**5G TERRA**
**5G infrastrucTure and sERvices foR public interest and sociAl inclusion**

# D2.1 Requirements Analysis & Use Case Definition

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# Executive Summary

The document addresses the detailed description of the UC scenarios, driven by the Healthcare, Education and Civil Protection domains, which are considered of high added value SGIs by the consortium members. The requirements as perceived by the users are presented and the network KPI targets are also discussed and agreed. This document will serve as a reference for the upcoming network architecture, configuration, and testing activities as well as a starting point for the specific applications and services scenarios to be validated.

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# List of Acronyms and Abbreviations

| TERM | DESCRIPTION |
|---|---|
| **4G** | Fourth Generation |
| **5G** | Fifth Generation |
| **5G-PPP** | 5G Infrastructure Public Private Partnership |
| **6G** | Sixth Generation |
| **AI** | Artificial Intelligence |
| **API** | Application Programming Interface |
| **AR/VR** | Augmented Reality/Virtual Reality |
| **CEF** | Connecting Europe Facility |
| **EC** | European Commission |
| **ECG** | Electrocardiogram |
| **EU** | European Union |
| **HADEA** | European Health and Digital Executive Agency |
| **IEEE** | Institute of Electrical and Electronics Engineers |
| **KPI** | Key Performance Indicator |
| **LTE** | Long Term Evolution |
| **RAN** | Radio Access Network |
| **RES** | Renewable Energy Sources |
| **SGI** | Services of General Interest |
| **TETRA** | TErrestrial Trunked RAdio |
| **TMV WG** | Test Measurement and Validation Working Group |
| **UC** | Use Case |
| **WP** | Work Package |

# 1 Introduction

As outlined in the EC's CEF-DIG-2022-5GSMARTCOM call [1], in order for numerous **Services of General Interest (SGIs)** [2], [3], to flourish and contribute to economic progress and social cohesion, key enablers are identified, with 5G networks characterized as one of the most crucial ones. Reliable and high-capacity connectivity, even in remote or sparsely populated areas is of utmost importance for EU -and world- citizens, for them to be able to take advantage of the latest advances of wireless communication technology in a plethora of their everyday life activities, related to Education, Health, Entertainment, Security, etc., as well as for industries and SMEs to increase efficiency, reduce costs and boost productivity in their business operations.

5G connectivity may not be an issue for urban areas where the adoption of 5G is progressing with a fast pace, driven by clear business models of stakeholders, but it becomes a significant bottleneck for rural and remote areas, which are lagging in terms of 5G deployments due to the low marketing/business potential in those areas. Geographical factors and heterogeneity among the EU Member States and respective territories result in diverse challenges when coming to providing equal opportunities, digital inclusion, and high-quality broadband services. However, it is important to cover the population of such areas in order **to reduce the digital divide, enhance digital inclusion** and provide high-quality services to people in need (especially in the sensitive Healthcare domain).

The strategic objective of 5G-TERRA is to **provide high-quality 5G connectivity to the end customers of remote and sparsely populated areas** in Greece, for personal, business, and governmental growth, **to enable efficient, state-of-the-art Healthcare, Education and Civil Protection SGIs** and to support the deployment of 5G infrastructure as part of the European Gigabit Society EU strategy.

This deliverable, D2.1, is the first technical deliverable published by the 5G-TERRA consortium and presents the "Requirements Analysis & Use Case Definition" as defined during the first months of the project. The deliverable is produced as part of the Work Package 2 (WP2) "Requirements, Architecture & Scope of work" and Task 2.1 "Requirements/Security Analysis and Use Case/KPI definition" and marks the completion of the project's milestone MS2 "Use Case definition and target KPIs ready".

In the sections that follow the document presents the detailed requirements analysis of supporting the selected UCs and the expected network performance. The requirements, as determined also by external stakeholders (e.g. health professionals), are mapped to the UC scenarios and translated into technical requirements. This allows for the most appropriate network settings/configurations to be selected. Additionally, the relevant security requirements for the network and its communication with the end-users are analysed which will drive the design of the protection and firewall systems to be included in the E2E architecture. Specific targeted KPIs are defined for the network performance. The outputs of this deliverable will be used to create the High- and Low-level Design of the network, and as such will act as input to Task T2.2 "5G End-2-End Architecture and Specifications" and Task T3.1 "Deployment prerequisites (procurement, licensing, etc.)".

The document is public and is addressed to a wide audience and specifically to the:

- project consortium itself, as a documented blueprint of the agreed technical scope and development plans and the means to validate that all objectives and proposed technological advancements have been analysed and, through the identified requirements, the next actions can be concretely derived.
- research community, other 5G projects and funding organisation, to summarise the scope, objectives and intended project innovations, describe the 5G-TERRA UCs and performance targets together with the identified requirements that must be tackled to achieve the expected results to open the floor for fruitful exchange of opinions and collaboration.
- public, to obtain a better understanding of the framework and scope of the 5G-TERRA project.

## 1.1 Structure of the document

The main topics addressed in this deliverable are presented through the following structure:

- Section 2 presents an overview of the project's scope of work, including the key objectives and core technical developments.
- Section 3 presents the demand analysis and requirements for the specifics of the involved Healthcare, Education and Civil Protection SGIs, and correlates this with regards to network and services platforms offerings to set the implementation targets. The 5G -TERRA use cases that are integral to the 5G-TERRA validation activities are elaborated.
- Section 4 provides concluding remarks and next steps for facilitating the delivery of fully operational and validated 5G-TERRA network by the end of 2026.

# 2 5G-TERRA Scope of Work

In the 5G-TERRA project, OTE will provide 5G connectivity for remote and sparsely populated areas in mainland Greece and islands, through the deployment of COSMOTE 5G public network (Figure 1). WINGS products offerings in the areas of Healthcare (STARLIT), Education (WINGSchool), Environment (ARTEMIS), Civil Protection (AIRWINGS), will be exploited to derive use case scenarios that will be used for testing and validating the new 5G infrastructure. The functional requirements and priorities will be set by the 5G-TERRA SGI providers, such as CitiesNet and Crete Regional Authority. Specifically, 5G-TERRA is set to implement the following objectives:

- To extend COSMOTE's 5G network (in terms of construction, configuration, and connection with the rest of the network) with almost 50 new 5G base stations, towards high capacity, reduced latency, and high reliability mobile services for up to now de-prioritized, rural, and sparsely populated areas in Greece as shown in the map that follows.

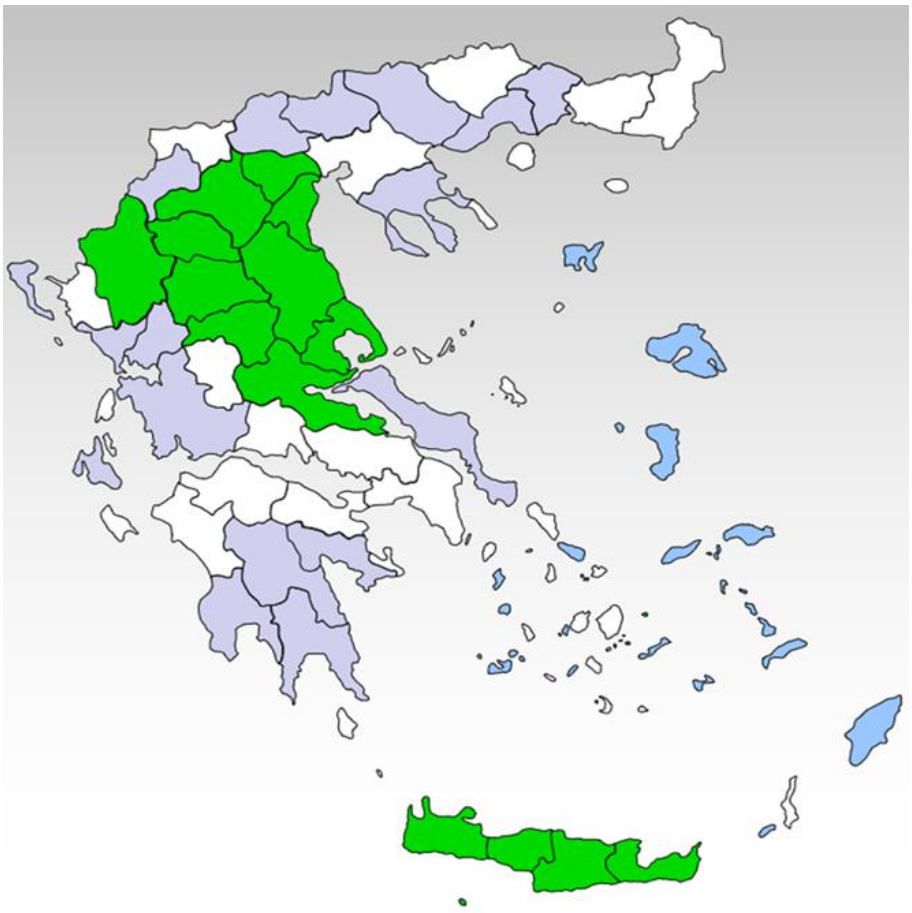


**Figure 1: 5G-TERRA target regions**

- To enable and demonstrate advanced Healthcare, Education and Civil Protection domain SGIs, such as telemedicine, leveraging the new 5G RAN infrastructure that will be implemented for different use case scenarios, static or mobile.
- To provide a blueprint for digital innovation projects for innovative solutions in remote and/or sparsely populated EU regions.
- Outreach to public audience, key stakeholders, dissemination and further exploitation of the project's main achievements.

