



IMAGINE-B5G

Advanced 5G Open Platform for Large Scale Trials and Pilots across Europe

IMAGINE-B5G Vertical Experiments

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1. Public Protection and Disaster Relief (PPDR)

PPDR sector focuses on the creation of a stable and secure environment for the citizens and protecting their lives in case of natural and provoked disasters. The activities considered in the PPDR sector are routine day-to-day activities (such as police, firefighting, medical attendance), planned events (fairs, sports, conferences) and unforeseen incidents (natural disasters, terrorists attacks). Due to the nature of these activities, there is an increasing need for ensuring the real-time collection and exchange of information, including control data, pictures, and video streams, along with voice to ensure the success of operations and the collaboration between groups of first responders. PPDR imposes several challenges to the network such as deploying wireless broadband coverage with the orchestration of different radio access technologies, portability, mobility, and specialized requirements for different services.

1.1 UC1: Firefighting and forest surveillance (French Facility)

1.1.1. UC Description

In the future, sensors, cameras, and other automatic devices will be a significant source of information for public safety and other professional users. Information from IoT will also become important for developing a full picture and thus providing better support – before and during incidents. Public safety organizations will have significantly more information on which to base decisions. This could help critical operations be more active, for example, moving from extinguishing fires to preventing fires in advance. The UC's goal is to improve event identification and characterization, operation, and disaster relief. To achieve this, the IMAGINE-B5 platform will leverage B5G features for reliable and efficient information collection (from UAVs and other sensors) and data processing to provide smooth real-time reporting, critical updates, and actionable intelligence, as timing and reliability can be the difference between life-or-death disasters. Furthermore, the platform relies on the computing continuum to overcome the complex decision-making process throughout the cycle.



1.1.2. UC Scenario

The scenario should focus on the role that flexible networking and computing infrastructure coupled with IoT may have for the detection, characterization, and operation of fire scenarios (deployed team status, fire progression, weather, and other multiple data). This will be done by deploying the project capabilities, enabling the collection, and monitoring of big amount of information from the field and in control centres. Organizations improve the quality and timeliness of their operational decisions and communications (e.g., field deployment decisions or updates). The project components will be challenged, addressing both the dynamic and mission critical nature of the scenarios.

Forest surveillance and firefighting involve various PPDR organizations (e.g., fire fighters, civil rescue, police, local organizations, private organizations), with field operation being coordinated both in local field commander positions and control centers, and by the remote headquarters. The goal is to validate the applicability, performance, and benefits of the project for supporting Mission Critical multimedia communication in firefighting scenarios, and its interaction with data centric IoT technologies to improve event identification and characterization, operation, and disaster relief by PPDR organizations.

During firefighting scenarios, decisions and operations should be strongly aided by technologies such as communication networks, multi-source data and IoT analysis and assisted decision-making platforms,

including UAVs / drones which are used both for realizing data collection (e.g., visible & thermal image, geo-references) and mission support (e.g., equipment delivery, signal repeating).

This UC is mainly based on:

- A 5G Core Network and a 5G RAN based on OAI and will run on a private edge based on Kubernetes.
- A vertical PPDR application, so called Mission Critical Multimedia Communication and Collaboration, a E2E solution, that implements the MCX services standardized in 3GPP services (MCPTT, MCData, and MCVideo).

1.1.3. OC Desired Contribution

The desired contributions include (but not limited to):

- Experiments that utilize UAVs/drones both for data collection (e.g., visible & thermal image, geo-references) and mission support (e.g., equipment delivery, signal repeating),
- Experiments involving IoT devices to improve fire forest surveillance (carbon monoxide, gas spreading, heat, ...),
- Applications of AI-based image recognition algorithms for different abnormal detection (fire, smoke), multimodal analysis (audio/video), data processing collection, UAV placement optimization,
- Experiments that leverage Augmented and Mixed reality (VR, AR, MR) to help situation awareness.

1.2 UC2: Critical Surveillance and inspection at a maritime port (Spanish Facility)

1.2.1 UC Description

Safety and protection are considered as major aspects that must be integrated into the port-logistic chain connected with daily activity of maritime ports and terminals. In this domain, surveillance and inspection activities are fundamental to minimize the risks that are intrinsic to the activities carried out at berthing areas, port accesses and terminal yards. In the last years, the use of Unmanned Aerial Vehicles (UAVs) in surveillance and infrastructure inspection activities has grown rapidly, since UAV enable safer, faster, and more accurate operation than traditional surveillance and inspection methods.



