5G-TRACE

5G-based TRAnsformation of a CanCEr Hospital to support patients' treatment in a "home like" environment

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 and Energy (Smart and Green Buildings) 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
AQI	Air Quality Index
AR/VR	Augmented Reality/Virtual Reality
CEF	Connecting Europe Facility
CEF-DIG	Connecting Europe Facility - Digital
DAS	Distributed Antenna System
EC	European Commission
ECG	Electrocardiogram
EU	European Union
E2E	End to End
GPRS	General Packet Radio Service
GPS	Global Positioning System
ICU	Intensive Care Unit
KPI	Key Performance Indicator
LORA	Long Range
NB-IOT	Narrowband Internet of Things
NSA	Non-Stand Alone
PM	(Airborne) Particulate Matter
RAN	Radio Access Network
RES	Renewable Energy Sources
RRF	Recovery and Resilience Facility
SGI	Services of General Interest
TMV WG	Test Measurement and Validation Working Group
UC	Use Case
WP	Work Package

1 Introduction

As outlined in the EC's CEF-DIG-2023-5GSMARTCOM-EDGE-WORKS 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. The proposed 5G infrastructures should be capable of delivering leading-edge connectivity with characteristics such as Gigabit performance, high-user-density, ubiquitous coverage, capacity to connect IoT devices, low latency, and high reliability. For healthcare centres in particular, "recent studies show that they need networks providing significant bandwidth to cover digital use cases integrating the use of electronic health records, real time medical imaging and patient health monitoring". 5G is selected for its capability to support real time services, high data rates and mass number of sensors.

The strategic objective of the 5G-TRACE project is to facilitate the digital transformation of the Theageneio Cancer Hospital to support patients' treatment in a "home like" environment through the deployment and operation of a 5G Indoor network that will enable the effective operation of the identified use cases.

The project will provide high-quality 5G connectivity to the end customers of healthcare facilities in Thessaloniki, Greece, to enable efficient, state-of-the-art healthcare and smart building Services of general interest (SGIs) and to support the deployment of 5G infrastructure as part of the European Gigabit Society EU strategy.

The new network will be validated through innovative and demanding patient monitoring and medical diagnosis services use cases. Furthermore, Smart and Green applications for building facilities will be validated, which are monitoring the hospital environment through AI analytics by processing data from smarts sensors for parameters such as consumption and level of heating oil tanks, electricity metering & drinking water consumption and smart air quality measurement systems.

This deliverable, D2.1, is the first technical deliverable published by the 5G-TRACE 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-to-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-TRACE 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-TRACE 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 Healthcare, and Smart & Green Building (Energy) SGIs, and correlates this regarding network and services platforms offerings to set the implementation targets. The 5G-TRACE use cases that are integral to the 5G-TRACE validation activities are elaborated.
- Section 4 provides concluding remarks and the next steps for facilitating the delivery of a fully operational and validated 5G-TRACE network by the end of the project.

2 5G-TRACE Scope of Work

5G-TRACE will target two healthcare facilities (Figure 1): Theageneio Hospital is the main medical center where medical records and expensive medical equipment resides; the "Nikos Kourkoulos" facility will serve as a "home care paradigm" where smart medical bed and health monitoring devices are used to ensure real time exchange of measurements, contact with doctors, decision making and transfer of medical files.

The identified areas are not sufficiently covered by 5G technology, so the investment will help in connecting these areas with cutting edge technologies and supporting demanding (high throughput, low latency) use cases.

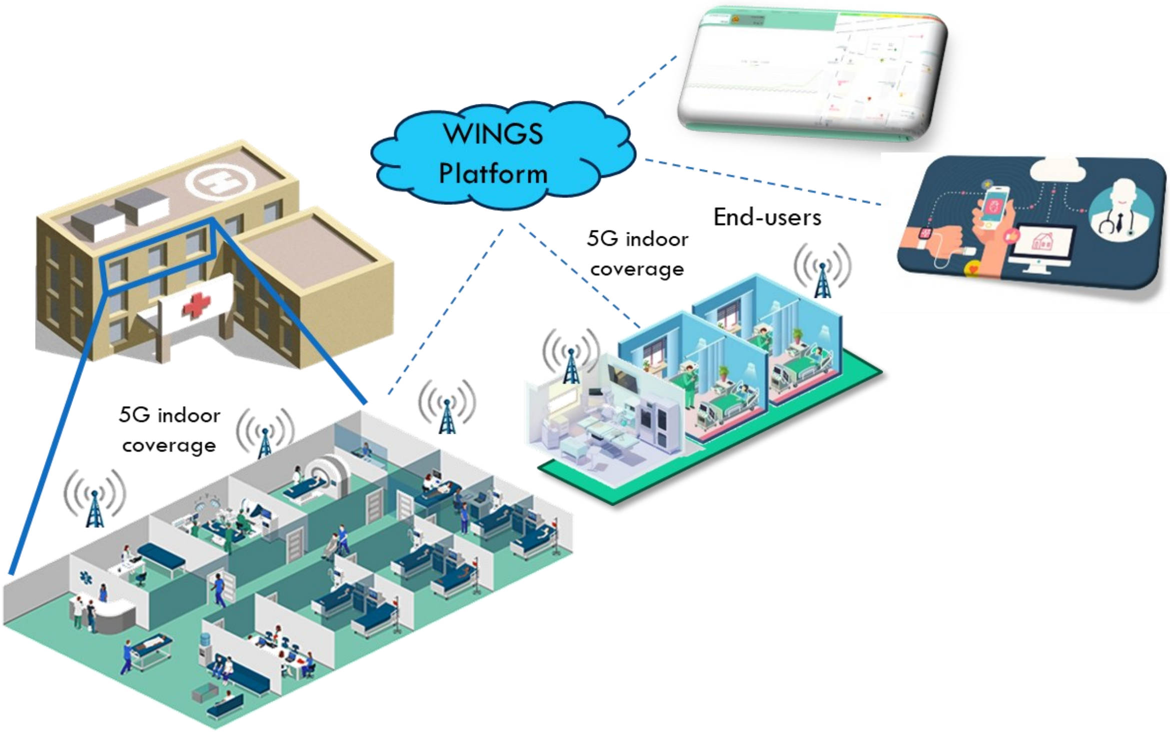

Figure 1: 5G-TRACE target areas

Specifically, 5G-TRACE is set to implement the following objectives:

O1. To extend the NOVA 5G network (in terms of construction, configuration, and connection with the rest of the network) with two indoor DAS for Theageneio main building and its satellite Nikos Kourkoulos, providing 5G coverage towards high capacity, reduced latency, and high reliability mobile services.

O2. To enable and demonstrate advanced Healthcare and Energy domain SGIs, such as patients' monitoring and Green Building applications, leveraging the new 5G RAN infrastructure that will be implemented for different use case scenarios, static or mobile.

O3. Support 5G best practices beacons in different sectors that can serve as templates for possible replication with other resources, national or EU (RRF).

O4. Outreach to public audience, key stakeholders, dissemination, standardisation and further exploitation of the project's main achievements

High-quality 5G (3.5 GHz) indoor network connectivity will provide coverage in the selected areas The novel 5G RAN base stations will be connected to NOVA'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 NOVA will provide performance monitoring, proactive/reactive fault management and anomaly detection functionalities. The 5G-TRACE 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 cases will be performed.

3 5G-TRACE Use Cases and Requirements

As the healthcare industry confronts an increasing and aging population, novel diseases, and worker shortages, the need for new solutions to address these challenges grows. “Digital” hospitals apply a comprehensive approach to technology integration, enabling them to unlock insights from the vast amount of collected data to improve patient outcomes and care experiences, optimize operations, and accelerate innovation.

The outcomes of hospital digitalisation, can be:

- Patient flow is seamless, effective and safe
- Indoor conditions and air quality are excellent
- Energy efficiency and cost effectiveness are optimised
- Surgical capability and diagnostics are improved
- Spaces can be adapted for different purposes
- Remote medical care is supported
- Critical systems for patients and the buildings have high redundancy and surveillance
- Trustworthiness is reinforced in all aspects

Section 3 sets the strategy to implement the 5G-TRACE mission to provide 5G network deployments suitable for Healthcare and Energy UCs. We will present what are the requirements for each of the services of interest in terms of 5G potential to digitally transform end user services and analyse 5G-TRACE scenarios for demonstrating these.

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 NOVA 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-TRACE UCs realisation.