5G deployment at 700MHz and/or 2100 MHz will provide coverage in the selected areas. The novel 5G RAN base stations will be connected to COSMOTE's transport and Core Network, the existing NSA (Non-Stand Alone) 3GPP Rel. 16 network at first, and then migrated to forthcoming SA (Stand Alone) to be deployed till the end of the project. Cloud and edge computing resources will be provided by WINGS to support the envisaged services. The network management framework of COSMOTE will provide performance monitoring, proactive/reactive fault management and anomaly detection functionalities. The 5G-TERRA network will be validated through extended amount of measurement data (both on physical/lower layer as well as service-level) to provide statistical confidence and heterogeneity. Furthermore, a detailed analysis of the performance of the 5G deployed infrastructure under various configurations and for various realistic network load conditions and use case will be performed.

# 3 5G-TERRA Use Cases and Requirements

Section 3 sets the strategy to implement the 5G-TERRA mission to provide 5G network deployments suitable for Healthcare, Education and Civil Protection SGI UCs. We will present what are requirements for each of the services of interest in terms of 5G potential to digitally transform end user services and analyse 5G-TERRA scenarios for demonstrating this per SGI.

The process of identifying the appropriate requirements has included the identification of the key stakeholders that are affected by the requirements considered. These include the end-users, the OTE engineering teams (such as planners, designers, operation teams) as well as the technology solutions providers (WINGS). The requirements gathered are organised as Technical and User Requirements. Furthermore, the process followed has addressed the full life cycle, design-deploy-operate, towards the appropriate 5G-TERRA SGIs realisation.

The Use Cases described in the next sections reflect the capabilities of the 5G-TERRA network and applications to serve the needs of local SGI providers. The actual implementations on site will be determined during the implementation phases, based on the specific requirements per case and selected out of the scenarios elaborated in the document.

The 5G-PPP TMV WG White Paper "5G PPP Trials Results 2022 - Key Performance Indicators measured in advanced 5G Trial Sites" [4], is used throughout the document as a benchmark with regards to state-of-the-art 5G network capabilities. In [4], not only are 5G KPIs defined and described but also results in terms of performance and validation requirements are summarized and compared for various applications and user communities (e.g. Health, Logistics, PPDR, Smart Cities, etc), covering Europe-wide trials of 5G-based networks.

## 3.1 Healthcare

A key baseline for the project is the work of "Global5G.org for Health", [5] which in association with 5G-PPP, promotes 5G Health use cases, navigates relevant standardisation efforts and timelines, and supports the new e-Health business landscaping. The advent of 5G seamless connectivity with guaranteed levels of performance including low latency, high throughput and reliability, smartphones and mobile apps, cloud services and smart connected devices, can enable distributed, patient-centred delivery at multiple points of care, individualised health information and the ability to track patient health metrics powered by big data analytics.

Such scenarios can create new avenues in personalised care, early remote diagnosis, remote surgery, and smart hospitalisation logistics. Increased accessibility to data will enable optimisation in intervention planning (e.g. transplant scenarios), lead to greater transparency, and improve overall patient engagement with healthcare providers.

A 5G-enabled decentralised healthcare model will allow remote consultation, diagnosis and health checks, making specialised and high-quality care more affordable for more people. This allows for reducing costs and time to access medical specialists, avoiding long waiting lists and complex logistics for rural dwellers, which is an important dimension of the 5G-TERRA project.

Decentralised healthcare is also an opportunity to bring about significant improvements in patient quality of life, such as chronic disease management and assisted living for the ageing population. Healthcare becomes more sustainable in view of demographic trends and the ageing society with increasing costs.

The "Global5G" verticals cartography [6], tracks the progress of Europe's 5G Public Private Partnership (5G-PPP) in developing 5G technology enablers and applications across diverse market segments through a large set of use cases, spanning proofs of concept, prototypes, demonstrations, trials and pilots to give consumers and vertical end-users tangible examples of 5G usage. The multiple stakeholders involved in a 5G and future

6G ecosystem in the health industry include e.g. healthcare service providers, financial sources, telecommunication operators, mobile device providers, medical device providers, and users [7], [8].

### 3.1.1 Use Case H1: Real-time remote health monitoring & emergency situation notification

This use case demonstrates the 5G-TERRA network capabilities to support the "connected patient", that allows for the personalization of care thanks to real-time monitoring of vital signs and more rapid and content rich interaction with clinicians independently from their location.

5G-TERRA will also bring benefits to the broader healthcare ecosystem supporting a more rapid cloud-based sharing of large datasets, as in the case of medical imaging, enhancing collaboration and boosting. With 5G the use of innovative user interfaces in augmented and virtual reality environments for clinical and educational purposes can be supported effectively.

This UC addresses solutions for remote health monitoring of people, especially when already diagnosed with a critical disease still compatible with home care (e.g. some form of cardiovascular disease, hypertension, diabetes, etc.). The main features offered by this UC involve: (a) remote health monitoring services, leveraging a variety of data sources, including (but not limited to) vital signs, air quality, weather conditions, site waiting times, transportation, traffic and location, and (b) quick, reliable notifications to nearby ambulances, medical professionals and family members in case of a health incident or a health emergency prediction.

The goal of the UC is to improve home care monitoring for patients with chronic conditions, and enable emergency care, depending on the local resources of formal and informal caregivers and care facilities. In particular, the communication between caregivers in the ambulance / near the patient, the medical regulator, remote experts and emergency department staff to save the life of more patients , improve the outcome for patients on the short and longer term as well as their wellbeing, reduce the workload and stress for all care providers and improve their effectiveness, and, last but not least, reduce the overall cost of care on the short and longer term so that patients can participate fully in society again after a quick recovery.

The UC will leverage wearable devices and patches tracking a person's vital signs and having them aggregated inside the platform named **STARLIT**[1] (Solutions for digital health and wellness based on artificial intelligence and 5G/IoT), (Figure 2) where they will be processed in a combined fashion exploiting also various sources through open APIs (e.g. Open Data Platforms, Google Maps, Dark Sky API). STARLIT's outcome will be the identification or the prediction of a health-related exacerbation of a patient with chronic diseases (eg Diabetes Mellitus, Hypertention) and emergency which will be followed by the immediate notification of the nearest emergency care providers or informal caregiver, customised to the local resources