Some potential applications of UAVs are maritime rescue support (e.g., man overboard situations), anchoring area inspection, oil spill detection, dangerous goods tracking, etc. This use case (UC) aims at enabling critical surveillance and inspection with UAVs in maritime ports and terminals thanks to the use of 5G Rel.16 capabilities, which will allow to meet the stringent URLLC requirements related to real-time inspection and surveillance activities. Additionally, optimal coverage will be achieved by exploiting a seamless combination of 5G private and public network services. These functionalities will be combined with traditional 5G Rel.15 broadband capabilities to transmit real-time video streams with high-definition resolutions from different inland and coastal locations.

1.2.2 UC Scenario

The port of Valencia offers its facilities, experience, and support to integrate the required components into the drone. The port is highly monitored with multiple cameras and sensors offering the possibility to test the UC in a real environment where multiple actors interact daily. Currently there is one 5G mmW node inside the

port facilities and the centre of control which will monitor the operation of the UAVs. In addition, a 5G sub-6 GHz node (SA) is expected to be installed. Available 5G modems will be procured and equipped in the UAVs for enabling 5G communications. The port will be responsible of controlling the drones and asking for the licenses.

1.2.3 OC Desired Contribution

The desired contributions include (but not limited to) :

- Experiments that will leverage the UAV and the USV inside the port facilities for surveillance and inspection applications (anchoring area inspection, infrastructure inspection, oil spill inspection, etc.)
- Experiments involving novel AI-based image recognition algorithms for different surveillance and identification applications.
- Solutions that focus on the design of an intuitive user interface for the final user that allows obtaining updated information (e.g., the visualization of real-time UAV video streams) and making decisions more quickly.

*Note that the execution of such experiments will require the procurement of the UAVs as well as integration of cameras, surveillance hardware and/or other IoT devices

1.3 UC3: Multi-functional remotely operated boat (Spanish Facility)

1.3.1 UC Description

Safety and protection are considered as major aspects that must be integrated into the port-logistic chain connected with daily activity of maritime ports and terminals. In this domain, surveillance and inspection activities are fundamental to minimize the risks that are intrinsic to the activities carried out at berthing areas, port accesses and terminal yards.



The use of Unmanned Surface Vehicles (USVs) for surveillance, bathymetry, environmental monitoring and facilities inspection is becoming more relevant in maritime ports. The automation of many of these tasks that currently are executed manually by on-site operators make these tasks very tedious and resources consuming. This use case (UC) aims to demonstrate that the use of 5G commercial or private networks in the Port areas of Valencia and Sagunto has many advantages to improve the port area security.

This use case (UC) aims at enabling critical surveillance and inspection with USVs in maritime ports and terminals thanks to the use of 5G Rel.16 capabilities, which will allow to meet the stringent URLLC requirements related to real-time inspection and surveillance activities. Additionally, optimal coverage will be achieved by exploiting a seamless combination of 5G private and public network services. These functionalities will be combined with traditional 5G Rel.15 broadband capabilities to transmit real-time video streams with high-definition resolutions from different inland and coastal locations.

1.3.2 UC Scenario

The port of Valencia offers its facilities, experience, and support to integrate the required components into the USVs. The port will be able to monitor many remote or inaccessible locations with cameras and sensors offering the possibility to test the UC in a real environment where multiple actors interact daily. Currently

there is 5G public coverage in the water surface inside the port facilities in Sagunto and Valencia that will be directly connected to the UPV Operations Center and to the “Port of Valencia” Control Center. Available 5G modems will be procured and equipped in the USVs for enabling 5G communications. The port will be responsible of controlling the drones and asking for the licenses.

1.3.3 OC Desired Contribution

The desired contributions include (but not limited to):

- Experiments that will leverage a USV inside the port facilities of Valencia and Sagunto for surveillance and inspection applications (anchoring area inspection, infrastructure inspection, bathymetries, oil spill inspection, etc.)
- Experiments leveraging the usage of a USV in the port facilities for safe and rescue operations (early signalization of accidents, first-aid and rescue operations launching a rescue net or floating device in situations involving persons overboard (POB))
- Experiments involving storage of data, video and images in the 5G cloud for integration of additional post-processing with AI-based algorithms or specialized sonar data post-processing.
- Solutions that focus on the design of an intuitive user interface for the final user that allows obtaining updated information (e.g., the visualization of real-time USVs video streams) and making decisions more quickly.

*Note that the execution of such experiments, the OC should cover the provision of a USV as well as integration of cameras, surveillance hardware, sonar, sensors and/or other IoT devices

1.4 UC4: VR/AR-enabled dispersed command post (Norwegian Facility)

1.4.1 UC Description

At present, the efficiency of command-and-control posts within Public Protection and Disaster Relief (PPDR) organizations and their operations is directly related to their scale, due to the intricate processes that necessitate interaction among numerous individuals from diverse expertise areas. Different units spread over a large disaster area needs to be able to be fast and efficient to establish a dispersed command and control post to facilitate the operations in disaster area. The objective of this Use Case (UC) is to facilitate the segmentation and distribution of the traditional single command post model, to enhance the efficiency of the operations during disaster scenarios. Simultaneously, it also aims to mitigate any reduction in efficiency by incorporating Virtual Reality (VR) and Augmented Reality (AR) technologies to ensure adequate interaction between humans.