The Use Cases described in the next sections reflect the capabilities of the 5G-TRACE network and applications to serve the needs of the Hospital. 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

Healthcare and life sciences organizations have long invested in individual technologies to advance care and discovery. While targeted solutions continue to provide great value, they are often disconnected from each other, resulting in data silos, disjointed patient experiences, and operational inefficiencies. Digital health represents the convergence between technology and care and is transforming how healthcare is delivered by incorporating technological innovations directly into patient treatment plans. Systems like telemedicine platforms, mobile health applications and cloud-based diagnostic tools connect patients with providers while enabling real-time health monitoring.

In digital hospital environments, IoT and 5G serve as the backbone of smart connectivity, linking devices, infrastructure and personnel to create an interconnected network. Furthermore, wearable health trackers and remote monitoring systems also transmit real-time data to healthcare providers, thereby enabling more proactive responses.

Artificial intelligence is reshaping diagnostics, treatment strategies and hospital operations. Machine learning algorithms analyse vast amounts of medical data to provide quicker and more accurate diagnoses. In addition, predictive models use this information to help create tailored treatment plans and improve the quality of care. AI-powered tools can also be used to manage routine tasks such as scheduling or monitoring, allowing healthcare professionals to prioritise critical responsibilities.

All these advancements reduce administrative workloads, streamline processes and improve clinical outcomes, making AI an essential resource for healthcare organisations facing modern medical challenges.

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.

For the requirements analysis and the uses cases scenarios, WINGS conducted a series of meetings with doctors, technical personnel and external expertise consultants of the Theageneio hospital, in order to define properly the exact needs of the hospital itself. It was suggested to involve a team of doctors (to ensure variety) and include the best possible range of digital solutions through the 5G connectivity. The thematics of these meetings included the use of smart watches with real time biometric data, HR, SPO2, temp, blood pressure and GPS position for patients via real-time voice/video communication and 24hrs monitoring centre and the use of an ultrasound 5G tablet and probe for outpatient cardiac exams – eligibility for chemotherapy – and real time sending of results to cardiology department of the hospital.

Considering the Nikos Kourkoulos home care unit in particular, 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 and bringing about significant improvements in patient quality of life, such as chronic disease management. This allows for reducing costs and time to access medical specialists, avoiding long waiting lists and complex logistics for home-care patients, which is an important dimension of the 5G-TRACE project.

The 5G-TRACE healthcare use cases concern the use of WNGS digital health platform **wi.CARE+**[1] (WINGS machine learning for health improvement), (Figure 2) which supports the simultaneous connection of high-tech and precision devices (Figure 3) to monitor vital signs of patients within the hospital by performing tests **(smart watch, cardiograph/digital blood pressure monitor, spirometer, portable thermometer)** in real time. It offers **instant warning for values that deviate from normal – expected and at the same time helps to prevent or detect** emergencies. The platform includes also Location Tracking & Fall Detection, for **emergencies within the hospital** and also **supports the use of a simple and easy-to-use panic button.** All data is synchronized in the Cloud, which can be accessed by Health Professionals (such as General Practitioner, Nurse, Hospital Executives). The monitoring of measurements can be carried out from any desktop, laptop, ipad and

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

any distance as long as the user is authorized by offering classified access. wi. CARE+ is already used in private clinics and hospitals (IASO Thessaly and Evangelistria Clinic in Athens).

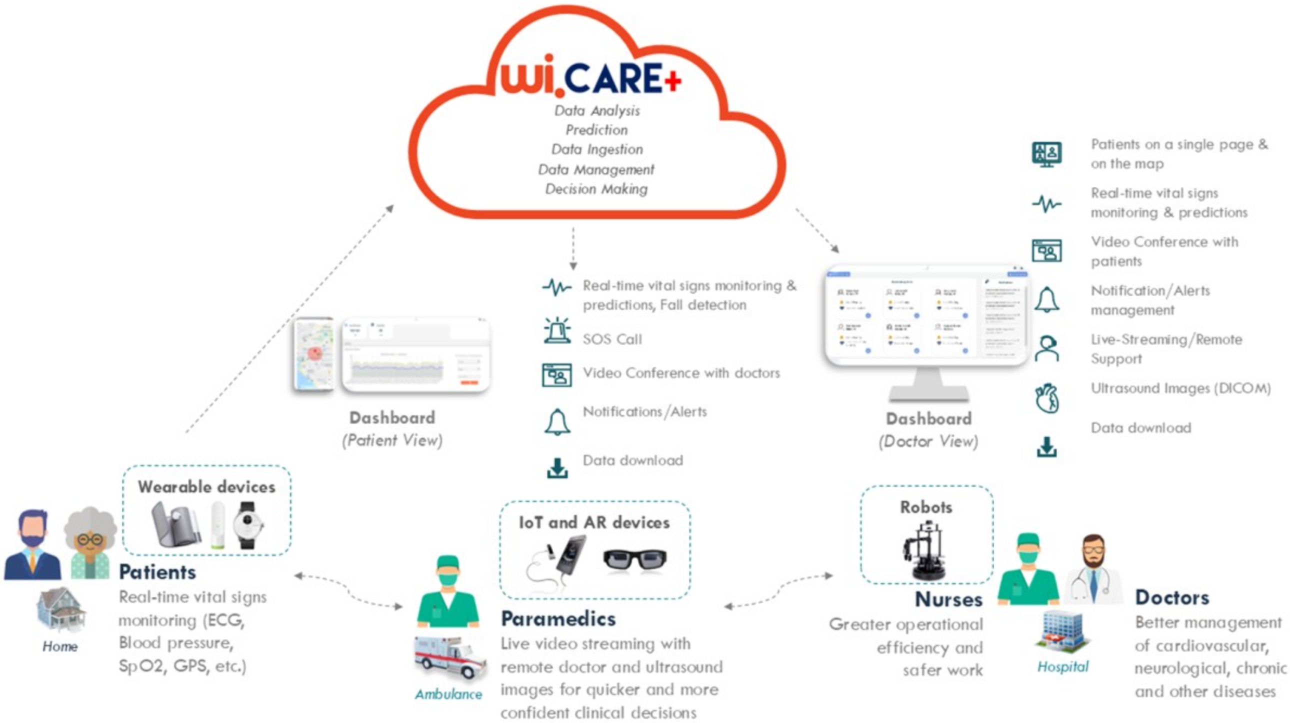

Figure 2 wi.CARE+ platfrom.

wi.CARE+ **i**ncorporates accredited and certified smart devices (Figure 3) which cover a diverse range of needs in terms of capabilities / cost / application, for accomplishing its role.

- **Wearable devices** which collect vital signs: Heart Rate, Cardiac Rhythm, arterial blood pressure, (Electrocardiogram/ECG), Oxygen Saturation (SpO2), Body Temperature
- **Smart Medical Devices** (spirometer, smart AR glasses, oximeter, blood glucose meter, Electrocardiogram/ECG 24/7 etc)
- **Specialized Devices** that provide other measurements and features e.g. GPS (geofencing), SOS buttons (emergency calls), Altitude, Acceleration, Activity, etc.
- **Wireless, handheld ultrasound** for whole-body scanning and delivery of crystal-clear images Smart glasses for live-video remote support.

Figure 3 wi.CARE+ devices.

wi.CARE+ comprises a suite of AI and predictive analytics algorithms for:

- Analysis of ECG signals to derive useful information for the detection of cardiovascular diseases such as arrhythmia and myocardial infraction.
- High blood pressure (hypertension) forecasting via personalized prediction models.
- Analysis of oxygen saturation signal to derive insights for the detection of apnea and hypopnea respiratory events.
- Analysis of blood glucose levels and prediction of future values, for the early detection of hypoglycemia.
- Analysis of Electroencephalograph (EEG) signals for the prediction of seizures
- Assessing the status of subjects with predisposition or symptoms of depression providing further insights to the medical experts.
- Prediction of asthma attack for the following day, based on weather and air quality as well as medical and lifestyle factors of the previous day(s).

The wi.CARE+ visualization dashboard (Figure 4) provides an intuitive, user-friendly interface for tracking patients' health metrics in real-time. Key features include:

- Dynamic Visualizations: Interactive charts and graphs display vital signs like heart rate, blood pressure, oxygen saturation, and temperature trends.
- Patient Overview: A centralized panel summarizes individual or grouped patient data.
- Alerts and Notifications: Real-time alerts flag abnormal readings, fall detections, etc. enabling timely interventions.
- Health Insights: Visualisation of predictive analytics highlight potential health risks, supported by AI-driven recommendations.
- Secure Access: Data is protected with encryption and user-based access controls to ensure privacy compliance.

