5G ExPerimentation Infrastructure hosting Cloud-nativE Netapps for public proTection and disaster RElief

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D1.1: 5G-EPICENTRE experimentation scenarios preliminary version

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List of abbreviations

Abbreviation	Definition
5GC	5G Core
AF	Application Function
AI	Artificial Intelligence
API	Application Programming Interface
APK	Android Package
APP	Application
AR	Augmented Reality
BES	Back-End Server
BK	Bag pack Kit
CAPIF	Common API Framework
CAS	Controlling Application Server
CC(C)	Command and Control (Centre)
C-CSCF	Controlling-Call Session Control Function
CMS	Configuration Management Server
CNF	Cloud-Native Network Function
CPU	Central Processing Unit
CU	Centralized Unit
DBS	DataBase Server
DMR	Digital Mobile Radio
DNS	Domain Name System
DU	Distributed Unit

E2E	End to End
ECC	Emergency Control Centre
ECG	Electrocardiogram
eMBB	enhanced Mobile BroadBand
FES	Front-End Server
FP	False Positive
GMS	Group Management Server
gNB	next Generation NodeB
GPS	Global Positioning System
GPU	Graphic Processing Unit
GUI	Graphical User Interface
HD	High Definition
HMD	Head-Mounted Display
HSS	Home Subscriber Server
HTTP	HyperText Transfer Protocol
I-CSCF	IMS-Call Session Control Function
IdMS	Identity Management Server
IMS	Internet Media Services
IP	Internet Protocol
IR	Infra-Red
ITU	International Telecommunication Union
KMS	Key Management Server
KPI	Key Performance Indicator
LB	Load Balancer

LD	Low Definition
LS	Local System
MB	Message Broker
MCData	Mission Critical Data
MCPTT	Mission Critical Push-To-Talk
MCS	Mission Critical System
MCVideo	Mission Critical Video
MEC	Multi-Access Edge Computing
ML	Machine Learning
mMTC	massive Machine Type Communications
MOS	Mean Opinion Score
MS	Multimedia Server
NAT	Network Address Translation
NEF	Network Exposure Function
NFVI	Network Function Virtualization Infrastructure
NRF	Network Repository Function
NTP	Network Time Protocol
OAM	Orchestration And Management
OS	Operating System
P2P	Peer to Peer
PAS	Participating Application Server
PCF	Policy Charging Function
P-CSCF	Proxy-Call Session Control Function
PIN	Personal Identification Number

PMR	Professional/Private Mobile Radio
PoP	Point of Presence
PPDR	Public Protection and Disaster Relief
QoE	Quality of Experience
RAN	Radio Access Network
RTC	Real Time Clock
RU	Radio Unit
SD	Standard Definition
SDK	Software Development Kit
SIP	Session Initiation Protocol
SpO2	Saturation Pulse O_2
TETRA	Trans European Trunked RAdio
TP	True Positive
TSS	Time Series Server
TURN	Traversal Using Relay NAT
UC	Use Case
UDP	User Datagram Protocol
UE	User Equipment
UML	Unified Modelling Language
URLL	Ultra-Reliable Low Latency Communications
VDU	Virtual Deployment Unit
VNF	Virtual Network Function
VR	Virtual Reality
WAN	Wide Area Network

Executive summary

The current deliverable “D1.1: 5G-EPICENTRE experimentation scenarios preliminary version” envisions eight experiments as use cases for the 5G-EPICENTRE platform, led by partners of the consortium, which will be carried out during the project lifetime on the proposed experimentation facilities. According to the course of the project, an updated version of this document will be delivered in M22.

The experiments ensemble is oriented towards Public Protection and Disaster Relief (PPDR) scenarios, based in the ITU´s 5G enabling service types (eMBB, mMTC, URLL), in which cross-discipline communications such as law enforcement, emergency medical services, command & control and disaster response are key to first responders present in the field, as well as dispatchers and operators stationed in emergency control centres for emergency situations. By means of a cloud-native and cross-testbed 5G platform, *i.e.*, 5G-EPICENTRE facilities, whose architecture is further elaborated in deliverable “D1.3: Experimentation requirements and architecture specification preliminary version”, the experimentation phases will be posteriorly executed and evaluated given the fixed objectives, requirements and defined KPIs for each of them.

