The detection algorithm combines threshold-based and unsupervised learning methods, triggering alerts via the 5G-IANA DENBS. Trials validated real-time detection accuracy, seamless 5G transmission, and integration with the 5G-IANA platform.

Testing Setup & Results

✓ Testing & Qualitative Evaluation

Setup & Demonstration

The system was developed in phases, starting with design and adaptation to 5G-IANA, followed by OBU development, component containerization, and **MEC** service deployment. After integration with **Nokia's 5G testbed**, it underwent **demonstration, data analysis, and reporting**. The core setup included an **OBU with a 5G module, a motion (IMU) sensor (LPMS-UTTL2), and GNSS** module for precise road surface tracking. Data was processed in real-time at the network edge, leveraging **5G-IANA's orchestration framework**. The OBU **collected and transmitted sensor data** to the MEC via an **MQTT broker**, ensuring **low-latency data transfer**. The setup was **validated at Nokia's testbed in Ulm, Germany**, using a **test vehicle to simulate real-world road conditions**.

Qualitative Analysis

The figure on the right presents the **identified road hazards** detected during **drive tests in Ulm** using Nokia's **5G-IANA test vehicle**. The system performed **effectively**, with all measurements successfully **stored, visualized, and analyzed** as planned. Given that **road conditions in Ulm are generally well-maintained**, the initial test **did not detect any significant anomalies**. To enhance sensitivity, **thresholds were adjusted** to trigger alarms more easily, and the vehicle operator was instructed to deliberately engage with pavement edges to introduce measurable disturbances. The figures below illustrate the system's ability to **capture and analyze these events**, demonstrating its **real-time detection capabilities and adaptability to varying road conditions**.

Technically, the system integrates **FERON OBU, a 5G module, LPMS-UTTL2 motion sensor, and GNSS** for **precise road tracking**. Data is processed **in near real-time** at the **network edge**, leveraging **5G-IANA's service orchestration framework** for efficient handling. A **high-accuracy anomaly detection algorithm** minimizes false positives, while a **user-friendly interface** enables **city planners and maintenance teams** to take proactive measures. The system underwent **rigorous testing** at **Nokia's Ulm testbed**, validating performance across **varied conditions**. **Edge computing** further enhances **network efficiency**, ensuring only critical insights are sent to the cloud. These innovations position the project as a **key enabler of smart city infrastructure**, driving **future road monitoring and urban mobility solutions**

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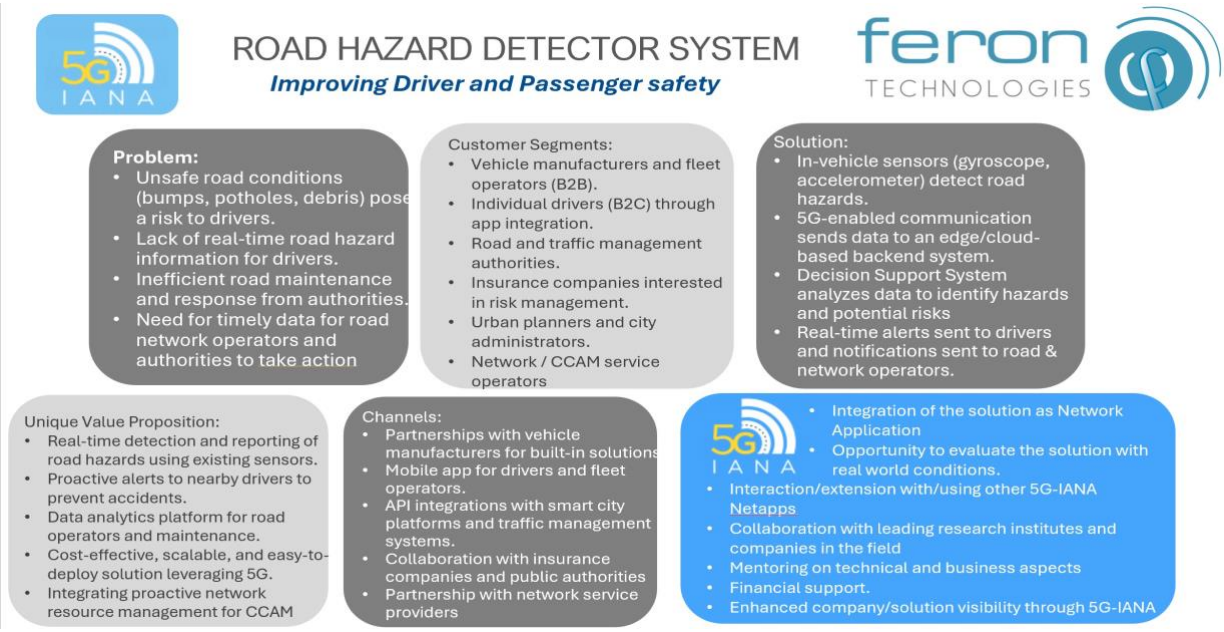
✓ Results

5G-IANA played a pivotal role in enhancing FERON's **road monitoring solution**, providing **resources, technical support, and a platform** to refine and demonstrate its **functionality and performance**. This opportunity allowed for **real-world validation**, strengthening the business case for **scalability and market deployment**. The **simplified business canvas below** outlines how **5G-IANA's support contributed to the evolution of our solution**.



Our experience at **Nokia's 5G testbed** was highly positive. The **Nokia team provided full support**, enabling us to work **extensively to complete our demonstrations**. The **network infrastructure** delivered **stable, high-performance connectivity**, ensuring **seamless data transmission** throughout our tests. The **test vehicle was well-suited for experimentation**, allowing us to conduct **meaningful, real-world assessments**. Additionally, collaboration with the **orchestrator and management team (Ubitech)** was **efficient and effective**, ensuring smooth deployment and execution of our trials.

Key Conclusions & Future Plans

Participation in the 5G-IANA 2nd Open Call

As an SME in the automotive sector, FERON saw this as a valuable opportunity to integrate our existing solution into a cutting-edge 5G-enabled ecosystem.
Our experience with 5G-IANA was highly positive, providing a seamless testing environment with full consortium support. Key highlights include:

- **Fully operational components** with no need for workarounds.
- **Real-world testing** in a **controlled environment** with backend and on-site assistance.
- **Successful transformation** of our solution to a **microservice-based architecture**, aligning with **5G and 5G-IANA standards**.

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Future Plans

Building on this success, we are now **exploring commercial opportunities** through **industry partnerships** and **new collaborations**. Our roadmap includes:

- **Scaling up the system** by integrating **multiple vehicles** for enhanced monitoring coverage.
- **Leveraging AI** to improve **accuracy and classification** of road hazards.

Expanding functionality by incorporating **smartphone and in-vehicle sensors** to enrich data collection.

Online & Multimedia Material

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

SCAN ME

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

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