The dashboard empowers healthcare professionals, municipalities, various private and public settings with actionable insights, promoting proactive and efficient remote care. Furthermore, mobile applications for both healthcare professionals and patients/beneficiaries have been implemented for iOS and Android. The mobile applications offer the same functions and capabilities as the wi.CARE+ web dashboard.

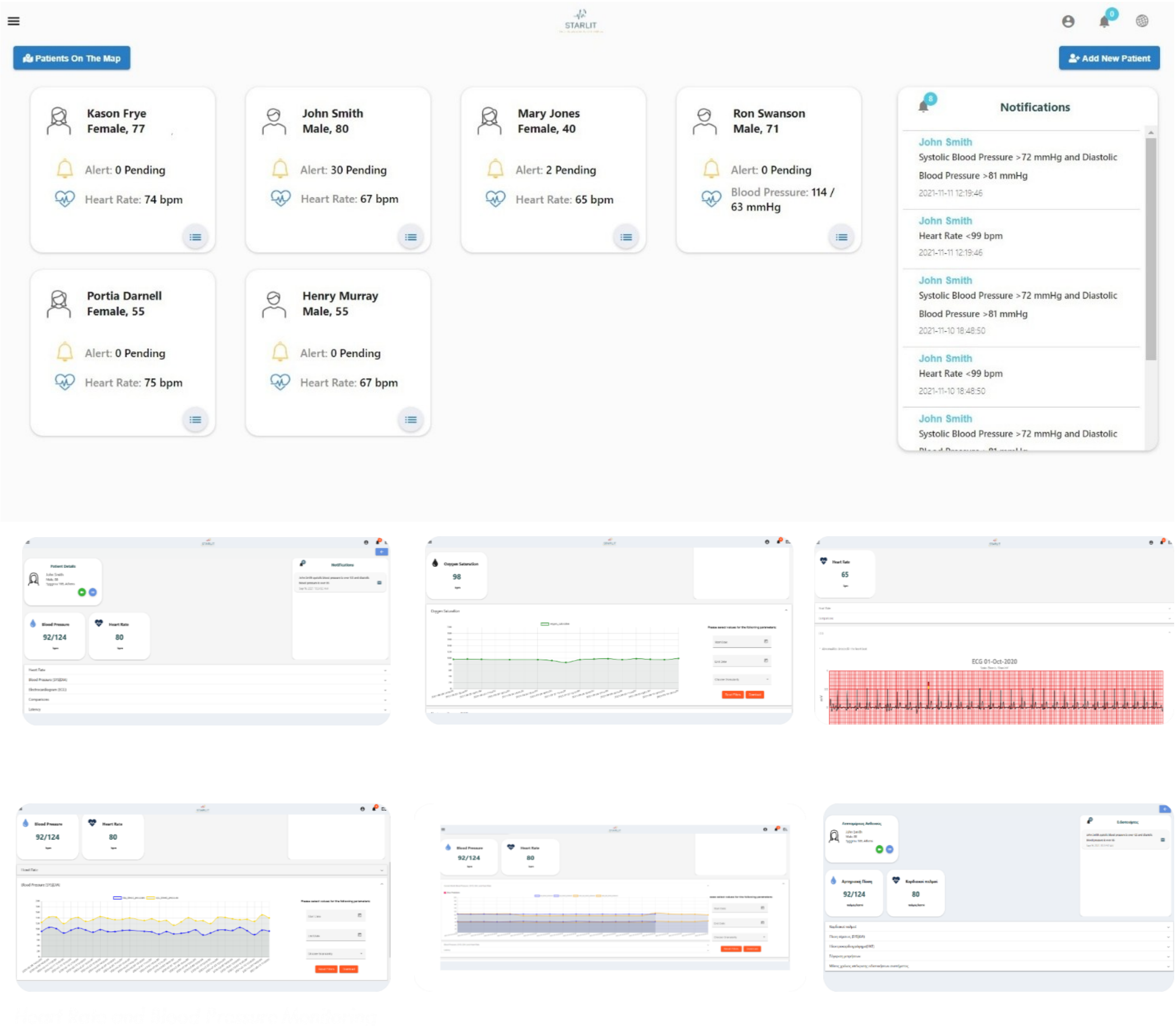

Figure 4 wi.CARE+ dashboard

The benefits for the hospital through the utilization of the proposed solutions in 5G-TRACE, can be identified as:

- Concentration of measurements and services in the patient's digital file for easy and direct access by hospital staff, eliminating the risk of the human factor – error.
- Using modern IoT and AI tools to predict out-of-normal values in the coming hours and days
- Increase the scope and quality of social welfare services.
- Upgrading the quality provision of nursing care to patients through the time that staff can use more efficiently, since they will no longer be burdened with the same number of face-to-face measurements as in the past.

- Provision of statistical reports on efficiency and management of alerts, through response times / response times of system alerts will promote the level of information regarding the situation of the citizen.
- Unpleasant emergencies can either be prevented or dealt with more quickly (increased sense of security for the citizen).
- Implementation of technologies that reduce the patient's length of stay (LOS) and optimize patient flow management. Reducing the variable costs associated with unnecessary prolonged hospitalization would improve operational margins and more efficient use of hospital beds.
- Enhancing the safety of hospitalized patients since prolonged hospital stays increase the risk of nosocomial infections and severe psychological complications.

3.1.1 Use Case H1: In Hospital health monitoring & emergency situation notification

This use case demonstrates the 5G-TRACE 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-TRACE 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.

In this scenario the focus is on the use of digital watches inside the hospital for internal patient use. A number of watches (about 20 devices) will be distributed in the main building and 5 devices in the N. Kourkoulos unit. These watches will be distributed according to the demand of the respective clinics and the doctors themselves will determine a) who will check their condition, b) how many patients will receive the watches in the hospital, c) what the watches will examine.

The use of the watches will take place during hospital hours and the patient must enter the premises to receive one. This scenario will offer immediacy and avoid problems and delays within the premises of both the Hospital and the Unit and the patient will be better monitored as the information will be received correctly and immediately.

The challenge here, relies on the fact that some clinics serve a larger number of patients than others, while there are also cases of patients who enter and leave the hospital on the same day or in a short period of time, while on the other side, there are cases who respectively enter the hospital and stay for a certain period of time (e.g. a few days). Therefore, there will be difficulties in the correct distribution of digital watches but also there is a possibility that they may not even be used. Furthermore, in clinics where a large number of patients are received, there will be a problem in serving them simultaneously and the doctors will have to conduct an assessment, which can cause problems.

Furthermore, this scenario includes the use of digital watches in specific clinics on a pilot basis, in order to help their proper functioning and the proper dissemination of information. The watches will be numerically allocated to specific clinics (the Endocrinology Clinic and the Radiotherapy Clinic are proposed) of the N. Kourkoulos Unit where a total of 15 to 40 patients are served daily. The number remains constant, so it is easier to determine the need and to implement in practice a better digital solution. In this unit, the usual flow is specific: nurse - doctor - pharmacist - administrator.

The watches will include basic functions: standard information characterization, blood pressure, oxygen measurement, etc., and will be used both for patient-doctor communication and for intrahospital communication.

This scenario offers immediacy and practicality. Communication will become simpler and easier while it will also be better disseminated among hospital staff. At the same time, it can be controlled by the respective nursing services and the doctor does not need to be permanently involved, unless there is a case of risk.

The challenge in this scenario lies in whether the patient will be able to keep up with this solution and will use the watch in an emergency within the hospital.

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

Table 1: UC H1 Scenarios

<table>
<tr><th>Use Case Name</th><th colspan="2">H1: In Hospital monitoring & emergency situation notification</th></tr>
<tr><th>Scenarios</th><th>Description</th><th>Actors</th></tr>
<tr><td>Vital signs monitoring and analysis (Blood Pressure, Glucose, ECG, etc)</td><td>• Blood pressure and or Glucose levels are monitored by the health professional, while the patient is either visiting the Hospital (outpatient) or is hospitalized in a clinic.
• The system is analysing trends and detecting/predicting outcomes.
• Respective alarms/notifications are issued to designated people.</td><td rowspan="2">Devices/Wearable patches/smart watch/application server</td></tr>
<tr><td>Location tracking</td><td>The position of the outpatient is available through the application to the health professional, so that in case of emergency first aid responders can be directed to the patient, no matter where he is in the premises.</td></tr>
<tr><td>Data download</td><td>The patient’s medical file can be accessed along with his current vital signs’ status, so that the health professional can assess the patients’ condition more effectively.</td><td>Application server</td></tr>
</table>

3.1.2 Use Case H2: Real-time remote health monitoring & emergency situation notification

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.