The document structure is divided into a first brief approach on 5G-EPICENTRE’s pillars, open and interoperable cloud-native and cross-testbed 5G platform servicing PPDR applications testing, followed by the description of each one of the eight experiment scenarios defining the: experimentation phases, deployment scenarios, main building blocks and targeted requirements and KPIs. Finally, the conclusions section regroups the common points and the shared objectives of each one of the experiments.

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1 Introduction

The aim of the current document is to give a detailed but preliminary definition of the 5G-EPICENTRE PPDR experimentation scenarios. It will help to settle the basis for a shared vision of experimentation activities, to facilitate the overall understanding and to serve as a point of departure for the definition of 5G-EPICENTRE platform requirements extracted from the set of use cases formulated. It will also serve in the development activities of all necessary network functions within the 5G-EPICENTRE framework.

This deliverable, associated with task "T1.1: Pilot experiments formulation", seeks the definition of a commonly agreed set of experiment scenarios which will be playing the role of use cases. The goal of the task is to describe the use cases, define the network services that need to be instantiated to deploy them on the 5G-EPICENTRE platform and the resources required for the experiment. This last point addresses, among others, the eventual utilisation of several testbeds for the experimentation accomplishment which has not been yet defined at this early stage of the project and will be included in the final version of this document in M22.

In the pursuit of answering the requirements of the task itself and looking both for an internal, among the partner's consortium, as well as an external comprehension of the experimentation activities being executed, the following sections have been defined in the deliverable.

First, Section 2 gives an introductory brief vision and context on the PPDR applications and the 5G-EPICENTRE's platform. Section 3 presents an overall description of the experiments provided by the use case leaders. It is enriched by the different deployment scenarios, the main building blocks composing the experiment, as well as the needed requirements. Also, a list of network services to be developed and the expected KPIs are detailed. Finally, the conclusions section brings the summarised results and proposes next steps for the final document contents completion.

1.1 Mapping of project's outputs

Table 1: Adherence to 5G-EPICENTRE's GA Deliverable & Tasks Descriptions.

5G-EPICENTRE Task	Respective Document Chapters	Justification
T1.1: Pilot Experiments formulation *"The goal of this Task is for consortium partners acting as experimenters to define a commonly agreed set of experiment scenarios, […]"*	Section 2 – 5G-EPICENTRE approach Section 3 – 5G-EPICENTRE experimentation	In these sections the eight chosen experimentation scenarios context is explained, a detailed mapping regarding the PPDR disciplines is addressed and a list of the partners responsible for each scenario is presented.
T1.1: Pilot Experiments formulation *"[…] the goal of this Task is to define, for each case: i) a thorough experiment description, relying on a formal approach and standard […], along clear definition of what constitutes a successful outcome; ii) indication of network services that should be instantiated in*	Section 3 – 5G-EPICENTRE experimentation	This section contains: *Experiment's description:* included in each of the first sections for each experiment scenarios descriptions of the current document. *Network services that should be instantiated*: included in each of the six sections for each

order for the experiment to be deployed on top of the 5G-EPICENTRE infrastructure; and iii) foreseen resources required for the experiment, including the utilization of multiple testbeds."		experiment scenarios descriptions of the current document. *Resources required for the experiment, multiple testbed utilization:* to be addressed in the final version of the current document.

2 5G-EPICENTRE approach

Mission Critical and Business Critical communication customers are starting a migration from legacy 2G Professional Mobile Radio (PMR) networks such as TETRA, TETRAPOL, DMR and P25 to broadband (4G/5G) enabled multimedia smart services. Among others, this means that we will see more and more new broadband Apps and devices from existing and new PPDR players which will need to be tested and experimented against 5G before going to the market, to ensure the full benefits of 5G capabilities, especially performance, are realised, and to demonstrate added value for end users.