1.4.2 UC Scenario

The scenario should envision 20-30 people who are collaborating on PPDR operations planning and processes, dispersed over an area of 3-10 kilometres, in smaller command nodes of up to 4 people in each. The 5G technology should be the underlying carrier for a VR/AR-application, providing robust local communication with sufficient bandwidth. Very few off-the-shelf VR-goggles have 5G built-in, and it is not a requirement of the use case that the goggles themselves are 5G enabled, but the communication between the command nodes must be 5G-based. The use of VR/AR is to provide better human-to-human interaction for people who are not physically co-located, and to provide a larger working space for people who would have very restricted movement and restricted working area within their vehicle. All factors that would improve human-to-human interaction should be considered, for instance the use of proper spatial sound which is an area we know that current video-teleconferencing solutions (in the field) are a bit lacking.



<https://www.google.com/search?q=virtual+command+post&tbm=isch&ved=>

Note: The accompanying picture is only for illustrative purposes and does not reflect the real scenario.

1.4.3 OC Desired Contribution

The desired contributions include (but are not limited to):

- Experiments that utilize either 5G local breakout or a self-sufficient private 5G-network, as the underlying technology for a VR/AR-solution for a dispersed command post.
- The beneficiary must provide at least 25 VR/AR-goggles as part of the experiment.
- Documented solution with a focus on reliability and local functionality within the command post (all the command nodes) - meaning that the degree of edge-compute has been carefully considered for both the application and the 5G-infrastructure.

- Documented which data needs to be transmitted, and which can be local, to support the VR/AR-application.
- An actual VR/AR-application that supports collaboration on PPDR organizations planning and processes

2. Media

The media industry is dedicated to creating multimedia content for a wide variety of applications, such as entertainment, gaming, sports, marketing, meetings, etc. Some media outlets are even appointed to be societal critical, in particular during crises. Traditionally, 2D video and stereo audio is used for these purposes, but with the introduction of new technologies such as stereoscopic video, 360 and volumetric capture, haptics, holograms, surrounding audio, immersive content is increasingly being demanded. However, this new kind of content asks for new functionalities and requirements from the networks that will carry the media, not only for the distribution of the content but also to produce it. Immersive technologies listed before are key for the future media ecosystem.

2.1 UC1: Robust and flexible remote production (Norwegian Facility)

2.1.1 UC Description

IMAGINE-B5G will develop and make trials for audio and video to be wirelessly transmitted from the capture setups to the production setup that will be finally broadcasted to the end nodes, where it is presented to the users, leveraging on B5G networks. This UC will cover the high-quality, studio or live content production, with capture and production sites remote or same.



In addition to utilizing 5G for improving production from content captured remotely, the media sector can also cut carbon emissions. Only a small crew need to travel to capture content, and the rest of the editorial staff can control the production from a central gallery.

The technical challenge is to achieve low latency and high quality on the camera-links as the controls *need to be responsive*. The lower the latency, the higher the bitrate needs to be (due to reduced coding efficiency with short GOP); thus, uplink favouring frame structures, MIMO in TX/RX, directional beamforming and stable low RTT is preferred. High uplink capacity is also of value when videographers in the field/studio will *upload recordings to utilize AI*, thereby achieving a more efficient workflow when production editors get immediate access and are empowered with image descriptors and transcribing of audio (editable/searchable text/images related to timestamps in the media stream speeds up editing).

The most important issue to solve for broadcasters, is creating *private nomadic networks* with robust and high-capacity wireless coverage *which extend, and ideally integrate, with the public network* (PNI-NPN). It is also preferred that the capacity available will be *prioritizing the camera on air* at the time (or in focus in PPDR-

rescue) and *share available capacity* in a way that does not limit the amount of cameras as multiple angles are vital for situational awareness both when covering critical news/events and aiding PPDR-operations.

For the trials, the content will be captured wirelessly in one facility/field and the production will take place in the same facility/field or another facility/location remotely. The trials will be coordinated and conducted in coordination with NRK, a main UC stakeholder for immersive media production and distribution in Norway. NRK is the Norway’s public owned broadcaster offering online, TV, radio, and audio content [NRK]. Live and studio broadcasting is an important part of NRK’s activity, e.g., covering sports and entertainment events.