[1] https://www.wings-ict-solutions.eu/startlit/

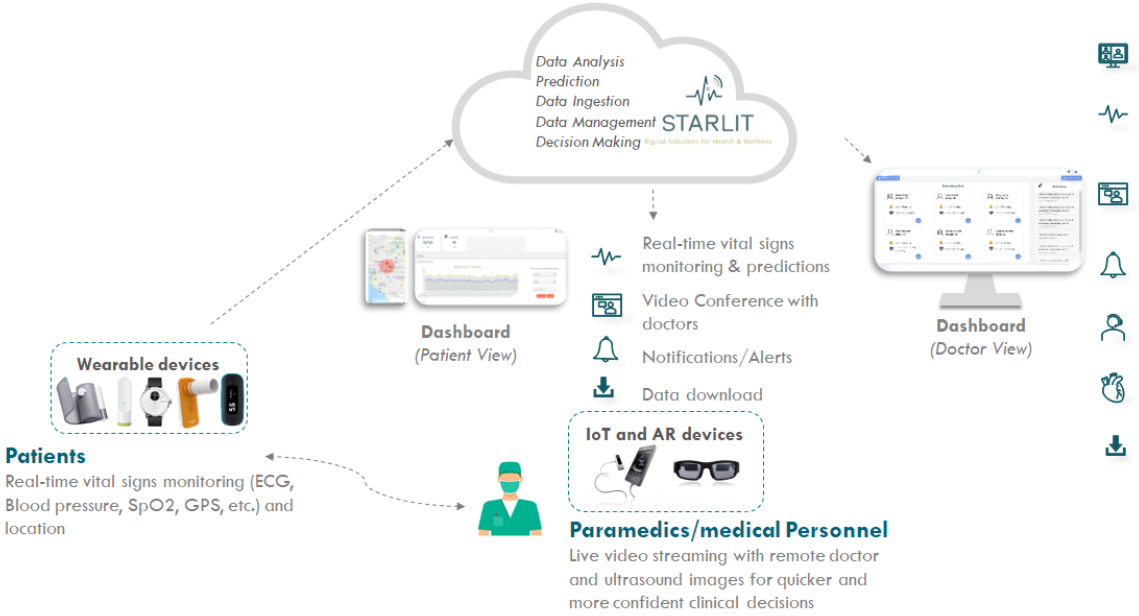



**Figure 2 WINGS STARLIT product.**

In the following Table 1, the targeted scenarios and individual elements of the offered system are extensively analyzed.

**Table 1: UC H1 Scenarios**

| Use Case Name | Real-time remote health monitoring & emergency situation notification | |
|---|---|---|
| Scenarios | Description | Actors |
| Vital signs monitoring (Blood Pressure, Glucose, ECG, etc) | Blood pressure and or Glucose levels are monitored by the health professional, while the patient is at home or work carrying out normal activities. | Devices/Wearable patches/smart watch/application server |
| Location tracking | The position of the patient is available through the application to the health professional, so that in case of emergency first aid responders can be directed to the patient. | |
| Data download | The patients medical file can be accessed along with his current vital signs' status, so that the health professional can assess the patients' condition more effectively. | Application server |

## 3.1.2 Use Case H2: Wellness remote monitoring

The goal of the UC is to provide real-time communication of the vital signs recorded by the wearable watch, which can be useful for personal care in training and wellness facilities.

The UC will leverage wearable devices such as smart watches tracking a person's vital signs and having them aggregated inside the **STARLIT** platform, where they will be processed in a combined fashion exploiting also various sources through open APIs (e.g. Open Data Platforms, Google Maps, Dark Sky API). In the following Table 2, an overview of the offered system functionalities is provided.

**Table 2: UC H2 Scenarios**

| Use Case Name | Wellness remote monitoring | |
|---|---|---|
| Scenarios | Description | Actors |
| Vital signs monitoring (Blood Pressure, Glucose, ECG, etc) | The trainer is monitoring the trainees/athletes' vital signs real time through the app and can adapt the training programme accordingly to sustain healthy condition while maximising the potential benefits. | Devices/Patches/Smart watch/application server |

## 3.1.3 Technical and User Requirements for Healthcare Use Cases

Based on [4] and in particular also three recent Horizon projects relevant to 5G for healthcare, 5G-VINNI [9], 5G-TOURS [10] and 5G-HEART [11], the network and user requirements and results stemming out of these projects are used as reference in the 5G-TERRA Healthcare Use Case. While varying in range depending on the actual scenario to be implemented, the network requirements identified in Table 3 are targeted.

**Table 3: KPIs with target values for Healthcare UCs**

| Use Cases | KPI | Target value |
|---|---|---|
| H1: Real-time remote health monitoring & emergency situation notification | Downlink throughput per device | 50 – 200 Mbps |
| | Uplink throughput per device | 10 - 50 Mbps |
| | Latency - round trip | <50 ms |
| | Latency - RAN | <10 ms |
| | Application round-trip latency | <100 ms |
| | Network Availability | 99,99% |
| | Network Reliability | 99,999% |
| | Device Density | 10 dev/km$^2$ |
| | Location Accuracy | <5m |
| H2: Wellness remote monitoring | Downlink throughput per device | 30 – 100 Mbps |
| | Uplink throughput per device | 10 Mbps |
| | Latency - round trip | <70 ms |

| Use Cases | KPI | Target value |
|---|---|---|
| | Latency - RAN | <10 ms |
| | Application round-trip latency | <200 ms |
| | Network Availability | 99,99% |
| | Network Reliability | 99,999% |
| | Device Density | 100 dev/km$^2$ |
| | Location Accuracy | <5m |

The network requirements are to be verified as part of the evaluation of the performance of the UCs. For the implementation of this UC the following requirements from the user perspective are identified (Table 4).

**Table 4: User requirements for Healthcare UCs**

| Use Cases | Requirement | Description |
|---|---|---|
| H1: Real-time remote health monitoring & emergency situation notification | Video Reception/Transmission | 1. The medical specialist requests a video connection via the WINGS STARLIT platform if patient status demands video communication.<br>2. The 5G-TERRA infrastructure is used for live video streaming and observation of the patient until an ambulance arrives. |
| | Data Reception/Transmission | 1. The wearable devices used for the monitoring of vital signs are connected and start sending real-time data to the STARLIT platform. The data is shared via suitable mobile apps and/or dashboards with family members and authorized medical specialists.<br>2. In case an emergency is identified by the STARLIT platform (e.g. due to one or more of the monitored vital signs or parameters exceeding a predefined threshold or indicating a problem), the WINGS STARLIT platform issues an emergency notification to the family members, the medical specialist, and the Hospital Dispatch Centre.<br>3. The Hospital Dispatch Centre consigns an ambulance, and the patient medical record and real-time data are sent to the ambulance as well via the WINGS STARLIT platform. |

| Use Cases | Requirement | Description |
|---|---|---|
| | Voice communication | The patient can have a voice call in parallel to/or alongside any type of video communication. |
| | Location information | The determination of the location is important for fast and efficient response. |
| | Fast response | Important to minimise video stuttering and frame-loss. |
| | Reliability/Availability/Users' Acceptance Survey | The network should provide uninterrupted connectivity, due to the sensitivity of the situation involving potentially critical conditions. In addition, a user's acceptance scale will be used for the respective evaluation. |
| | Battery life | Wearable and UE devices should provide reasonable autonomy, while maintaining essential connectivity. |
| | Security/Privacy | A patient registers to the Remote Health Monitoring service of the WINGS STARLIT platform. This way data privacy is ensured. |
| H2: Wellness remote monitoring | Data Reception/Transmission | The wearable devices used for the monitoring of vital signs are connected and start sending real-time data to the STARLIT platform. The data is shared via suitable mobile apps and/or dashboards with family members and authorized medical specialists. |
| | Reliability/Availability/Users' Acceptance Survey | The network should provide reasonably uninterrupted connectivity, since the information exchanged is important but not critical. In addition, a user's acceptance scale will be used for the respective evaluation. |
| | Battery life | Referring to wearables such as smart watches, battery usage is a premium concern. |
| | Mobility | This can entail the ability of the person to move in the training or wellness environment in order to fulfill a specific programme of activities. |
| | Location information | Important, but not as critical as in previous UC. |

## 3.2 Education

The Digital Education Action Plan (2021-2027) [12] is a renewed European Union (EU) policy initiative to support the sustainable and effective adaptation of the education and training systems of EU Member States to the digital age. As the European Commission's flagship initiative adopted in September 2020, it calls for high-quality, inclusive and accessible digital education supported by reinforced cooperation and exchange at EU level.

Smart schools are a modern concept in the field of education. They have recently received a lot of attention from countries and educational institutions (e.g. [13], [14], [15]). With the enormous technological advancements of recent decades, smart schools have become one of the modern and effective methods of improving the quality of education and providing a more interactive and efficient learning environment.

Although the challenges facing smart schools are still many [16], the direction of countries and educational institutions towards the implementation of smart schools indicates the importance of them in the field of education and the necessity to overcome the challenges and risks that may face to reach better levels of education quality and enable students to learn in more effective and interactive ways.

As new data services and applications require networks of ever-higher capacity, the Commission set strategic connectivity targets in 2016 for all main socio-economic drivers such as schools. According to these targets, all schools should have a high-speed broadband connection by 2025, which means access to internet connections offering downlink and uplink speeds of at least one gigabit per second [17]. Connecting schools to high-speed broadband would facilitate innovative ways of teaching and learning, allow teachers and students to benefit from up-to-date learning materials, and thus enhance digital skills.