The 5G-EPICENTRE project´s goal is to facilitate PPDR related European SMEs and developers to conduct diverse experimentations of their products and applications, by means of an open-standard, innovative and interoperable end-to-end 5G experimentation ecosystem, focused on the requirements to give response to diverse PPDR operational scenarios services.

The project´s platform will be based on an open Service Oriented Architecture and will accommodate open access to 5G networks' resources, acting this way as an open-source repository for PPDR 5G networks.

This is the focus of the 5G-EPICENTRE project as more specifically reflected in Objective 1 "To build an end-to-end 5G experimentation platform specifically tailored to the needs of the public safety and emergency response market players" and Objective 3 "To cultivate a '5G Experiments as a Service' model, which will enable developers and SMEs to experiment with PPDR applications in parameterised, easily repeatable, and shareable environments.".

The 5G-EPICENTRE project has targeted a wide range of experiment scenarios to represent the variety of end-user PPDR verticals, such as police forces, firefighters, ambulance services, civil defence and rescue services, and use cases which may range from routine operations to large planned or unplanned events or crisis situations, exercising the main 5G enhanced capabilities: enhanced Mobile BroadBand (eMBB), Ultra Reliable Low Latency Communications (URLLC), and massive Machine Type Communications (mMTC). This is reflected in the selection of the first-party experimentation activities as depicted in Figure 1.

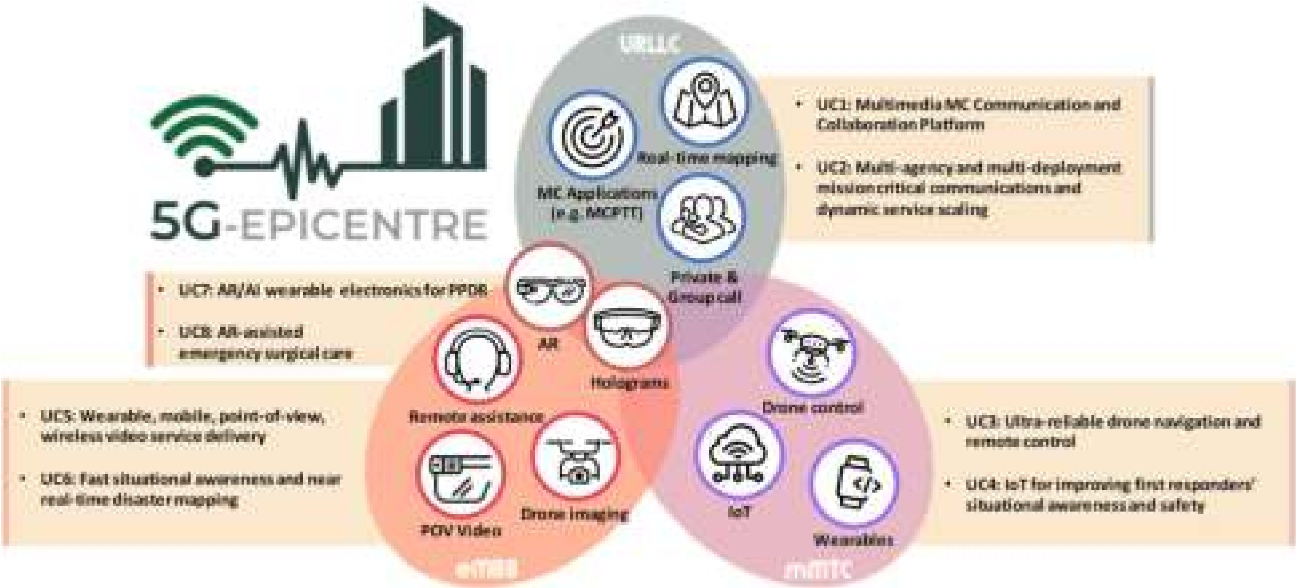

Figure 1: 5G-EPICENTRE first-party experiments mapping to ITU's 5G enabling service types.