This scenario concerns the use of digital watches for the purpose of remote patient monitoring. This will include various functions that will complement the patient's electronic file, such as spirometer, blood pressure monitor, oximeter, blood levels and will be assigned to specific patients after careful consideration that will be conducted by a team of doctors. Patients will be divided into groups and the watches will be given to them for a period of 14 to 21 days. Afterwards, the watches will be returned to the hospital, where they will be assigned to the next group and so on.

This digitalization of services will bring positive changes as access for patients will become easier and faster, while they will be able to communicate their condition to their doctor at the touch of a button. Accordingly, at any time, the doctor will also be able to access the patient's medical data.

There are various challenges in this scenario. Initially, Theageneio will have to appoint a specific person, who will have the appropriate medical knowledge to monitor the results from the watches and any emergencies. Secondly, there is a risk of losing the watch or improper using it, as it will be at the patient's disposal.

This scenario needs further elaboration are there are several difficulties in both its practicality and regulatory context.

The UC will leverage wearable devices such as smart watches tracking a person's vital signs and having them aggregated inside the wi.CARE+ 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	H2: Remote monitoring & emergency situation notification	
Scenarios	Description	Actors
Vital signs monitoring and analysis (Blood Pressure, Glucose, ECG, etc)	• Blood pressure and or Glucose levels are monitored by health professionals. • The system is analysing trends and detecting/predicting outcomes. • Respective alarms/notfications are issued to designated people.	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 patient's 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

3.1.3 Use Case H3: Smart bed with sensors and automatic pressure profile adjustment

In hospital wards, especially in intensive care units (ICUs), long-term care facilities, and oncology units, many patients spend extended periods immobilized in bed. This immobility increases the risk of pressure ulcers (bedsores), and other complications related to poor circulation and prolonged pressure on specific body areas. To address this challenge, UC H3 deploys smart beds equipped with a pressure-sensing layer that continuously monitors the patient's body pressure distribution. These sensors detect how weight is distributed across different parts of the bed, identifying areas of high pressure that require relief.

The sensor data is streamed in real-time over 5G connectivity to an AI-powered control unit, which analyzes the distribution patterns and determines whether the bed needs to adjust its pressure zones. If needed, the system automatically inflates or deflates air cells in the mattress or changes the bed's inclination or posture, effectively redistributing pressure across the patient's body without manual intervention. This process happens continuously and autonomously, ensuring that patients receive optimal pressure relief, and that nursing staff are alerted only when necessary, reducing workload and allowing them to focus on more critical tasks. Furthermore, the data from the bed sensors is logged and can be reviewed by clinicians remotely via a central dashboard. Patterns over time help inform decisions about patient positioning, risk of ulcer development, or the need for physical therapy interventions.

5G's ultra-reliable low latency ensures that adjustments are made instantly in response to sensor data, and high bandwidth enables streaming of continuous sensor data without bottlenecks - even in wards with dozens of connected beds.

Smart hospital beds are enhanced with a sensor layer embedded in the mattress to continuously monitor the pressure distribution exerted by the patient's body. These sensors detect prolonged pressure points that could lead to pressure ulcers, especially in immobilized or critically ill patients.

This UC will be handled by NOVA ICT and can be applied both in Theageneio Cancer Hospital and the N. Kourkoulos Unit. The UC targets patients on bed rest, at risk of bed sore development.

Key functionalities:

- **Real-time monitoring:** The pressure map is updated continuously and transmitted via 5G connectivity to an AI-driven control system.
- **AI-based analysis**: AI algorithms analyze sensor data to detect high-pressure zones and predict areas at risk of developing ulcers.
- **Automated adjustments**: Based on the AI output, the system dynamically adjusts bed settings (inflation/deflation of mattress zones or bed tilt) to redistribute pressure.
- **Remote oversight**: The real-time data and adjustment history are visible to clinical staff via tablets or monitoring dashboards, enabling proactive interventions.
- **Patient comfort & recovery**: Aside from clinical benefits, the system also enhances comfort and supports faster recovery by reducing physical stress.

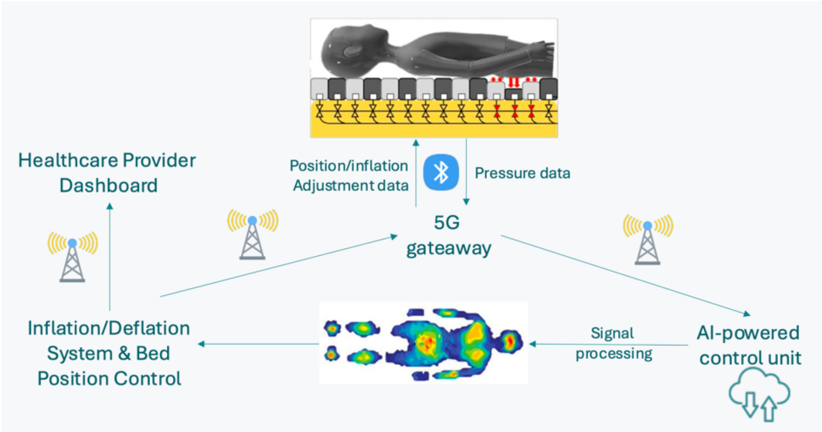

Figure 5 Smart Bed overview

In the following Table 3, the targeted scenarios and individual elements of the offered system are extensively analyzed.

Table 3: UC H3 Scenarios

Use Case Name	H3: Smart bed with sensors and automatic pressure profile adjustment	
Scenarios	Description	Actors
Pilot deployment in oncology ward	One (1) smart hospital bed will be deployed in Theageneio or N. Kourkoulos unit, targeting a patient on long-term bed rest. The bed includes an embedded pressure-sensing layer and is connected via the hospital's 5G infrastructure.	- Bed user (patient) - Clinical staff - Deployment engineer
Deployment steps	1. Selection of target room and patient case 2. Installation of smart bed and sensor integration 3. Test AI control unit for bed adjustment logic. 4. Test integration with nurse dashboard/tablets for monitoring. 5. Staff training and pilot run. 6. Logging and evaluation of performance over time.	
Real-time monitoring & AI-driven adjustments	Once deployed, the bed continuously monitors pressure distribution. AI processes the data locally and adjusts bed posture or mattress zones to relieve high-pressure areas. Changes are logged and alerts are triggered only when manual attention is needed.	- AI control system - Bed embedded sensors - Smart actuator system
Remote clinical oversight	The real-time data and adjustment history are visible through a 5G-connected dashboard accessible by clinicians. This enables informed decisions about repositioning, physiotherapy, or ulcer prevention strategies.	- Oncologists - Nurses - Physiotherapists

3.1.4 Use Case H4: Smart infusion pumps to ensure precise medication injection

During chemotherapy treatment sessions at Theageneio Cancer Hospital and the N. Kourkoulos Unit, patients often require continuous infusion of cytotoxic or immunotherapeutic drugs. These treatments are high risk and can lead to acute adverse reactions, especially changes in cardiovascular status like rapid fluctuations in blood pressure or heart rate.

To enhance patient safety and treatment precision, patients are equipped with smart infusion pumps, which are wirelessly linked to a central monitoring dashboard, while patients are also connected to wearable smartwatches. The smartwatch collects real-time physiological data (heart rate, blood pressure, oxygen saturation, activity levels), which are then transmitted via 5G to an AI-assisted monitoring system.

This system continuously evaluates the patient's condition and, upon detecting signs of physiological distress, sends real-time alerts to the nursing or oncology staff. Medical personnel can then remotely modify the infusion parameters, either slowing down the drug administration, temporarily pausing it, or adjusting the dosage rate, without physically intervening at the pump. This allows near-instant reaction time during potentially dangerous events. Additionally, this system supports personalized medicine approaches, adjusting treatment intensity based not only on protocols but also on individual, moment-to-moment patient responses, contributing to safer, more responsive oncology care.

UC H4 will also be implemented by NOVA ICT, at Theageneio Cancer Hospital and the N. Kourkoulos Unit, where patients undergo chemotherapy treatments requiring close monitoring and precise control of drug administration.

Key functionalities:

- **Vital monitoring via wearables:** Each patient wears a smartwatch that continuously tracks key vital signs—such as heart rate, heart rate variability, blood pressure, and activity levels.
- **Real-time alerts & adjustment**: If abnormal vital values are detected (e.g., hypertension or sudden heart rate changes), alerts are sent in real time to attending medical staff.
- **Dynamic infusion control:** Medical professionals can immediately adjust infusion speed or pause medication delivery remotely based on the patient's current condition, reducing the risk of adverse events.
- **Data visualization & logging:** A connected dashboard allows clinicians to view live vitals, infusion parameters, and event history for every patient session.