2.1.2 UC Scenario

The UC will be deployed in the Norwegian facility. Media-specific functions and applications for content production and distribution can be hosted on the central site at Fornebu, on Network on Wheels (a nomadic network) or on the edge site in Svalbard. Three RAN sites (Fornebu, Svalbard, Network on Wheels (NoW)) will be available to support the experiments.

2.1.3 OC Desired Contribution

The desired contributions include (but not limited to) innovative (immersive) media production/distribution solutions.

*The beneficiary is expected to have/procure any media hardware and software necessary for the scenario implementation and experiments, as well as relevant 5G UEs (e.g., 5G CPE or smartphones, to be coordinated with the Norway facility for the list of validated models).

2.2 UC2: Holographic communication (Spanish facility)

2.2.1 UC Description

Immersive communication technologies, such as holography and XR, are becoming increasingly popular as they provide the users with more immersive visual and auditive information with respect to traditional media. Holographic and XR technologies are considered a key element in the future 5G-Advanced and 6G ecosystem, which aims to create a more interconnected, immersive, tactile, holographic Internet, providing a seamless connection between the real and digital worlds. This UC primary objective is to explore the potential of holographic and XR technologies in pre-recorded or real-time scenarios. It will consist in performing multiple tests and trials for different verticals to understand the value and requirements of these technologies transmitted through 5GA/6G networks. To achieve this, the IMAGINE-B5G platform will leverage beyond-5G features for high data rates and low latencies. In addition, through the IMAGINE-B5G platform numerous tests and trials will be performed to understand the specific requirements and value of these immersive technologies.



2.2.2 UC Scenario

The UC will be mainly deployed in the UPV immersive laboratory premises but and it also can be deployed in other remote locations to test different scenarios, such as in the port of Valencia (e.g., for remote maintenance). Use case scenarios spanning through multiple locations are valuable, as they can demonstrate holographic and XR communications in a remote and distributed manner, achieving telepresence.

In this UC, the platform will examine the potential and requirements via relevant KPIs and KVIIs of holographic and XR technologies. By leveraging beyond-5G features, such as high data rates and low latency, the platform will enable the transmission of this augmented content. This will allow for a more immersive and interactive experience for users, whether in remote teaching, training, marketing, showrooms, concerts, talks, events, webinars, etc. By enabling users to view and interact with virtual objects and environments, holographic and XR technologies can bring a new level of realism and excitement to these industries.

2.2.3 OC Desired Contribution

The desired contributions include (but not limited to) novel solutions for holographic and XR communications and experiments exploring KPIs and optimizing the performance of immersive communications. Additionally, this OC is related but not limited to the project's PE4: Holographic and XR equipment and SW.

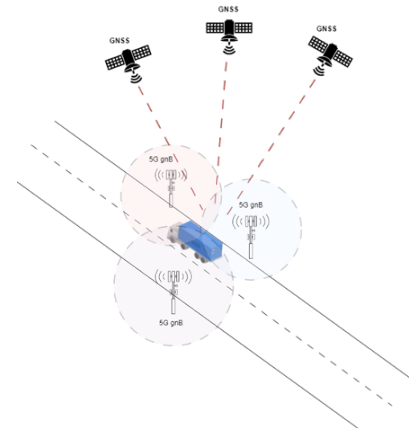
3. Transportation and Logistics

This vertical is dedicated to the organization and implementation of transportation workflows. The associated UCs must be enabled by high performance networks, but still very flexible communication architecture empowered by B5G functionalities. For example, advanced location functionalities have the potential to improve industrial environment by enabling utilization scenarios that range from flexible asset tracking and route optimization to Automatic Guided Vehicles (AGVs). Moreover, transportation scenarios are not limited to logistics, instead they are heterogenous by nature and may involve critical and non-critical communications, which imposes stringent requirements to the subjective networking system. Eventually, requirements will reach a level where the communication-related resources are not enough, requiring the combination of different technologies, empowered at large by advanced edge computing resources. As such, transportation and logistics scenarios will play a fundamental role in the validation of the IMAGINE-B5G functionalities.

3.1 UC1: Improved localization mechanisms for transportation and logistics (Portuguese Facility)

3.1.1 UC Description

This UC depicts a scenario of autonomous driving that relies on a hybrid positioning system utilizing both GNSS and 5G terrestrial base stations to provide an improved position accuracy and FTTF. This system utilizes RTK corrections and 5G signal information to achieve better accuracy. The road vehicle moves around a transportation route where the algorithms will determine its most accurate position. In principle, GNSS positioning can be accessed globally, anywhere on the Earth, without requiring any local or regional infrastructure and with great accuracy but have a not-so-great latency. On the other hand, 5G network-based positioning demonstrates good latency performance but requires indoors scenarios to achieve good accuracy in most of the cases. However, the latency of GNSS positioning can be improved with the assistance of 5G network-based positioning as a complementary trade-off between them, since on GNSS positioning we have a better accuracy while on 5G positioning we have a better latency, so joining them together we can have the better of both technologies.