The eight selected use cases are mapped to a federation of four already existing heterogeneous and geographically dispersed 5G testbeds: 5G VINNI[1] Aveiro, CTTC 5G testbed in Barcelona, 5G Berlin[2] and 5GENESIS[3] Málaga; conforming the 5G-EPICENTRE platform.

In addition to the selection of the above-mentioned use cases, the 5G-EPICENTRE platform will be open to third-party experimenters in the last technical iteration stage of the project. It will allow them to experiment on top of the 5G-EPICENTRE infrastructure by designing and deploying innovative mission-critical applications for first responders during 5G-themed hackathons.

In order to serve the purpose of the requirements of the first-party experimentation use cases, the following section contains a description of the selected PPDR experiments, use cases' overall architecture, requirements and KPIs that will ultimately conclude in a validation process over the 5G-EPICENTRE platform.

[1] https://www.5g-vinni.eu/

[2] https://5g-berlin.de/en/

[3] https://5genesis.eu/

3 5G-EPICENTRE experiments

3.1 Use cases descriptions

The use case's presentation and description that follow in the subsequent sections is summarised in Table 2 below.

Table 2: Use cases mapping.

Use case number	Title	PPDR disciplines addressed	5G Service Types	Experimenter partner
UC1	**Multimedia MC Communication and Collaboration Platform**	• Law enforcement • Emergency Medical Services • Command & Control	URLLC	AIRBUS
UC2	**Multi-agency and multi-deployment mission critical communications and dynamic service scaling**	• Command & Control	URLLC	nemergent
UC3	**Ultra-reliable drone navigation and remote control**	• Disaster response • Command & Control	mMTC	Fraunhofer
UC4	**IoT for improving first responders' situational awareness and safety**	• Command & Control	mMTC	ONE SOURCE
UC5	**Wearable, mobile, point-of-view, wireless video service delivery**	• Emergency Medical Services	eMBB	RedZinc
UC6	**Fast situational awareness and near real-time disaster mapping**	• Disaster response • Emergency Control Centres	eMBB	Opto Precision
UC7	**AR and AI wearable electronics for PPDR**	• Law enforcement • Emergency Medical Services	eMBB URLLC	youbiquo
UC8	**AR-assisted emergency surgical care**	• Emergency Medical Services	eMBB URLLC	ORama VR

3.2 UC1: Multimedia MC Communication and Collaboration Platform

3.2.1 Use case description

UC1 (Multimedia MC Communication and Collaboration Platform) will support the following sub use cases:

- PPDR mobile users and dispatchers will be able to experiment with Mission Critical Services (MCS) applications enabling the following functionalities:
  - Group and individual voice calls.
  - Group and individual messaging.
  - Group and individual multimedia messaging.
  - Individual video calls.
  - Emergency calls.
  - Location and map services.
- Applications developers will be able to integrate their solution with the Airbus MCS enabling the same functionalities as listed above. This will be done via Application Programming Interface (API) methods.
- Video device providers (such as fixed, wearable, and drone cameras) will be able to send video streams coming from their devices to MCS clients (both mobile and dispatcher). This will be done either:
  - via network protocols for establishing and controlling media sessions and for delivering media
  - or via MCS APIs
- PPDR mobile users and dispatchers will be able to experiment with Mission Management mobile and desktop applications enabling the tactical situation information exchange (resources detail and positions, drawing, documents and instant messages).