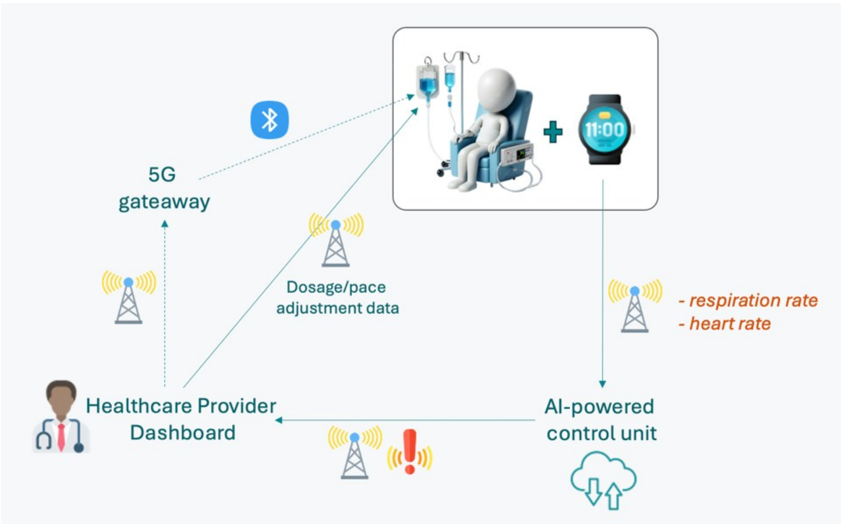

Figure 6 Smart Infusion Pumps overview

In the following Table 4, an overview of the offered system functionalities is provided.

Table 4: UC H4 Scenarios

<table>
<tr><th>Use Case Name</th><th colspan="2">H4: Smart infusion pumps to ensure precise medication injection</th></tr>
<tr><th>Scenarios</th><th>Description</th><th>Actors</th></tr>
<tr><td>Pilot deployment in chemotherapy unit</td><td>One (1) smart infusion pump will be deployed in either Theageneio or N. Kourkoulos, paired with a smartwatch for real-time vital sign tracking. The system will be tested during an actual chemotherapy session to assess performance, safety, and real-time responsiveness.</td><td rowspan="2">- Patient (pilot case)
- Nursing staff
- Medical staff
- Clinical engineer</td></tr>
<tr><td>Deployment steps</td><td>1. Select an eligible patient scheduled for infusion therapy.
2. Deploy smart infusion pump at bedside and connect it to the 5G hospital network. The smart pump will not be connected to the patient. Instead, it will be programmed to mimic the quantity and pace administered to the patient.
3. Provide patients with a smartwatch configured for vital monitoring.
4. Set up and link monitoring dashboard with both pump and smartwatch data streams.
5. Train medical staff on remote infusion control and alert system.
6. Conduct test run and monitor real-time alerts, responses, and infusion control actions.
7. Log event data for post-session evaluation and clinical feedback.</td></tr>
<tr><td>Vital monitoring and alert generation</td><td>During infusion, the smartwatch continuously streams vitals (heart rate, BP, oxygen saturation) via 5G to the monitoring system. If any abnormal patterns are detected (e.g., spike in blood pressure), an alert is instantly triggered.</td><td>- smartwatch
- Alert engine
- Clinical staff (on alert dashboard)</td></tr>
<tr><td>Medical dashboard with infusion control</td><td>The medical team uses a 5G-enabled dashboard to monitor patient vitals in real time and remotely adjust the infusion pump. Upon receiving alerts, clinicians can change flow rate or pause therapy instantly. This ensures immediate response to patient-specific reactions and supports personalized, precision chemotherapy delivery.</td><td>- Oncologists
- Nurses
- Infusion control interface
- Medical dashboard</td></tr>
</table>

3.1.5 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 [6], 5G-TOURS [7] and 5G-HEART [8], the network and user requirements and results stemming out of these projects are used as reference in the 5G-TRACE Healthcare Use Case. While varying in range depending on the actual scenario to be implemented, the network requirements identified in Table 5 are targeted.

Table 5: KPIs with target values for Healthcare UCs

Use Cases	KPI	Target value
H1: In Hospital 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: Remote monitoring & emergency situation notification	Downlink throughput per device	30 – 100 Mbps
	Uplink throughput per device	10 Mbps
	Latency - round trip	<70 ms
	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
	Uplink throughput per device	10 - 50 Mbps

Use Cases	KPI	Target value
H3: Smart bed with sensors and automatic pressure profile adjustment	Latency - RAN	<10 ms
	Network Availability	99,99%
	Network Reliability	99,999%
	Device Density	10 dev/km^2
H4: Smart infusion pumps to ensure precise medication injection	Downlink throughput per device	30 – 100 Mbps
	Uplink throughput per device	10 Mbps
	Latency - RAN	<10 ms
	Network Availability	99,99%
	Network Reliability	99,999%
	Device Density	100 dev/km2
	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 6).

Table 6: User requirements for Healthcare UCs

Use Cases	Requirement	Description
H1: In Hospital health monitoring & emergency situation notification	Video Reception/Transmission	1. The medical specialist requests a video connection via the WINGS wi.CARE+ platform if patient status demands video communication. 2. The 5G-TRACE 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 wi.CARE+ platform. The data is shared via suitable mobile apps and/or dashboards with family members and authorized medical specialists. 2. In case an emergency is identified by the wi.CARE+ 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

Use Cases	Requirement	Description
		wi.CARE+ platform issues an emergency notification to the medical specialist
	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, but not as critical as in next UC.
	Fast response	It is 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 wi.CARE+ platform. This way data privacy is ensured.
H2: Remote monitoring & emergency situation notification	Data Reception/Transmission	1. The wearable devices used for the monitoring of vital signs are connected and start sending real-time data to the wi.CARE+ platform. The data is shared via suitable mobile apps and/or dashboards with family members and authorized medical specialists. 2. In case an emergency is identified by the wi.CARE+ 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 wi.CARE+ platform issues an emergency notification to the family members, the medical specialist, and the Hospital Dispatch Centre. 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 wi.CARE+ platform.

Use Cases	Requirement	Description
	Voice/video communication	The patient can have a voice call in parallel to/or alongside any type of video communication.
	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 home-care environment or outside in order to fulfill a specific programme of activities.
	Location information	The determination of the location is important for fast and efficient response.
H3: Smart bed with sensors and automatic pressure profile adjustment	Data Reception/Transmission	High-frequency transmission of sensor data to the AI engine and actuation commands back to the bed in near real-time
	Fast response	Instantaneous system reactions (<100 ms) are needed to adjust bed configuration based on patient pressure patterns
	Reliability/Availability/Users' Acceptance Survey	System must operate autonomously and reliably, with minimal need for human intervention, enhancing staff trust and usability
	Security/Privacy	Full encryption of patient sensor data and secure access to the AI system and dashboards to ensure GDPR compliance
H4: Smart infusion pumps to ensure precise medication injection	Data Reception/Transmission	Vital signs and infusion parameters are exchanged between wearable devices, infusion pumps, and medical dashboard in real-time
	Location information	Critical alerts should include the patient's location in the hospital to guide rapid staff intervention
	Reliability/Availability/Users' Acceptance Survey	Reliability of system is key to trust from oncologists and nursing staff; the system must be perceived as clinically safe and usable

Use Cases	Requirement	Description
	Battery life	Especially for smartwatches, battery life must support full treatment session duration (6–8 hours minimum)
	Security/Privacy	Sensitive patient health data must be protected through encryption and access control—compliance with GDPR and hospital IT policies is mandatory
	Fast response	Real-time AI and medical decision support must ensure infusion changes happen within seconds

3.2 Smart and Green Hospital: Energy, Air Quality and Water Management

Smart hospitals are connected, energy-efficient, and optmised to promote healing and wellbeing. A hospital needs to be a safe and functional environment – for patients, visitors and health care experts. Modern building solutions can shape the future of our hospitals, in the sense that they help create hospitals that are safer, more sustainable and more capable of adjusting to the changing needs of health care. The better a hospital works, the better the patient experience, quality of treatment, safety and efficiency of the hospital.

Traditional hospitals have their fair share of technology, however in a smart hospital, all systems and devices are meaningfully and intelligently interconnected to monitor and adjust to real-time information and conditions. The seamless flow of information facilitated by IoT and 5G connectivity, plays also a vital role in optimising energy management, asset tracking and resource allocation, addressing both operational and financial priorities.