5G technology offers faster internet speeds and more reliable connections compared to previous generations of wireless technology. This improvement in connectivity is crucial for educational applications, where timely access to resources and smooth communication are essential. With 5G, educators and students can benefit from quicker access to educational materials and a smoother online learning experience. 5G can also improve the quality of video conferencing, add haptic response capabilities, strengthen immersive learning experiences using virtual reality (VR) and augmented reality (AR), and allow for the personalization of education.

**WINGSchool**[2] is the innovative solution developed by WINGS for a strategic partnership to optimize the adoption of technology in education (Figure 3). WINGSchool is a combination of different WINGS solutions:

- Air Quality Indoor & Outdoor monitoring
- Smart Energy Management for consumption monitoring per sector (water, energy, gas)
- Dashboard for the calculation & visualization of the ESGs impact (e.g. % of energy resources savings has been achieved)
- Student Awareness and Rewarding Platform
- Wireless (Wi-Fi) network coverage extension
- Study programs based on AR/VR technologies (Augmented / Virtual Reality)

[2] https://www.wings-ict-solutions.eu/wingschool/


**Figure 3 WINGSchool environment.**

WINGSchool integrates with a wide range of diverse solutions such as AIRWINGS for monitoring air quality management both indoor and outdoor and ARTEMIS for the management of energy /gas, and water sensors.

**AIRWINGS**[3] (Air Quality Solution) is WINGS product that covers air quality management, for a variety of applications and environments (Figure 4), such as:

- End-to-end solution (devices, communications, cloud platform, AI-powered apps)
- Air quality for cities, highways, airports, ports, schools
- Air quality for offices, hotel rooms, hospitals, factories
- Air quality and live streams for forests and cities
- Air quality for rural areas, production, agriculture and manufacturing environments

[3] https://www.wings-ict-solutions.eu/airwings/

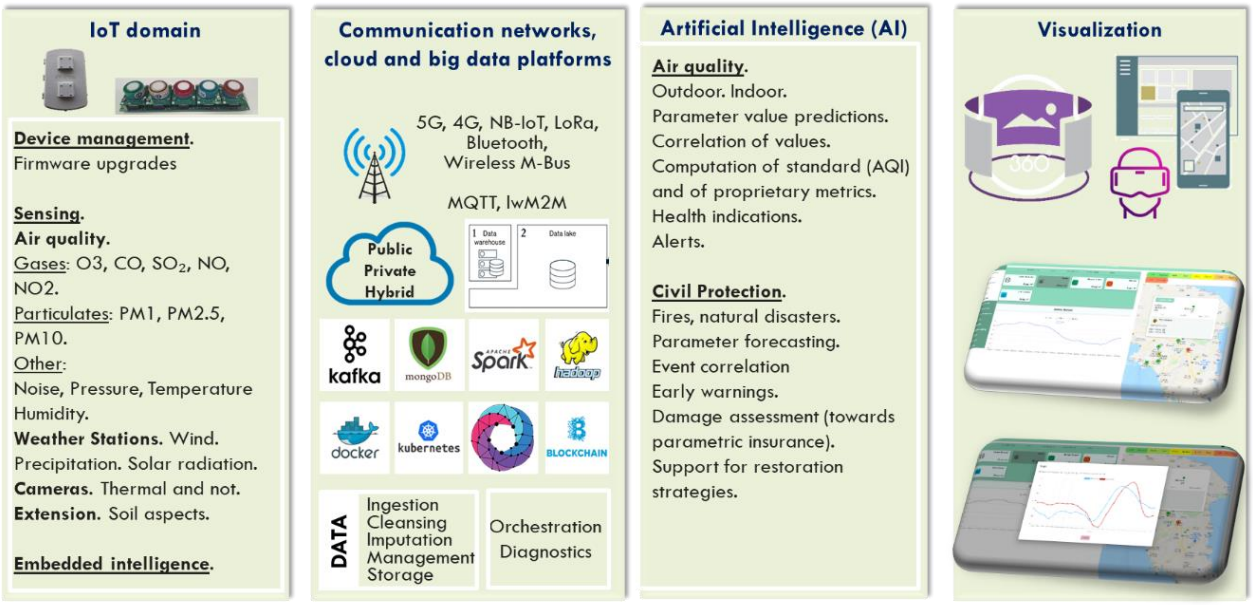



**Figure 4 WINGS AIRWINGS product.**

In particular, for indoor/outdoor environment such as the ones in the 5G-TERRA targeted Green School use case, the monitored parameters are Noise, Temperature, Humidity, CO/$CO_2$, VOC, $O_3$, $NO_2$, PM1/2.5/10. AIRWINGS product offers:

- Indoor/Outdoor Air quality monitoring, forecasting, and management actions
- A low-cost multi-sensor station that can be easily installed in various places.
- Measurements accuracy due to thorough calibration procedures
- Live evaluation of environmental characteristics of buildings that may affect human health, comfort, or performance.
- High precision indoor air quality forecasting.
- Immediate detection of air pollution and alerting
- Early warnings – personalized recommendations
- Forecasts for general air quality as well as for each pollutant separately, for the next 2 days, using advanced forecasting algorithms. These algorithms take also into account other parameters that may affect air quality, such as weather and traffic.

In Figure 5 below, we can see how the installations of AIRWINGS system can look like in a real environment.

**Figure 5 Indicative installations of AIRWINGS system.**

WINGS **ARTEMIS**[4] (Artificial Intelligence and IoT Powered Platform for the Proactive Management of Utilities) product suite comprises of a set of solutions addressing:

- Water: Metering, Quality, Floods, Irrigation
- Energy: Predictions, RES deployment, Buildings / Cities / Factories
- Gas: physical and cybersecurity
- Supplementary services: waste management applications

WINGS Smart Gateways interface to meters & sensors (e.g. water, water quality, electricity, gas) and transmit data & measurements over any available network (4G/5G, NB-IoT, GPRS, LoRa). Through networking with core/edge cloud, big data and AI infrastructure, visualization, remote management capabilities and alerts are provided to end users. The modular approach and lower cost per meter/sensor compared to commercial

[4] https://www.wings-ict-solutions.eu/artemis/

connected devices (e.g. NB-IoT devices), result in efficiency, economy of scale, controllability, extensibility, and scalability benefits (Figure 6).

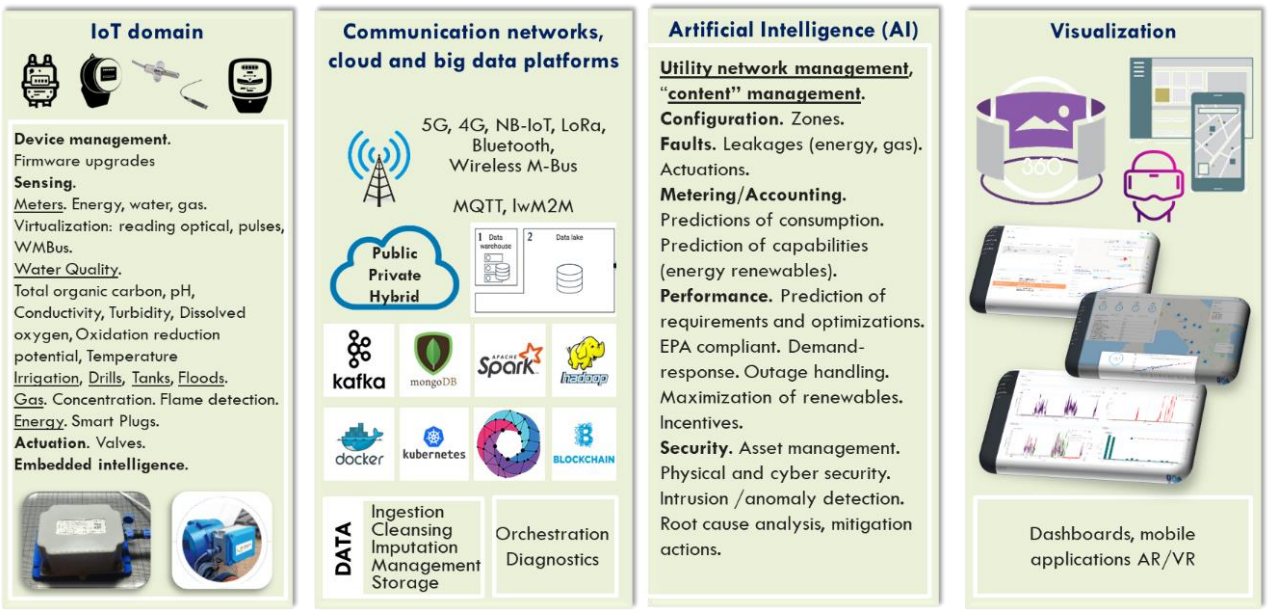



**Figure 6 WINGS ARTEMIS product.**

Furthermore**, WINGShool study programs** based on AR/VR technologies create innovative, accessible training resources for teachers that help implement and integrate active and collaborative learning pedagogical approaches (Figure 7). The networking capabilities of 5G-TERRA will provide a unique opportunity to experience the benefits of AR/VR based tools for:

- Interaction with digital content.
- Enhanced learning like problem-solving and technical knowledge to better prepare students for the future.
- Distance education using mobile devices, smartphones, tablets and laptops.
- Possible use of avatars and creation of multiplayer mode for simultaneous, group user experience and student-teacher relationship.