As shown in Figure 2– the following elements will be deployed:

- Airbus MCS Server: the MCS Server provides the control and management of voice, video and data communications for both private and group calls according to the 3GPP standard. It includes the MCS Controlling Server, the MCS Participating Server, the API gateway, the Identity Management Server (IdMS), the Key Management Server (KMS), the Group Management Server (GMS), the Configuration Management Server (CMS), the Session Initiation Protocol (SIP) Core, the HyperText Transfer Protocol (HTTP) Proxy and the MCS Configuration Server.
- Map Server for delivering map static tiles in real-time to MCS mobile user and dispatcher applications.
- Mission Management Application Server.
- Smartphone and tablet devices.
- MCS Clients.
- Mission Management Application Clients.
- Mobile PPDR users.
- 5G network elements.
- External video sources such as Wearable Camera, Drone Cameras and Fixed Cameras.
- External Applications and Control Room Applications.
- PPDR Dispatchers /Control room application users.
- Domain Name System (DNS) Server: it is used by MCS servers to resolve IP addresses of hosts.
- Network Time Protocol (NTP) Server: it is used for time synchronization of MCS server components.

3.2.2 Experiment phases or deployment scenarios

The following experiment phases and associated results are expected:

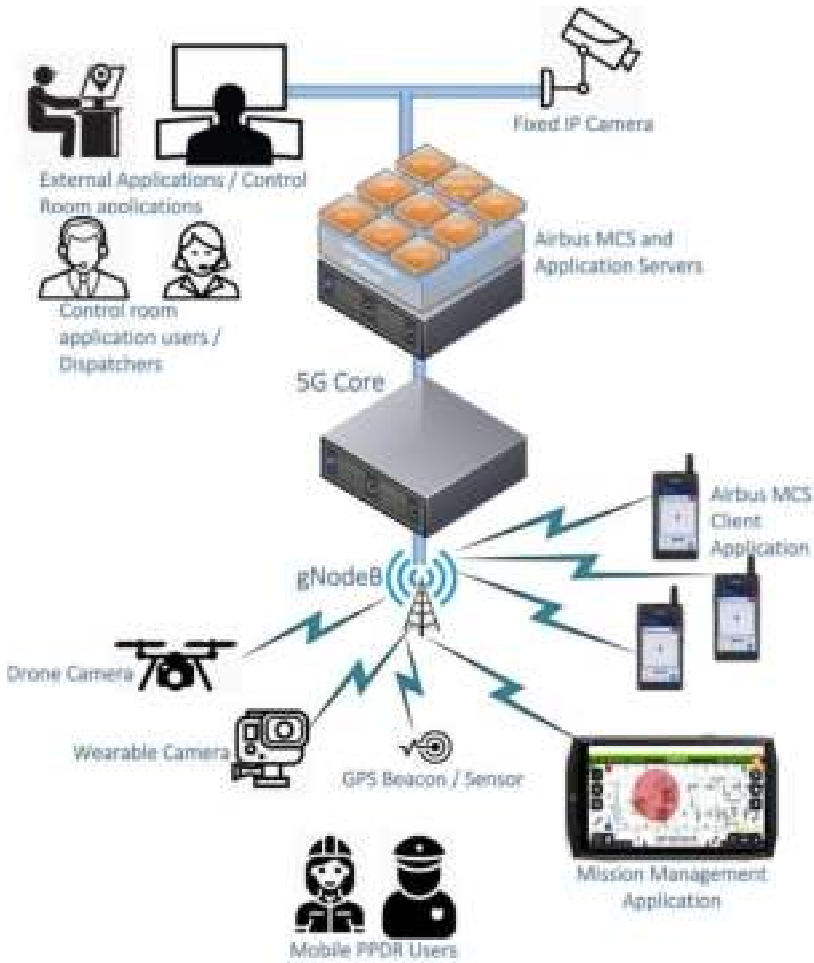

Figure 2: UC1 deployment overview.