The result is a data-rich ecosystem that enhances decision-making and minimises manual errors. For businesses, digital health also offers scalable solutions for managing resources while improving patient satisfaction. Smart building management systems are at the heart of the hospital's performance, ensuring comfortable environments to support patient recovery and ensure critical systems including ventilation and climate conditions are always performing as they should.

Maintaining hospitals is different from many other properties as they contain plenty of technical systems that have to function 24/7 in all circumstances. High patient flows and operating costs also call for holistic maintenance of the property. Predictive maintenance relies on analytics and real-time monitoring to detect potential equipment issues in hospital environments. Advanced sensors paired with cutting-edge technology can identify concerns before they escalate, reducing downtime and keeping critical devices in continuous operation. These systems support uninterrupted care delivery while also cutting repair costs and boosting safety measures. Such approaches embody the forward-thinking mindset required to shape the future of smart healthcare infrastructure.

Modern hospitals face growing pressure to manage energy consumption while meeting sustainability goals. Smart hospitals use energy-efficient systems inspired by similar innovations in smart cities, aiming to reduce environmental impacts and operating costs.

Indoor Air Quality is also a topic that in recent years has obtained great attention in healthcare facilities [9]. Several studies are reporting a growing number of data and research works that investigate all the possible indoor levels and the development of management procedures (such as materials' choice, products for cleaning and disinfection, improvement of HVAC system, etc.) in order to improve the healing environments and health of medical and technical staff, patients, ambulatory users and visitors. Ensuring a good IAQ in hospitals is fundamental because there are the most vulnerable categories of the population for their health conditions, although the assessment of IAQ results may be arduous.

WINGS solutions for 5G-TRACE focus on:

- Air Quality Indoor & Outdoor monitoring
- Climate control sensors,
- Centralised lighting management systems
- 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)

In more detail, in the 5G-TRACE project, WINGS brings in the **wi.BREATHE-air**[2] (WINGS Building Resilience Empowered by Artificial Intelligence for Healthier Air and Environment) solution (Figure 7). This is a comprehensive solution for the live monitoring, measurement, and management of air quality and fire/wildfire detection in cities and municipalities. Leveraging innovative AI and IoT technologies, our solution is deployed in urban areas to safeguard citizen health and mitigate environmental risks.

wi.BREATHE enables you to:

- Monitor air quality in cities, ports, buildings, schools, industrial parks, construction sites, airports & more.
- Measure both indoor and outdoor air quality
- Track real-time ambient parameters that can threaten public health
- View Air Quality Index (AQI)
- Get early warnings, alerts and assessment for fires/wildfires

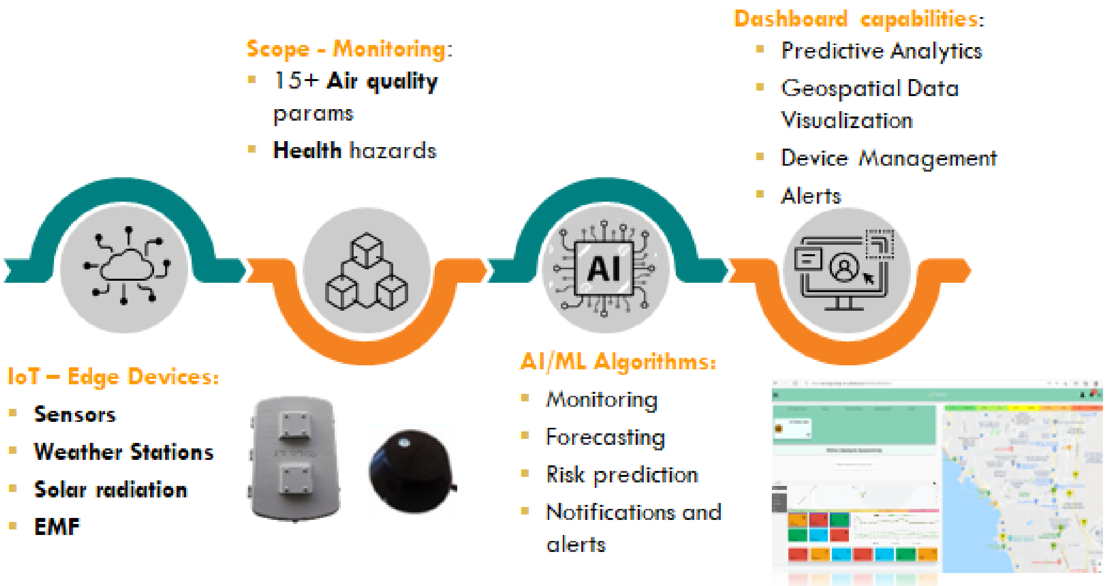

Figure 7 wi.BREATHE product scope.

The **wi.BREATHE** solution offers an integrated system of advanced hardware and software technologies for the continuous monitoring of air quality in urban environments. (Figure 8)

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

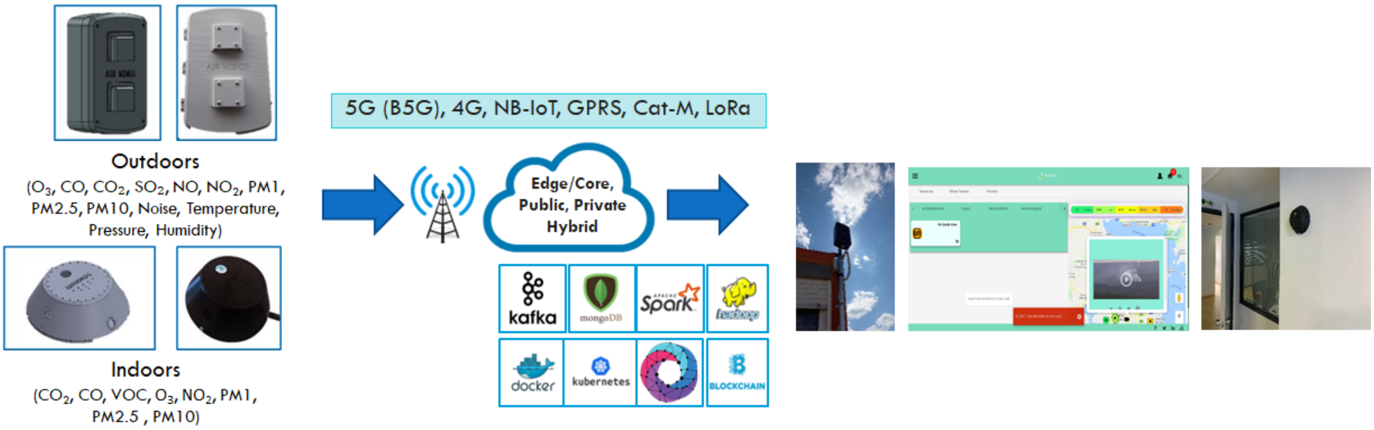

Figure 8 wi.BREATHE operation overview.

For indoor/outdoor environment such as the ones in the 5G-TRACE targeted use cases, the devices can sense the following parameters: (a) Gases: O3, CO, CO_2, SO_2, NO, NO2; (b) Particulates: PM1, PM2.5, PM10; (c) Other: Noise, Pressure, Temperature, Humidity. Our AI-powered software platform can predict parameter values, calculate standard (AQI – Air Quality Index) and proprietary metrics, detect early hazardous conditions and alert authorities to take action. The product offers the following capabilities:

- Outdoor and Indoor Air quality monitoring, forecasting and management actions
- Low-cost multi-sensor stations that can be easily installed in various places, and offer device autonomicity (integrated antenna, power by solar panels if outdoor)
- Measurements accuracy due to thorough calibration procedures
- Live evaluation of environmental characteristics of buildings that may affect human health, comfort or performance
- High precision Air Quality forecasting
- Immediate detection of air pollution and alert
- Integration of external sensors e.g., weather sensors
- Early warnings – personalized recommendations

In Figure 9 below, we can see how the installations of wi.BREATHE system can look like in a real environment.