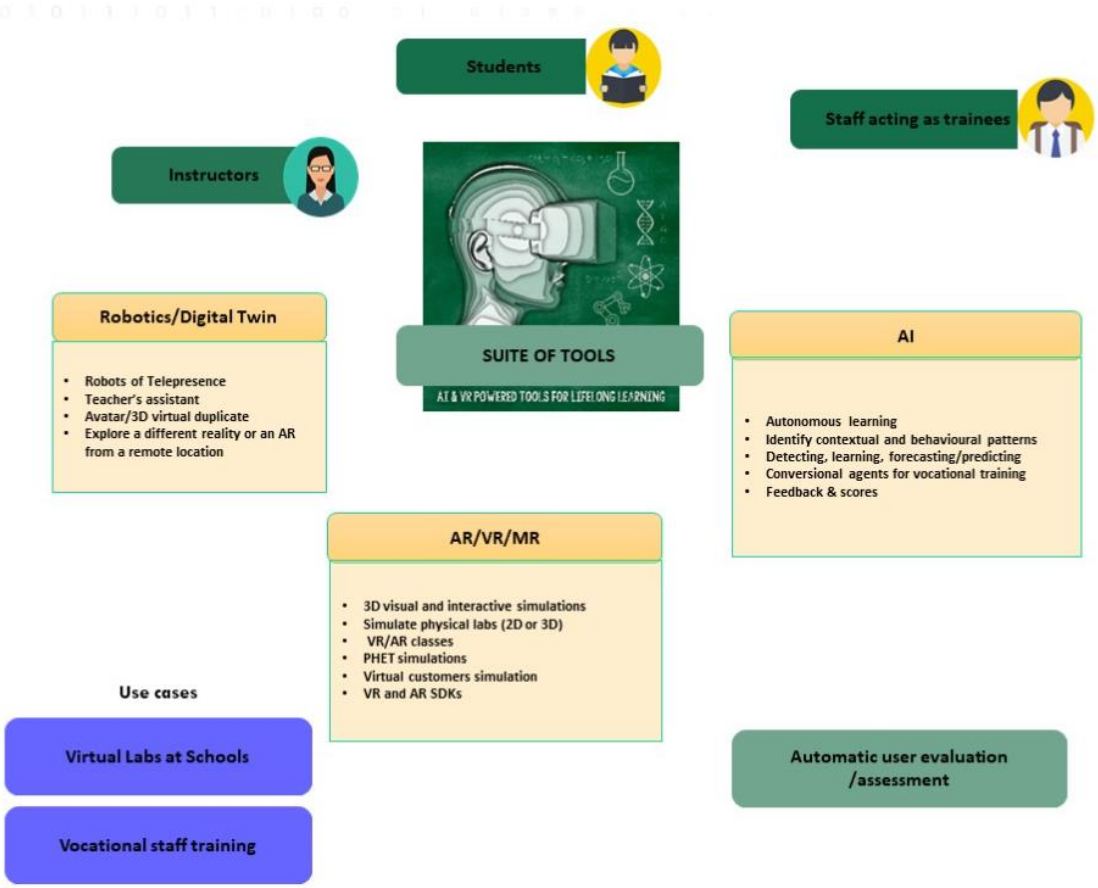
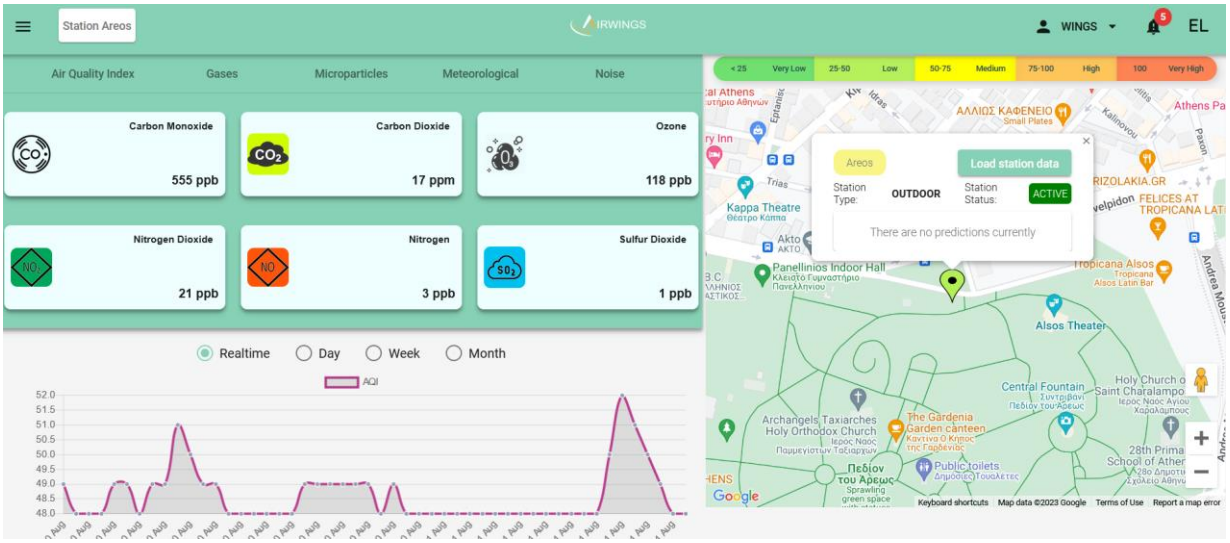



**Figure 7 WINGSchool educational tools.**

All relevant WINGSchool information (data, alerts, etc) can be presented in a Dashboard, where administrator/usage privileges are controlled according to users' roles by the platform (indicative examples in Figure 8).



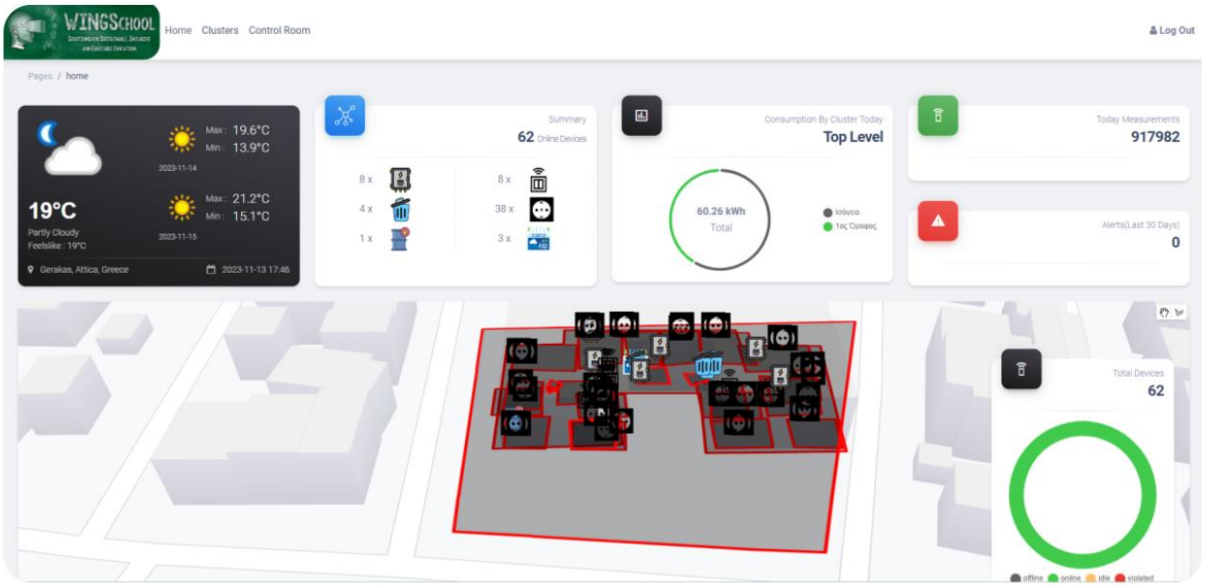



**Figure 8 WINGShool dashboards.**

## 3.2.1 Use Case E1: Electronic Dashboard

This use case demonstrates the 5G-TERRA network capabilities to support the “electronic dashboard”, that allows students and teachers to deploy and interact with a variety of digital educational applications. Key factors contributing to the success of this use case include the 5G-TERRA network capabilities to provide consistent high quality video communication, mainly in terms of high bandwidth but low latency as well.