- Successful demonstration of Mission Critical Services: Mission Critical Push-To-Talk (MCPTT), Mission Critical Video (MCVideo) and Mission Critical Data (MCData) communication between users, dispatchers and external application users with measurements of low end-to-end latency as given in the corresponding KPI requirement below.
- Successful demonstration of real-time MCVideo communication and video streaming encoded with high-resolution and high bitrate and measurements of the throughput and reliability in order to validate the KPIs listed in the UC1 requirements.
- Measurement of file transfer as part of the MCData service in order to validate the throughput KPI.
- Location accuracy of one meter as part of KPIs will be verified using the MCS and/or Mission Management applications.
- Innovative functionalities and services will be developed and demonstrated during the project lifetime with the integration of devices (such as external video systems) and applications via the available APIs and interfaces. This will be achieved by interfacing solutions coming from both first-party (5G-EPICENTRE consortium members) and third-party experimenters.

Several sub use cases are supported as part of UC1:

- Mobile PPDR users, dispatchers and external application users will be able to communicate using the Airbus MCS Server and MCS Clients, enabling group and individual audio/video/emergency calls and messaging.

- Mobile PPDR users and dispatchers will be able to collaborate using the Mission Management Application by exchanging resources details and positions, drawing, documents, and instant messages.
- Mobile PPDR users and dispatchers will be able to update their location and receive and view the location of other PPDR users.
- Mobile PPDR users, dispatchers and external application users will be able to receive the video flows from external video sources.

3.2.3 Use case main building blocks

This section explains the UC1 main building blocks and describes the system elements, the interactions between the system elements and the interfaces.

- Mobile PPDR users, dispatchers and external application users will be able to communicate using the Airbus MCS Server and MCS Clients, enabling group and individual audio/video/emergency calls and messaging:
  As shown in Figure 3 – the following steps will be performed:
  1. The PPDR Mobile User uses the Airbus MCS Mobile Client to access to the MCS functionalities.
  2. The Airbus MCS Mobile Client authenticates with the Airbus MCS Server.
  3. The PPDR Dispatcher User uses the Airbus MCS Dispatcher Client to access to the MCS functionalities.
  4. The Airbus MCS Dispatcher Client authenticates with the Airbus MCS Server.
  5. The External Application User uses the External Application to access the MCS functionalities.
  6. The External Application authenticates with the Airbus MCS Server through the Airbus MCS API Gateway.
  7. The PPDR Mobile User, PPDR Dispatcher and External Application User are able to communicate using the following services:
     a. Group and individual voice calls.
     b. Group and individual messaging.
     c. Group and individual multimedia messaging.
     d. Individual video calls.
     e. Emergency calls.

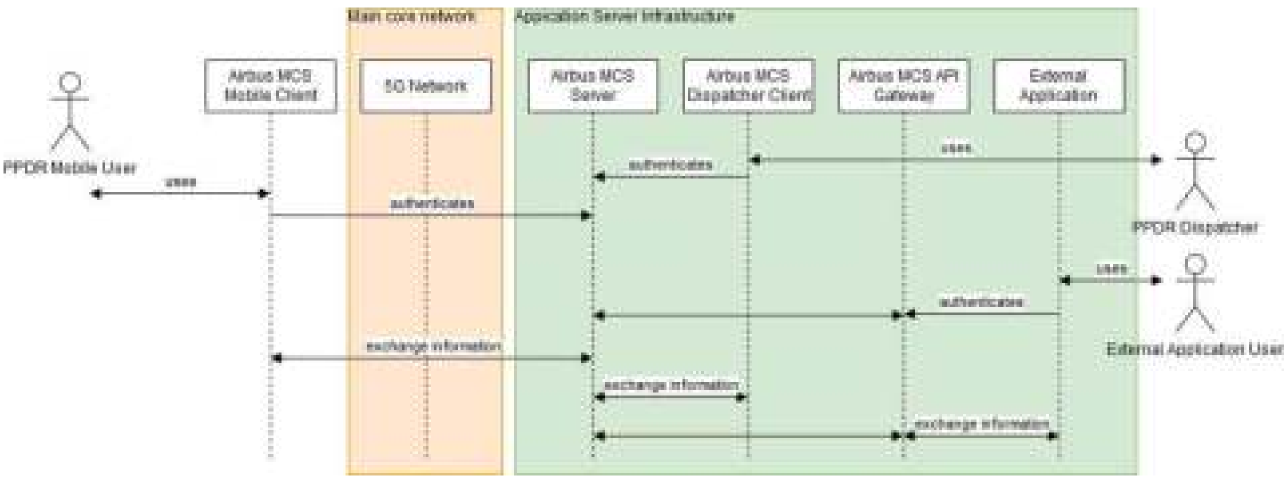

Figure 3: UC1 UML diagram 1.