3.1.2 UC Scenario

First, we will have a standalone solution using only the GNSS positioning solution and using the new 5G network to calculate the position of UE (User equipment) like a vehicle. The position calculation in 5G appears in Release 16, and there are enhancements in Release 17. To make this happen, it will be necessary to use dedicated algorithms that take the RAN information and can calculate the position of the receiver (UE). This is not enough, and the 5G core needs a new function to control the position side. That function will need to run the necessary algorithms to calculate the position. The Location Management Function (LMF) is responsible for tracking the position of the vehicle and other connected devices in the network. It is also responsible for selecting the methods that will be used to calculate the vehicle's position, such as AOA (Angle of Arrival) or others.

3.1.3 OC Desired Contribution

The desired contributions include (but not limited to) solutions that require localization information in the transport and logistics domain. Stakeholders such as logistics operator (e.g., cargo trucks), motorway/road/private operators that can deploy RSUs are encouraged to apply. Apart from the contributions described above, we are enthusiastic about investigating novel delivery techniques, mainly using employing smaller self-driving cars and UAVs to transport small packages effectively. Particularly in urban and challenging-to-reach areas, these technologies offer a frontier for improving last-mile delivery solutions by providing faster delivery times and greater accessibility. Proposals that use these vehicles are welcome if they include information on integrating, operating, and coordinating them with the current transportation and logistical networks and be kin to integrated hybrid position methods.

The use of Open-RAN technologies offered by the Portuguese facility (see IMAGINE-B5G Facility Description) is highly encouraged and will be considered a plus in the selection criteria.

3.2 UC2: Telepresence-aided Maintenance (Spanish Facility)

3.2.1 UC Description

The reparation or maintenance of machines in logistic environments is a highly expensive task, due to the necessity of sending experts to physically check the equipment. If the asset to repair is very specific, it may require experts from other countries to travel long distances, with the consequent carbon footprint. However, a minimally qualified engineer may also perform the task if he receives the proper assessment from a remote expert. By using immersive technologies such as telepresence and haptics, boosted by the capabilities of B5G networks, the remote expert would be able to provide the required instructions to the field engineer in real-time. The field engineer will place a robot or an AGV equipped with a 360°/PTZ camera next to the damaged machine, allowing the remote expert to connect via 5G to visualize the video on a VR/AR HMD, controlling the viewing perspective via the HMD's IMUs. Moreover, the field engineer can be equipped with other VR/AR HMD to visualize instructions from the remote expert, who shows the action to perform using haptic gloves. The introduction of immersive communication into the workflow will be assessed and compared with traditional methods. Different slices will be available so that multi-user deployments can be enabled based on GBR (Guaranteed Bit Rate) profiles for ensuring the required minimum quality in terms of assigned bandwidth for every single UE taking place in the UC.



3.2.2 UC Scenario

The remote collaboration for maintenance or reparation of logistic machinery with audio-visual feedback will be performed either in the Valencia Port or in the Rural Site. A field engineer located there will be supported by a remote expert located in the UPV Immersive Lab.

UPV's Immersive lab is an experimental facility that supports telepresence, AR/XR, volumetric/360° capture, haptics, and holographic technologies. If needed, the lab's equipment will be available for the VE, including chromas, LEDWall, and VR/AR headsets; volumetric and 360° video capture; haptic gloves and suits; and immersive cockpits for remote driving.

3.2.3 OC Desired Contribution

The desired contributions include (but not limited to) immersive telepresence solutions for maintenance of machines in logistic environments.

*The beneficiary should have experience in robotics, haptics and/or VR, to integrate the necessary components that guarantee a full view and feedback of the machine to the remote expert, as well as a full view and feedback of the instructions to the field engineer.

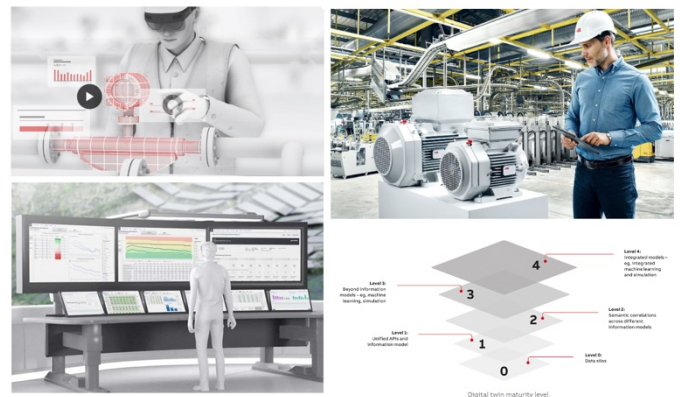
4. Industry 4.0

The industry vertical is dedicated to the production of goods, with the help of equipment, machines, tools, etc. Industries of the future aim to be benefited by emerging technologies that can enhance the production processes. These processes will be increasingly smart, connected, and automated and will allow for a more efficient, cost effective, faster, and greener production industry. The transformation envisioned for this vertical is focused on the smart automation and optimization of the production processes. This will be thanks to the advanced mobile network technologies, IoT, big data analytics, ML, AI, and robotics.