In Table 5 below, some characteristic scenarios are described.

**Table 5: UC E1 scenarios**

| Use Case Name | Electronic dashboard | |
|---|---|---|
| Scenarios | Description | Actors |
| Digital content | Study programs based on AR/VR technologies (Augmented / Virtual Reality) | AR/VR glasses |
| Student Awareness and Rewarding Platform | AR games for mobile devices are an original and innovative approach to raise awareness and educate in a fun way specific target groups to enhance environmental awareness. The game will use the physical space the user is in, using the mobile camera and superimposing 3D elements into the space creating the game's AR environment. Through the game, the user tries to achieve specific goals by adopting specific practices. In this way, these practices are imprinted on the user and become his experience, while at the same time he has fun. In this way, the goals of raising awareness and educating the game are achieved, in the context of a | AR game (Android/iOS) |

| Use Case Name | Electronic dashboard | |
|---|---|---|
| Scenarios | Description | Actors |
| | wider project and contribution to the environmental footprint. | |

### 3.2.2 Use Case E2: Green School

The Green School Use Case will be implemented in specific schools in remote municipalities targeted by 5G-TERRA. The promotion and experimentation of sustainability is an important part of this use case. The contribution to the environmental footprint refers to the effect that our activity has on the environment, specifically global climate change and the depletion of natural resources. It includes the production of greenhouse gases (such as carbon dioxide), energy consumption, waste production and the use of water and other resources.

Reducing the contribution to the environmental footprint is important for preserving the environment and the sustainability of our eco-system. Some examples of mitigation measures are energy efficiency, recycling, the use of renewable energy sources, reducing water consumption and reducing the greenhouse gases produced by our activity.

Through the integration of the AIRWINGS and ARTEMIS solutions provided by WINGS, it will be possible to experiment and provide measurements with respect to these aspects. 5G-TERRA connectivity will allow the metrics and associated results to be communicated and processed in real-time. Table 6 provides an overview of the Green School scenarios.

**Table 6: UC E2 scenarios**

| Use Case Name | Green School | |
|---|---|---|
| Scenarios | Description | Actors |
| Smart system of energy saving and management of the school building | The integrated intelligent solution for the energy management of school buildings, concerns the remote supervision of the fuel level in tanks to calculate fuel consumption and send this data in real time to a management platform in the Cloud. | • Sensors (such as smart electricity meters, smart sockets to control individual appliances, smart panel-level switches, oil tank fullness sensor) which will be installed in buildings for remote monitoring of consumption and control of building automations.<br>• Smart transmission devices, which will be installed in the field (school) and will ensure the reliable transmission of information from the sensors and communication with the management platform in the Cloud.<br>• Dedicated platform for visualizing the data transmitted by the smart |

| Use Case Name | Green School | |
|---|---|---|
| Scenarios | Description | Actors |
| | | transmission devices and recording for further processing. The features offered by this software are very diverse and range from simple monitoring to more complex tasks (analyzing sensor data, extracting reports and forecasts, etc.) while always maintaining user-friendliness. |
| Monitoring the levels of air quality and greenhouse gas emissions | The proposed scenario will include an indoor air pollution meter, an outdoor air pollution meter, Weather Station, EMF along with the management platform in the Cloud for monitoring and statistical analysis of measurements. | • Air monitoring devices that can measure the concentration of many harmful gases (e.g. CO, NO, NO2, O3, SO2), microparticles that cannot be detected with the naked eye (e.g. PM1, PM2.5, PM10), noise, brightness, and meteorological parameters such as temperature, humidity, pressure, electromagnetic radiation, wind speed and direction, precipitation levels.<br>• The data of the measurements are transferred from the devices to the cloud application through the 5G-TERRA mobile network.<br>• The visualization of the measurement data is carried out with the help of a complete web-based electronic monitoring and management application, which is hosted on the Cloud. |
| Monitoring water quality within the school unit | For this scenario, an integrated smart solution for managing water networks and water meters should offer capabilities such as real-time consumption monitoring and leak detection as well as water quality monitoring for early detection of critical events.<br>The data is transmitted from the local sensors in real time to a management platform that will offer easy and immediate analysis of the water quality and sending timely notifications / alarms in case of unacceptable measurements. The collected and stored data on the platform will be | • Sensors which will measure various parameters for water quality, such as water PH, conductivity/temperature, salinity etc.<br>• Smart transmission devices, which will be installed in the field and will ensure the reliable transmission of information from the sensors and communication with the management platform in the Cloud.<br>• Platform used for visualizing the data transmitted by the smart transmission devices through the available 5G TERRA network and recording for further processing. |

| Use Case Name | Green School | |
|---|---|---|
| Scenarios | Description | Actors |
| | accessible by all interested users (director, citizens, environmental organizations, educational institutions, etc.), through a centralized measurement display screen (dashboard), and will also be offered as open data for further information and processing.<br>The proposed solution for intelligent water quality measurement aims both at the reliable recovery of the data/measurements from the sensors that will be installed and at the transmission of the information through the available network. | |

### 3.2.3 Technical and User Requirements for Education Use Cases

The Education Use Cases 5G related requirements and KPIs have been examined in a series of recent publications such as [18], [19]. Based on these we suggest the requirements in Table 7 and Table 8 below.

**Table 7: KPIs with target values for Education UCs**

| Use Cases | KPI | Target value |
|---|---|---|
| E1: Electronic Dashboard | Downlink throughput per device | 100 – 500 Mbps |
| | Uplink throughput per device | >70 Mbps |
| | Application round-trip latency | <500 ms |
| | Network latency | <50 ms |
| | Network Availability | 99,99% |
| | Downlink throughput per device | 50Mbps |

| Use Cases | KPI | Target value |
|---|---|---|
| E2: Green School | Uplink throughput per device | 10 Mbps |
| | Network latency | <50 ms |
| | Application round-trip latency | <500 ms |
| | Network Availability | 99,99% |

**Table 8: User requirements for Education UCs**

| Use Cases | Requirement | Description |
|---|---|---|
| E1: Electronic Dashboard | Video Reception | 3D AR/VR content – high quality |
| | Data communication | High throughput in receive – medium in transmit |
| | Fast Response | Low latency is of high importance |
| | Security/Privacy | Medium (pupils/teachers' personal data) |
| E2: Green School | Inclusion | Digital inclusion is an important aspect of modern society and through the integration of smart devices in a school environment, there will be clear contribution to narrowing the gap of digital inclusion among different categories of users, especially in a remote rural area/community. |
| | Sustainability | Through the integration of the platforms mentioned above it will be possible to experiment and provide measurements with respect to environmental sustainability aspects. |
| | Energy consumption | The energy optimisation and monitoring control through the platform is of high importance. |
| | Air/ Water Quality | The capability to monitor in real time the environmental quality aspects is pivotal in establishing a green and sustainable school environment. |

## 3.3 Civil Protection

Civil protection encompasses **preventive measures** to reduce the impact of future emergencies or disasters and **aid delivered** to populations in need following a natural or man-made disaster. Depending on the nature of the disaster, this aid can take different forms, such as:

- search and rescue operations
- forest and urban firefighting
- medical personnel deployment
- medical equipment and medicines
- water purification
- temporary emergency shelter
- safe repatriation of EU citizens

The EU civil protection mechanism [20] coordinates the response to natural and man-made disasters at EU level. The mechanism was also activated to help countries deal with **natural disasters such as forest fires**, floods, marine pollution, volcanic eruptions, extreme weather conditions and storms. The EU civil protection mechanism was activated more than **650 times between 2007 and 2022**. The number of requests related to natural disasters has also been growing in the last years, reaching a peak in 2022 mostly due to the wildfires that took place in Europe in summertime.