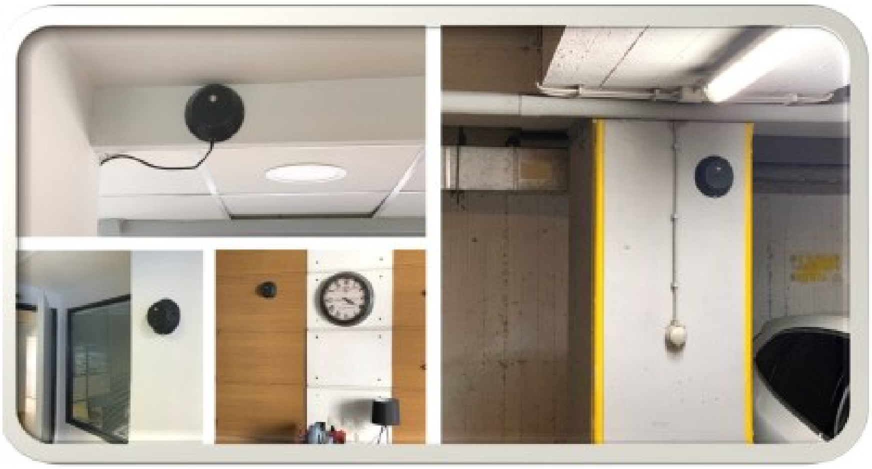

Figure 9 wi.BREATHE system indicative installations.

WINGS also brings in 5G-TRACE the **wi.SENSE**[3] (WINGS IoT based Intelligent Platform for Sustainable Environments) 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

The promotion and experimentation of sustainability is an important part of these solutions. 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.

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 (Figure 10, Figure 11). The modular approach and lower cost per meter/sensor compared to commercial connected devices (e.g. NB-IoT devices), result in efficiency, economy of scale, controllability, extensibility, and scalability benefits.

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

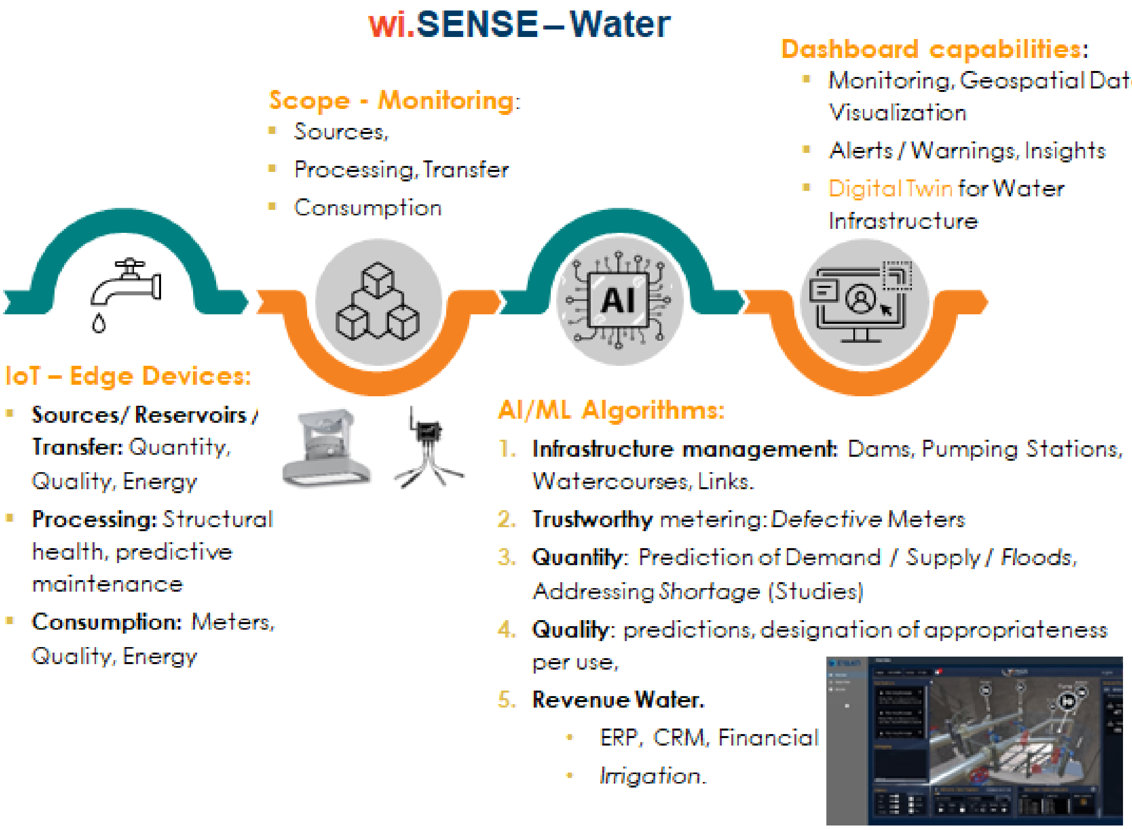

Figure 10 wi.SENSE-water product.

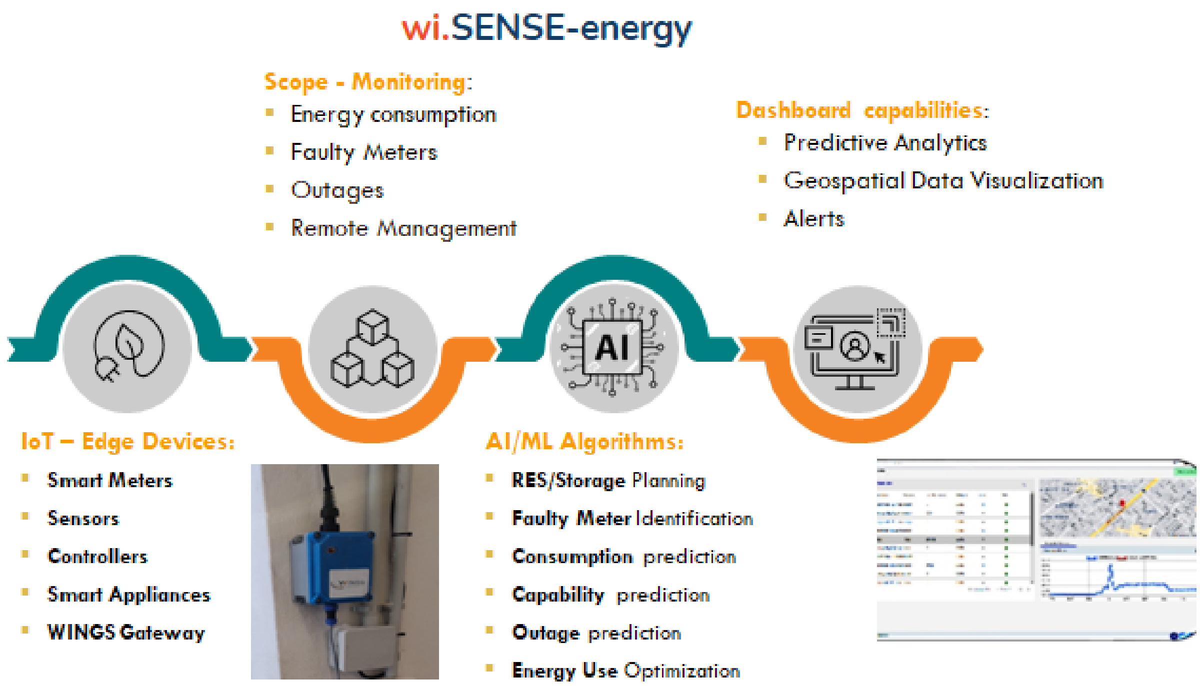

Figure 11 wi.SENSE-energy product.

All relevant wi.SENSE information (data, alerts, etc.) can be presented on a Dashboard, where administrator/usage privileges are controlled according to users' roles by the platform (indicative examples in Figure 12).