4.1 UC 1: Industrial Infrastructure Automation (Norwegian Facility)

4.1.1 UC Description

The aim of this UC is to empower industries with B5G technologies to facilitate the prediction of problems, increase production, flexibility, safety, mobility, scalability, reduce downtime, maintenance intervention and costs, thus improving manufacturing competitiveness. In this context, IMAGINE-B5G advanced features will be leveraged to explore novel UCs on the process plants such as industrial control systems to support realtime communication between sensors, actuators and controllers, equipment tracking via precise positioning, close loop control for process automation, network-based AGV control, analytics for predictive maintenance, augmented reality for repairs, digital twins with Realtime feedback, among others. Moreover, leveraging edge computing capabilities and the integration of such technologies with factories' Manufacturing Execution System (MES) and production line will enable a low latency closed control loop targeting diverse production aspects including orders, machinery status and asset location. This UC will then leverage B5G technologies to provide very low latency and advanced edge based IoT solutions, while satisfying industry isolation requirements.



4.1.2 UC Scenario

The UC will be deployed in the Norwegian facility. Industrial-specific functions and applications can be hosted either on the central site at Fornebu, or on the edge site in Svalbard. Two RAN sites (Fornebu, Svalbard) will be available to support the experiments. An additional private 5G network at ABB premises can be foreseen for purposes of use case execution (ABB is a main stakeholder of the Norwegian facility).

4.1.3 UC Desired Contribution

The desired contributions include (but not limited to):

- Advanced edge based IoT solutions for running process applications in the field.
- Extracting stranded performance and health data from field equipment utilizing private 5G network.
- Networks convergence for running E2E OT & IT applications over the common private 5G network.

- Merging virtual control system with private 5G network.
- Framework or toolkit for real time private 5G network performance assessment.
- AR/VR industrial applications for repairs, digital twins, predictive maintenance, and improved safety.

*The beneficiary is expected to have/procure any industrial hardware and software necessary for the scenario implementation and experiments, as well as relevant 5G UEs (e.g., 5G CPE or smartphones, to be coordinated with the Norway facility for the list of validated models).

5. Education

The education vertical is dedicated to the transmission of knowledge. Education practices are evolving nowadays since information technologies are being introduced in this field. Rethinking education in the digital age should become a central matter for today’s society: first, remote teaching should be allowed to facilitate the attendance of students who cannot be physically present in the classrooms and second, they should enhance improve the current means of knowledge transmission to enhance understanding and retention. During the COVID-19 pandemic, online classes and digital media resources became very common but were unable to replace physical presence for hands-on education, group work and social interactions. Seeing the benefits of online education, further steps forward must explore ways to exploit them. New technologies like immersive telepresence, holograms, XR and haptics are key to the evolution of education.

5.1 UC1: Immersive remote education (Spanish, Norwegian Facilities)

5.1.1 UC Description

As information technologies are being introduced in this field, education practices and opportunities are rapidly evolving worldwide. The primary challenge that this UC will aim to address is remote/distance teaching to facilitate the participation of both teachers and students who cannot be physically present in the classroom. On the other hand, certain skills such as lab work and hands-on experiences, require extra tactile stimulation to produce the same level of learning online as in real life and real-time. Learning such skills or visualizing abstract concepts in an interactive way can benefit from the integration of AR and VR into immersive classrooms. Further, haptic responses that are possible through tactile internet, and can reproduce the feeling, touch, or motion of interacting directly with a physical object, could introduce tactile forms of learning to a classroom through traditional video conferencing platforms, thus enriching the interactions. 5G/B5G can help in this direction as it will improve personalization by creating intelligent systems, using Artificial Intelligence, to understand the unique needs of each student and create targeted learning pathways. To achieve a highly immersive and interactive experience between the two ends (e.g., by using VR Robotics, Figure 16), it will exploit B5G features and KPIS, mainly focusing on low latency and network reliability aspects, as well as advanced data analytics and AI algorithms to perform predictive analyses (e.g., latency) and enhance the end-to-end performance. In addition, it will explore solutions towards improving the current means of knowledge transmission from a learning retention perspective.