- Mobile PPDR users and dispatchers will be able to collaborate using the Mission Management Application by exchanging resources detail and positions, drawing, documents, and instant messages:
  As shown in Figure 4– the following steps will be performed:

  1. The PPDR Mobile and Fixed Users are using the Mission Management Application either as a mobile or a dispatcher user.
  2. The PPDR Mobile and Fixed Users are able to authenticate and collaborate by exchanging information such as resources, location drawing, document, media files, *etc*.
  3. The PPDR Mobile and Fixed Users information is synchronised through the Mission Management Server.

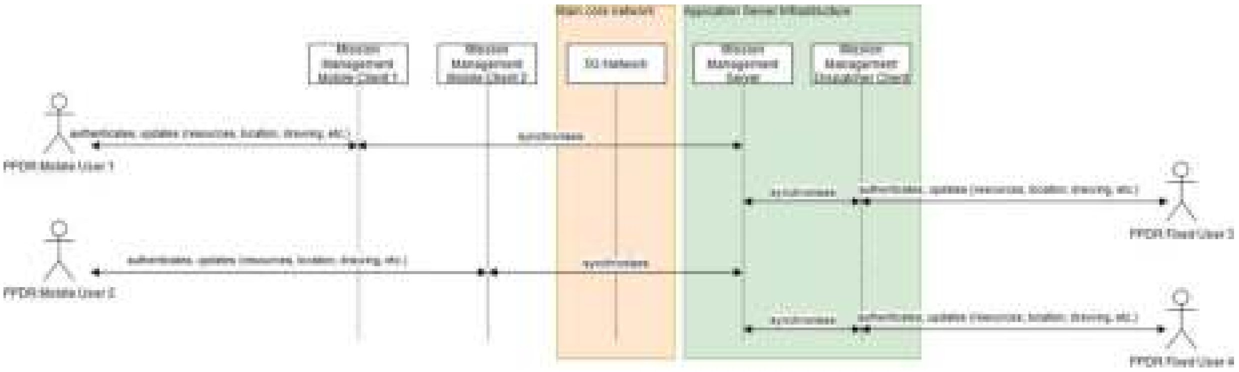

Figure 4: UC1 UML diagram 2.

- Mobile PPDR users and dispatchers will be able to update their location and receive and view the location of other PPDR users:
  As shown in Figure 5– the following steps will be performed:

  1. The PPDR Mobile User uses the Airbus MCS Mobile Client to access to the MCS functionalities.
  2. The Airbus MCS Mobile Client authenticates with the Airbus MCS Server.
  3. The PPDR Dispatcher User uses the Airbus MCS Dispatcher Client to access the MCS functionalities.
  4. The Airbus MCS Dispatcher Client authenticates with the Airbus MCS Server.
  5. The External Application User uses the External Application to access the MCS functionalities.
  6. The External Application authenticates with the Airbus MCS Server through the Airbus MCS API Gateway.
  7. The Airbus MCS Mobile Client updates its location periodically.
  8. The Airbus MCS Dispatcher Client receives the Airbus MCS Mobile Client’s location.
  9. The External Application uses the Airbus MCS API Gateway methods to request the location of the Airbus MCS Mobile Client.
  10. The External Application receives the Airbus MCS Mobile Client’s location.
  11. The External Application uses the Airbus MCS API Gateway methods to update its location.
  12. The External Application’s location is received by the Airbus MCS Mobile Client and the Airbus MCS Dispatcher Client.