In particular, we note that according to the Regional Fire Services of Crete Prefecture, (SGI provider of 5G-TERRA), **733 wildfires took place at the Island of Crete in 2023** with around 1635 acres of burned area. In all cases, the lack of an early warning system played a crucial role. Moreover, a vast amount of search and rescue cases from canyons and mountains concern the regional authorities, due to the restricted access and low reliability of communications in such areas for the rescue teams and civil protection stakeholders. Also, in 2023, 67 cases took place in areas such as Samaria and Ibrou Canyon in Chania, Psiloritis mountain in Rethymno, Silamos Canyon in Heraklion and Richtis Canyon in Lasithi among others, with major amount of injured and casualties (43 injured and 3 deaths).

The European Commission and the EU Member States have devised 5 disaster resilience goals [21] to steer work in disaster prevention and preparedness.

The goals include anticipating and preparing for risks, enhancing early warnings, scaling up response capacities and securing robust civil protection systems.

5G can serve these goals, through enhanced capacity and low-latency capabilities, whereas reliability of communications is strengthened. A key factor for successful emergency operations is reliable communication and access to critical information in real-time. 5G can provide civil protection with multi-agency cooperation and interoperability mechanisms (such as police, fire brigade, medical units, etc.), a supportive regulatory environment where first responder priority is given, advanced services (such as UAV, mobile nodes, robots, etc.) and interoperability with other technologies (such as TETRA, 4G / LTE). 5G's role in civil protection is about continuous connectivity under any circumstances.

5G networks allow also direct and reliable communication between the members of the civil protection staff, whether they are at the site of the disaster (First Responders) or the headquarters of the civil protection command center, collecting information, analyzing it and coordinating the disaster management process.

### 3.3.1 Use Case C1: Fire prevention/detection

This use case aims to demonstrate the effectiveness of 5G through an integrated fire warning, detection, and response system in selected 5G-TERRA sites areas, which will be based on the **AIRWINGSplus**[5] product [22].

The AIRWINGSplus solution offers an integrated system of advanced hardware and software technologies for wildfire prevention and early detection needs. AIRWINGSPlus ensures the 24/7 surveillance of the selected areas. It provides early detection of fires automatically and without requiring human intervention. Fire is detected within the first 3 minutes upon the initial emergence of smoke at the site. AIRWINGSPlus consists of:

- Cameras (hybrid, optical-thermal for 24/7 surveillance)
- Multi-sensor stations (AIRWINGSPlus devices) for environmental and meteorological monitoring
- Transmission devices for communications over 4G/5G/NB-IoT networks
- Cloud management platform (AIRWINGSPlus platform), which includes all software for early fire detection and alerting
- Artificial Intelligence algorithms for predicting the degree of risk, detecting incidents and predicting the evolution of fires

The main goal is for the offered system to be an effective tool for preventing and dealing with fire risks. The system should remotely monitor the areas of interest and manage the individual sensors that will be installed to detect potential fire events and send immediate alerts and necessary measures / counteractions to deal with them. The remote monitoring of the selected areas should be achieved by checking various meteorological parameters, such as rainfall, air quality, etc., as well as checking the data of the optic-thermal sensors (cameras). Through advanced artificial intelligence algorithms, early detection of incidents and notification of the relevant agencies will be carried out to achieve a faster response to critical situations and to notify citizens of upcoming risks. An overview of the system and the user dashboard are presented in Figure 9 and Figure 10 below.

The offered system utilizes the image of optical & thermal cameras in **real time** that will be installed in the field for the detection of smoke or flame and the timely export of **notifications** to the competent authorities/services of the Municipality. In detail, the following will be supplied and installed in the area of interest:

- Optical & thermal cameras for complete monitoring
- Air Quality & Meteorological sensors
- Software system (artificial intelligence and operation support) for signal/video analysis, and early warning.

[5] https://www.wings-ict-solutions.eu/airwingsplus/

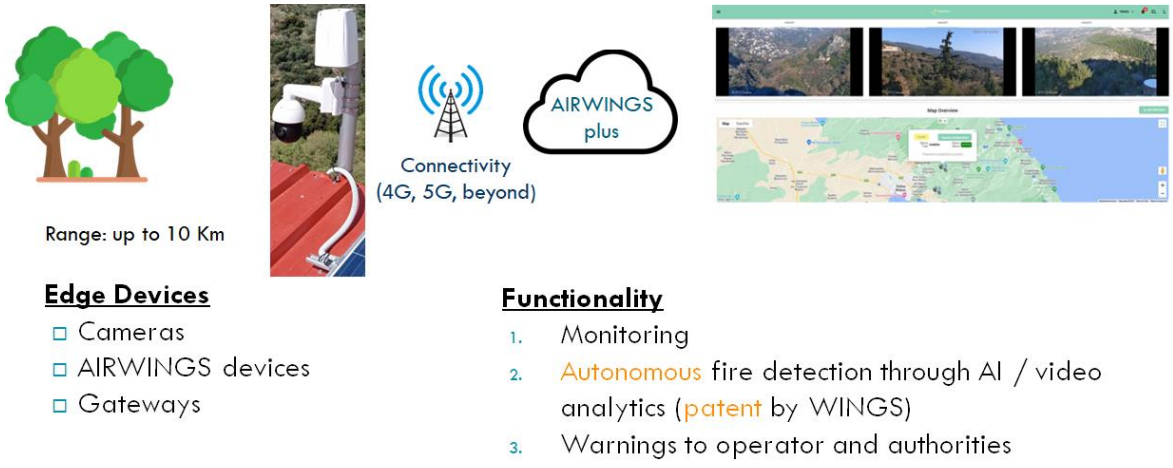



**Figure 9 AIRWINGSplus product.**

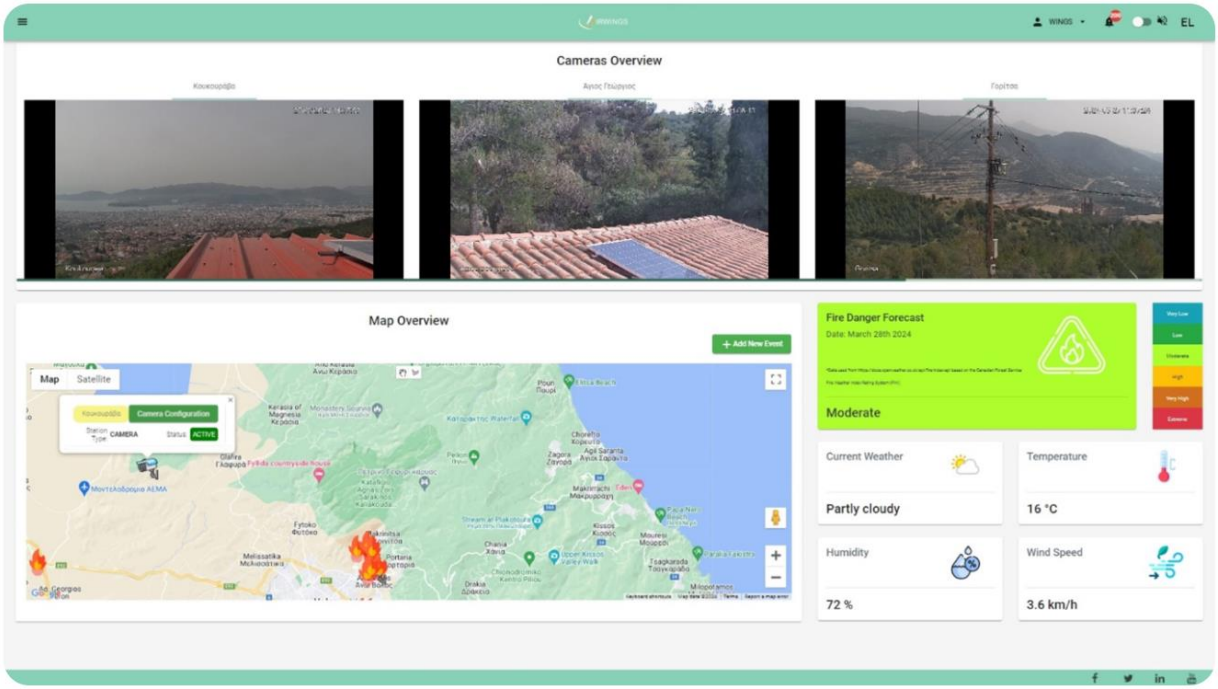



**Figure 10 AIRWINGSplus dashboard.**

In the following Table 9, the targeted scenarios and individual elements of the offered system are analyzed.