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5.1.2 UC Scenario

This UC will be deployed in two different facilities: UiO's SIN-Lab is a playground for immersive networking research. SIN-Lab consists of state-of-the-art cameras and LIDARs, such as tracking camera, Velodyne LIDAR, Intel RealSense LIDAR(L515), Azure Kinect, and several headsets for VR and AR. In addition, the lab is equipped with a Shadow Hand and a UR10e arm. For the haptics equipment, it has Gloves and Suit Full Body.

UPV's Immersive lab is an experimental facility that supports telepresence, AR/XR, volumetric/360° capture, haptics, and holographic technologies. To bring these capabilities, the lab provides multiple equipment for each type of communication: chromas suited with specific processing hardware and software from Brainstorm multimedia, Alfalite LEDWall, and several VR/AR headsets (e.g. Meta Quest Pro) for telepresence; Evercoast volumetric video capture, YBVR 360° video capture; several haptic gloves (e.g. bHaptics TactGlove) and suits (e.g. bHaptics TactSuit X40, OWO Vest) for haptic feedback and control of UR5e arm; and immersive cockpits for remote driving of AGVs/AMRs (e.g. Robotnik Summit XL) equipped with RoboSense LiDAR and 360° cameras.

5.1.3 OC Desired Contribution

The desired contributions include (but not limited to) novel solutions for VR/AR/XR educational environments, intelligent personal assistants, and experiments exploring and optimizing the performance limits of immersive remote education.

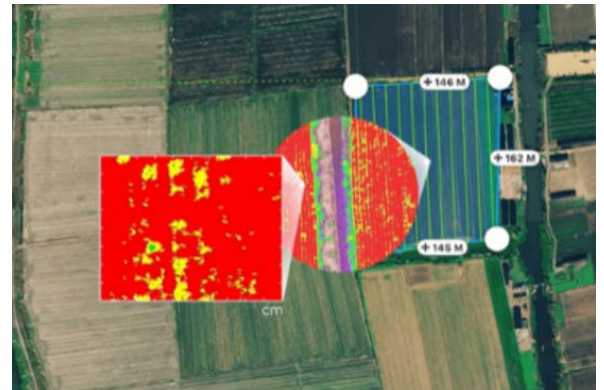
6. Smart Agriculture & Forestry

The agriculture vertical is focused on the cultivation of plants and livestock. The world of agriculture is changing towards an unprecedented digitalization and automation. The use of autonomous vehicles for preparation of the soil, sowing, harvesting, etc. is common, but much more enhancements can come into play with the introduction of new technologies such as advanced mobile networks, vehicles, imaging techniques, AI, ML, immersive communications, etc. These new technologies can be used for infestation detection, fertilization, fields performance analysis via imaging, teleoperation of machinery and vehicles, surveillance, weather prediction, etc.

6.1 UC1: Smart agriculture in rural areas (Spanish Facility)

6.1.1 UC Description

IMAGINE-B5G aims to improve the agricultural efficiency helping to increase the performance of the cultivation providing accurate and real time information that can be used for agro-management decisions, thus reducing the environmental impact of pesticides or saving water. To achieve this, the use of Agricultural AGVs and the use of new sensors with multispectral cameras deployed in sensor networks will be supported. The use of these new devices in 5G networks will support the remote visual monitoring of remote or difficult-to-access crops, also the phenological monitoring of large areas of agricultural crops must be automated. It is very relevant to facilitate the monitoring of phenological changes in crops with advances or delays in the start of activity.



6.1.2 UC Scenario

The Matanza 5G experimental site is ideal for the experimentation of agricultural isolated areas using private 5G infrastructure for the automation of industrial or agricultural tasks. Currently the experimental site is logging data from sensors deployed in the coverage area of the 5G radio. The information of the sensors is updated in real time, including electrical energy devices consumption, electrical energy generated by wind, electrical energy generated by sun, electrical energy consumed by servers and radio baseband. The site will support also the NaC and CAPIF APIs for third parties to integrate easily the 5G connectivity and features, like the provision of Slices and QoS 5Qis profiles that can be updated on-the-go as the connected devices changes dynamically the operations requirements.

6.1.3 UC Desired Contribution

The desired contributions include (but not limited to):

- Solutions based on advanced video processing automated tasks that help the phenological monitoring of large areas of agricultural crops.
- Solutions based on high temporal resolution imaging for estimating quantitative and qualitative parameters in phenological monitoring of large areas in agricultural crops.
- Solutions based on a proximal multispectral sensor network for ripeness monitoring, incorporating artificial intelligence.
- Solutions for AGV missions, the implementation of some AI algorithms for improving the treatment of plants, the implementation of programmed multispectral drone missions, the generation of detailed report on scalability of the proposed solutions and the cost of energy for each mission.
- Autonomous AGV-based monitoring solutions, integrating cameras for live, high-definition crop surveillance accessible from anywhere via 5G, with no latency, specifically for technicians, agronomists, and experts.