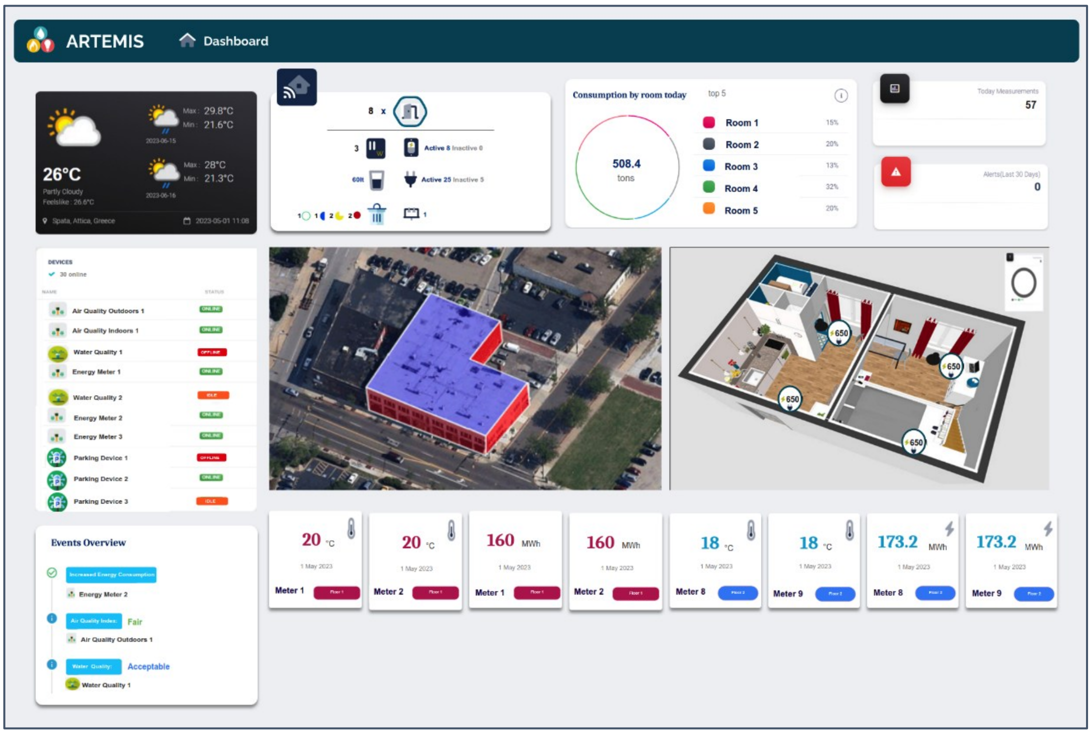

Figure 12 Smart Building dashboard.

3.2.1 Use Case E1: Air Quality Monitoring

In 5G-TRACE the Air Quality Monitoring system will be applied in selected areas inside and outside the Main Hospital unit as well as the Niko Kourkoulos day care unit.

Regarding the "N. Kourkoulos" unit, it is important to monitor indoor pollution, and it was proposed by the technical service to use the large waiting area on the ground floor, one large treatment room (the A') and some clinics located in the area (1-2).

In terms of the Theageneio Hospital building, the scenaria investigated target the installation of sensors that will measure the pollution of the indoor space by microparticles (waiting room and operating rooms), the periodic "clean-air" measurements of the operating rooms, the medical air and its quality (temperature, humidity, monoxide and dioxide gases, microparticles, etc.). With respect to the outside air quality, a possible air quality measurement location is at the corner of the Symeonidio medical center, part of and adjacent to Thegaeneio (terrace).

Through the integration of the wi.BREATHE solutions provided by WINGS, it will be possible to experiment and provide measurements with respect to these aspects. 5G-TRACE connectivity will allow the metrics and associated results to be communicated and processed in real-time. Table 7Table 9 provides an overview of the Air Quality Monitoring scenarios.

Table 7: UC E1 scenarios

Use Case Name	Air Quality Monitoring	
Scenarios	Description	Actors
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. • The data of the measurements are transferred from the devices to the cloud application through the 5G-TRACE mobile network. • 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.
Alerts	Notifications and early warnings will be issued to designated Hospital personnel, in case certain pre-defined metrics are reached	• The Management platform will issue warnings via SMS. E-mail • The personnel involved upon reception of the information will decide on further (maybe automated) actions

3.2.2 Use Case E2: Energy Management

In terms of promoting energy efficiency, we aim to install and operate energy consumption meters and smart lighting actuators in conjunction with specific electricity installations of the Theageneio and Nikos Kourkoulos units.

The topics for Energy Management in the N. Kourkoulos unit involve sensors related to energy consumption (machinery, lights, panels that will "control" the space remotely/automatically), as well as heating management (air conditioning) mainly in the waiting room in combination with sensors for air quality.

In the Theageneio emergency room, energy consumption is controlled, and it is possible to put sensors related to consumption counts in conjunction with 4-5 different fields – counting totals, from existing instrument measurements.

Through the integration of the wi.SENSE-energy solutions provided by WINGS, it will be possible to operate and provide measurements with respect to these aspects. 5G-TRACE connectivity will allow the metrics and associated results to be communicated and processed in real-time. Table 8 provides an overview of the Energy Management scenarios.

Table 8: UC E2 scenarios

Use Case Name	Energy Management	
Scenarios	Description	Actors
Smart system of energy saving and management of the hospital(s) building	The integrated intelligent solution for the energy management, concerns the remote supervision of the electricity boards to calculate energy 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 power-hungry medical equipment, smart panel-level switches) which will be installed in buildings for remote monitoring of consumption and control of building automations. • Smart transmission devices, which will be installed in the selected rooms/areas and will ensure the reliable transmission of information from the sensors and communication with the management platform in the Cloud. • Dedicated platform for visualizing the data transmitted by smart 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.
Smart Lighting	Interaction with user and visualization of results, statistics, notifications, lights control: • Select the lamps or a group of them • Activate / deactivate / dim the lamps in real time (real time mode) following a relevant command from the software or even according to a schedule (schedule mode) • Have a graphic representation of the lamp installation points • Show statistics/ notifications.	• Enabling connection and management of smart LED lamps (or other smart devices) through PC or through a mobile application • Smart lamps can be used with the ability to enable remote control by the user. • Control is possible through the cloud management system and through APIs which is integrated into **wi.**SENSE-energy platform.

3.2.3 Use Case E3: Water Management

The topics for Water Management in the N. Kourkoulos unit involve sensors for the measurement of residual chlorine in the water (installation of network and sensors in the basement).

Water Management is of particular interest to the hospital so that they can see its chlorination levels and take the necessary actions to upgrade the water quality.

In the Theageneio building boiler room, sensors must be inserted into the water tank to take measurements for residual chlorine, temperature and quality.

Through the integration of the wi.SENSE-water solutions provided by WINGS, it will be possible to experiment and provide measurements with respect to these aspects. 5G-TRACE connectivity will allow the metrics and associated results to be communicated and processed in real-time. Table 9 provides an overview of the Water Management scenarios.

Table 9: UC E3 scenarios

Use Case Name	Water Management	
Scenarios	Description	Actors
Monitoring water quality within the Hospital 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. 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 accessible by all interested users (director, citizens, environmental organizations, healthcare institutions, etc.), through a centralized measurement display screen (dashboard), and will also be offered as open data for	• Sensors which will measure various parameters for water quality, such as water pH, Conductivity, Turbidity, Oxidation Reduction Potential (ORP), Total Organic Carbon (TOC), Total Suspended Solids (TSS), Temperature, Salinity. • 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. • AI-based Platform will be used for visualizing the data transmitted by the smart transmission devices through the available 5G TRACE network and recording for further processing.

Use Case Name	Water Management	
Scenarios	Description	Actors
	further information and processing. 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.	

3.2.4 Technical and User Requirements for Smart and Green Hospital Use Cases

The Smart and Green Hospital Use Cases 5G related requirements and KPIs have been examined in a series of previous publications such as [10], [11]. Based on these we suggest the requirements in Table 10 and Table 11 below.

Table 10: KPIs with target values for Smart and Green Hospital UCs

Use Cases	KPI	Target value
E1: Air Quality Monitoring	Downlink throughput per device	100 – 500 Mbps
	Uplink throughput per device	>70 Mbps
	Application round-trip latency	<500 ms
	Network latency	<30 ms
	Network Availability	99,99%
E2: Energy Management	Downlink throughput per device	50Mbps
	Uplink throughput per device	10 Mbps
	Network latency	<30 ms
	Application round-trip latency	<500 ms
	Network Availability	99,99%

Use Cases	KPI	Target value
E3: Water Management	Downlink throughput per device	50Mbps
	Uplink throughput per device	10 Mbps
	Network latency	<30 ms
	Application round-trip latency	<500 ms
	Network Availability	99,99%

Table 11: User requirements for Smart and Green Hospital UCs

Use Cases	Requirement	Description
E1: Air Quality Monitoring	Air Quality	The capability to monitor in real time the environmental quality aspects is pivotal in establishing a green and sustainable hospital environment.
	Data communication	Reliable and steady throughput in transmit
	Fast Response	Low latency is of medium to high importance
	Security/Privacy	Medium to low (no personal data)
E2: Energy Management	Data communication	Reliable and steady throughput in transmit
	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	Energy optimisation and monitoring control through the platform is of high importance.
E3: Water Management	Data communication	Reliable and steady throughput in transmit
	Water Quality parameters	The capability to monitor in real time the environmental quality aspects is pivotal in establishing a green and sustainable hospital environment.

4 Conclusions

This document provides the UC scenarios and associated network and platforms characteristics to articulate the functional and performance requirements of the 5G-TRACE SGIs, Healthcare and Energy. 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-TRACE. 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-TRACE 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 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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