**Table 9: UC C1 scenarios**

| Use Case Name | Fire prevention/detection | |
|---|---|---|
| Scenarios | Description | Actors |
| Wildfire detection | • The offered solution for dealing with fires and forest monitoring is suitable for the early detection of incidents, the immediate information of those concerned, but also for the best possible and coordinated treatment of problems through the use of innovative cameras, sensors, software, but also advanced algorithms.<br>• The videos from the cameras will be transmitted in real time to the Cloud platform for processing and detection of events (fires). Similarly, the manipulation of the cameras will be possible from the Cloud platform, as well as the support of automatic operation (e.g. camera rotation). | • Fire detection system with Surveillance cameras: rotatable optical thermal cameras that will monitor the area of interest automatically & periodically and can be rotated ($360^{O}$) to focus in the event of an incident.<br>• Cloud management platform, which is a fully online (web-based) electronic monitoring and management application (Dashboard) of the data and measurements received from the sensors and cameras. The platform is hosted in the Cloud and the available network is used to transmit data and measurements. |
| Timely alerting (early warnings) | • Fire detection (smoke or flame) within 3 minutes based on AI techniques.<br>• In case of fire detection, a notification is sent, together with an image or video and the location of the possible event on the map (approximate) from the area of the event. In this way immediate evaluation and visual verification of the alarm can be done and the criticality of the event can be decided.<br>• Notifications can also be sent to the user's option by setting selected thresholds and creating rules. For each installation point, it is possible to define the parameter for which the notification will be sent and the corresponding threshold. | • The platform outputs alerts for each camera and sensor, which can be sent when dangerous reading fluctuations are detected, or smoke/flame is detected.<br>• In any case, notifications are sent to selected users defined on the platform, via email and SMS. Generated alerts can be filtered according to their type, severity level and time of occurrence. |

| Use Case Name | Fire prevention/detection | |
|---|---|---|
| Scenarios | Description | Actors |
| | • Finally, in case of loss of communication between the devices and the platform, appropriate notifications are issued to solve the problem. | |
| Authorized access and user management | • The platform supports login only to authorized users with graded access and specific roles (administrator or simple user).<br>• The management platform supports the display on a map of the location of each camera and device with color differentiation depending on the status of each point.<br>• The remote management of cameras and sensors is also achieved through the platform. Finally, the platform can be interconnected with third party systems through APIs for the exchange of information and data. It provides information but can also make use of advanced capabilities of other systems. | • GPU-enabled Cloud infrastructure<br>• Open APIs |

### 3.3.2 Use Case C2: First responders support / medical emergency handling

The goal of this use case is to develop profound understanding on how 5G-TERRA can be used to improve emergency care, and how it can improve the co-ordination between civil protection agencies, such as police, fire brigade, medical first-aid providers and public authorities allowing them to communicate and have a holistic view of the critical situation. Furthermore, the enhanced connectivity capabilities along with WINGS **STARLIT** platform functionalities allow medical caregiver in the ambulance / near the patient, the medical regulator, remote experts and emergency department staff to team up effectively to save the life of more patients than before. To save lives and improve outcomes for patients, it is essential to realize fast and precise diagnosis of life-threatening conditions in order to be able to give patients the necessary lifesaving treatment as quickly as possible.

The solution developed for this use case is leveraging the capability of 5G-TERRA network, in particular high throughput, low latency, and ultra-reliability, to provide vital signs monitoring and live video streaming support and ultrasound images from the scene. This way clinicians and carers are empowered to know what's

actually occurring with the people in need and reach quicker and more confident decisions to support emergency care. The relevant scenarios are presented in Table 10.

**Table 10: UC C2 scenarios**

| Use Case Name | First responders support / medical emergency handling | |
|---|---|---|
| Scenarios | Description | Actors |
| Audio/Video communication | Live high-quality audio/video, in addition to voice communication between involved authorities and also with remote clinician. | UE devices and/or AR/VR sets |
| Remote Ultrasound | Digital ultrasound data streaming, concerning the transfer of multiple streams of digital high quality medical ultrasound images (DICOM) [6] and associated metadata. | UE devices |
| Vital signs monitoring of first responders | It is important to be able to monitor the vital signs of the emergency personnel (e.g. firefighters) that are entering a risky environment. | Wearable patches/application server |
| Connected Ambulance | A camera based in the ambulance transmits high-definition footage to the remote clinician with close to zero latency. Using a VR headset, the clinician can then remotely guide the paramedic through a series of procedures that allows the clinician to recognise vital signs, access medical records remotely and ultimately respond much faster. | AR/VR sets |

### 3.3.3 Technical and User Requirements for Civil Protection Use Cases

Following again the performance benchmarking discussed in [4], [9], and[11] we arrive to the target figures in Table 11 below.

**Table 11: KPIs with target values for Civil Protection UCs**

| Use Cases | KPI | Target value |
|---|---|---|
| C1: Fire prevention/detection | Downlink throughput per device | 100 – 400 Mbps |
| | Uplink throughput per device | 50 - 100 Mbps |
| | Latency - round trip | <30 ms |

[6] https://www.dicomstandard.org/

| Use Cases | KPI | Target value |
|---|---|---|
| | Latency - RAN | <10 ms |
| | Application round-trip latency | <300 ms |
| | Network Availability | 99,999% |
| | Network Reliability | 99,999% |
| | Location information | >1000 m |
| C2: First responders support / medical emergency handling | Downlink throughput per device | 100 – 500 Mbps |
| | Uplink throughput per device | 50 - 200 Mbps |
| | Latency - round trip | <30 ms |
| | Latency - RAN | <10 ms |
| | Application round-trip latency | <200 ms |
| | Network Availability | 99,999% |
| | Network Reliability | 99,999% |
| | Location information | <50 m |

The identification of user requirements for civil protection use cases (Table 12), is based on the feedback received by 5G-TERRA SGI providers as well as references such as [21], [23] and [24].

**Table 12: User requirements for Civil Protection UCs**

| Use Cases | Requirement | Description |
|---|---|---|
| C1: Fire prevention/detection | Efficiency increase | The coordinated and unified monitoring capabilities of the proposed applications support management efficiency |
| | Fast and Reliable communications | The advanced networking capabilities of 5G-TERRA allow for reliable deployment and operation of all elements required for monitoring and alerting |
| | Coverage | The system offers wildfire degree of danger rating at micro-scale (scale at the range of 1 km), while it can detect fires at a distance up to 10 km. |

| Use Cases | Requirement | Description |
|---|---|---|
| | Complexity reduction | Common application for all civil protection mechanisms |
| | Security/Privacy | Civil protection systems must remain operational 24/7, during and after disasters, when they are most needed. Further actions include updating business continuity plans and procedures and ensuring coordination and information sharing across sectors, including with critical infrastructure providers. Image and data transmission are secured through 5G-TERRA network design. |
| C2: First responders support / medical emergency handling | Coverage specifics | The service must be available in remote or difficult to access areas |
| | Localisation capabilities | The actual position of the person in need must be identified with reasonable accuracy |
| | Audio/Video communication | UE devices and AR/VR tools used by first responders rely on 5G capacity and reliability |
| | Security/Privacy | Any private medical data or records transmitted are secured through 5G-TERRA network design. |

# 4 Conclusions

This document provides the UC scenarios and associated network and platforms characteristics to articulate the functional and performance requirements of the three 5G-TERRA SGIs, Healthcare, Education and Civil Protection. These requirements will be considered by architecture, system design and implementation experts in WP2, 3 and 4, to select for each site location the most relevant scenario and parameters to validate 5G-TERRA. These UC requirements will be taken forward in WP5 to determine the most appropriate way to measure performance against the required KPIs and develop verification and validation implementations.

Requirements management in 5G-TERRA has not finished for WP2. It is not a one-way or waterfall process, but rather a concurrent or iterative development process. UC analysts have identified a need for validation of requirements, and particularly the User requirements. User expectations of 5G capabilities based on their desires may in some cases exceed expected standard 5G deployments, and in some instances even though 5G can meet the requirements, requirements are potentially over specified. Thus, WP2 has identified a need to, and shall, maintain user requirement dialogues through to project completion.

The phased delivery of the sites and services will result in a continual evolution of deployed and available capabilities at each of the UC trial sites. This presents challenges for WP3, WP4 and WP5. UC and platform verification and validation relies on correlating technical performance measurements from the systems along with data gathered from users based on their Quality of Experience and willingness to pay responses.

The final version of the technical requirements of the UCs, economic and deployment implications will be included in the last deliverable of WP5, D5.3, to be delivered at the end of the project.

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