- Integration of the AGVs and sensors network with the NaC & CAPIF APIs for the automation of the use of the 5G network facilities including: provision of SIMs, configurations of profiles and storage of Applications KPIs storage.
- Experimentation in large areas of agricultural crops in Spain where there is 5G public network coverage.

*Note that the execution of such experiments will require the procurement of the agricultural AGVs as well as integration of cameras, sensors network, and/or other IoT devices

7. eHealth

The healthcare vertical is dedicated to maintaining or restore physical, mental, or emotional well-being. The healthcare of the future can be greatly enhanced with the introduction of new technologies. The future healthcare systems will provide remote assistance to people in their own home by means of remote monitoring devices, immersive experiences for cognitive rehabilitation, or robots that can provide home care to people with special needs. Both action and feedback are essential and time-critical to perform a medical activity, safely and in a natural manner. Such scenarios require, in general, fine motion control and low latency. The combination of the eMBB for increased bandwidth and URLLC can prove difficult to achieve. Additionally, in medical applications, the interface between the doctor and the patient must be seamless for a correct treatment. This interface supposes a great challenge for development and integration.

7.1 UC1: Enhanced care facilities (Portuguese Facility)

7.1.1 UC Description

World Health Organization (WHO) defined eHealth as “the cost-effective and secure use of Information and Communications Technologies (ICT) in support of health and health-related fields, including healthcare services, health surveillance, health literature, health education, knowledge and research” [UC5-IT-01]. So, the inclusion of ICT technologies can bring a revolution to the health system, increasing access, efficiency, and quality of care, while providing high control to the patient.

5G and beyond technologies are expected to support novel eHealth UCs, which will significantly improve the health system. This includes the usage of smart sensors to monitor the vital signs of patients while having the flexibility and mobility of wireless communications; improving hospital processes with logistics tracking; early connecting the patient to hospital personnel during emergencies; and helping in the processing of complex diagnoses.



Imagine-B5G will aim at exploring eHealth UCs in the context of enhancing the operations of care facilities to provide improved health services. The goal is twofold: on the one hand better understanding the challenges in leveraging advanced 5G features; and on the other to increase the awareness of care facilities of the potential solutions to be achievable through the adoption of 5G technologies as part of their process of digitalization.

This UC focuses on enhancing care facilities by means of advanced 5G technologies to improve the overall quality of the health system and its delivery to patients. To this end, the UC considers three different stages

of the health system: (i) the proactive/continuous care; (ii) the care in emergency situations; and (iii) improved health facility logistics.

7.1.2 UC Scenario

The Portuguese facility has available different kind of end-user devices including 5G CPEs, Mobile Phones and 5G Communication Modules. These devices could be used to access the services deployed at the edge of the network. By having different 5g Core and Radio solutions scenarios involving different domains PNI-NPN could be realized in the facility.

7.1.3 OC Desired Contribution

The desired contributions include (but not limited to) experiments aiming to explore advanced 5G technologies to enhance care processes such as proactive/continuous care, the care in emergency situations; and improved health facility logistics. Stakeholders in the larger eHealth ecosystem (e.g., a care facility, an eHealth solution provider) are encouraged to apply.

*The beneficiary is expected to have/procure any medical hardware and software necessary for the scenario implementation and experiments.

7.2 UC2: Remote care with immersive media facilities (Norwegian Facility)

7.2.1 UC Description

The aim of this UC is to develop and make real-world trials regarding remote care by providing immersive equipment (e.g., MR/AR/VR headsets, controllers, 3D cameras) for seamless interactions between a remote medical expert and the local doctor/technician or the patient that needs specialized consultation, diagnosis, monitoring, or treatment. Such interactions are considered mission critical, however, do not imply dedicated applications for the purpose. For this UC to work, future B5G technologies will be leveraged to provide high-quality immersive media with very low latency between the remote and local sites.

7.2.2 UC Scenario

The UC will be deployed in the Norwegian facility. eHealth-specific functions and applications can be hosted either on the central site at Fornebu, or on the edge site in Svalbard. Two RAN sites (Fornebu, Svalbard) will be available to support the experiments.

7.2.3 OC Desired Contribution

The desired contributions include (but not limited to) the implementation of innovative (immersive) remote care solutions and performance studies.

*The beneficiary is expected to have/procure any medical hardware and software necessary for the scenario implementation and experiments, as well as relevant 5G UEs (e.g., 5G CPE or smartphones, to be coordinated with the Norway facility for the list of validated models).