- Mobile PPDR users, dispatchers and external application users will be able to receive the video flows from external video sources:
  As shown in Figure 6– the following steps will be performed:

  1. The PPDR Mobile User uses the Airbus MCS Mobile Client to access the MCS functionalities.
  2. The Airbus MCS Mobile Client authenticates with the Airbus MCS Server.
  3. The PPDR Dispatcher User uses the Airbus MCS Dispatcher Client to access the MCS functionalities.

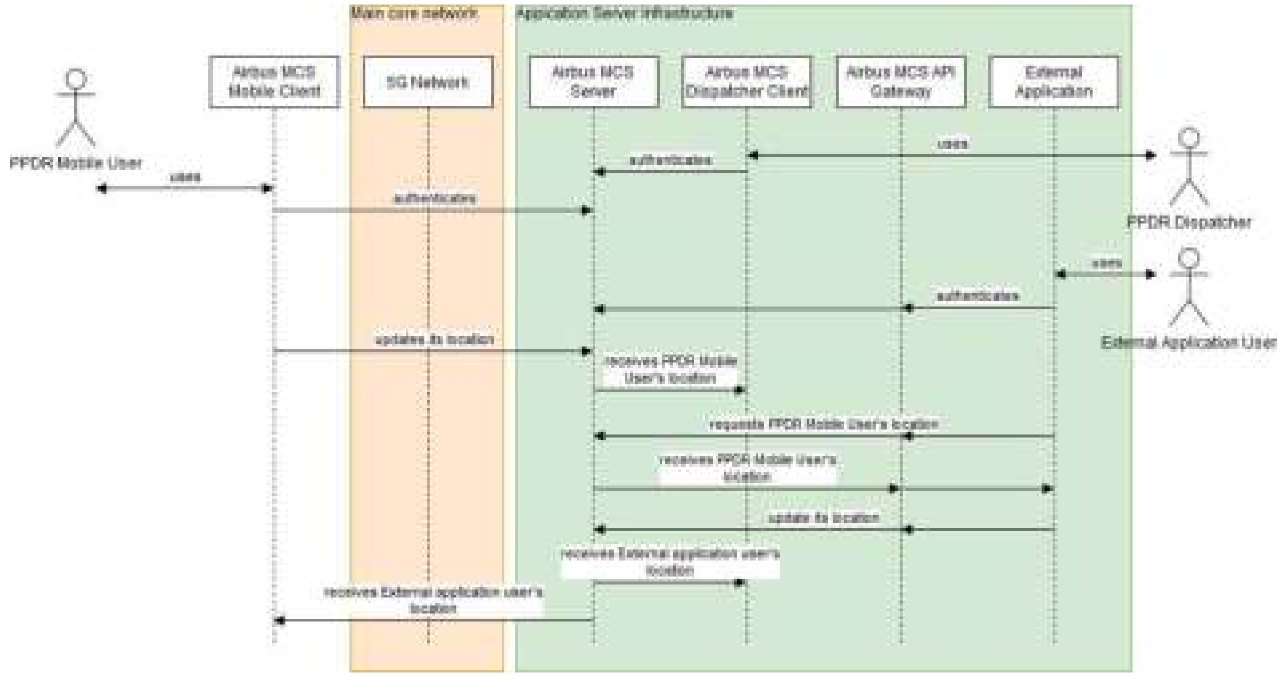

Figure 5: UC1 UML diagram 3.

4. The Airbus MCS Dispatcher Client authenticates with the Airbus MCS Server.
5. The External Application User uses the External Application to access the MCS functionalities.
6. The External Application authenticates with the Airbus MCS Server through the Airbus MCS API Gateway.
7. The External Video Source (a wearable camera, a fixed IP camera, a drone camera, *etc.*) sends its video flow to the Airbus MCS Server.
8. The Airbus MCS Server forwards the video to the Airbus MCS Mobile Client, the Airbus MCS Dispatcher Client and to the External Application.
9. The video is viewed by the PPDR Mobile User, PPDR Dispatcher User, and External Application User.

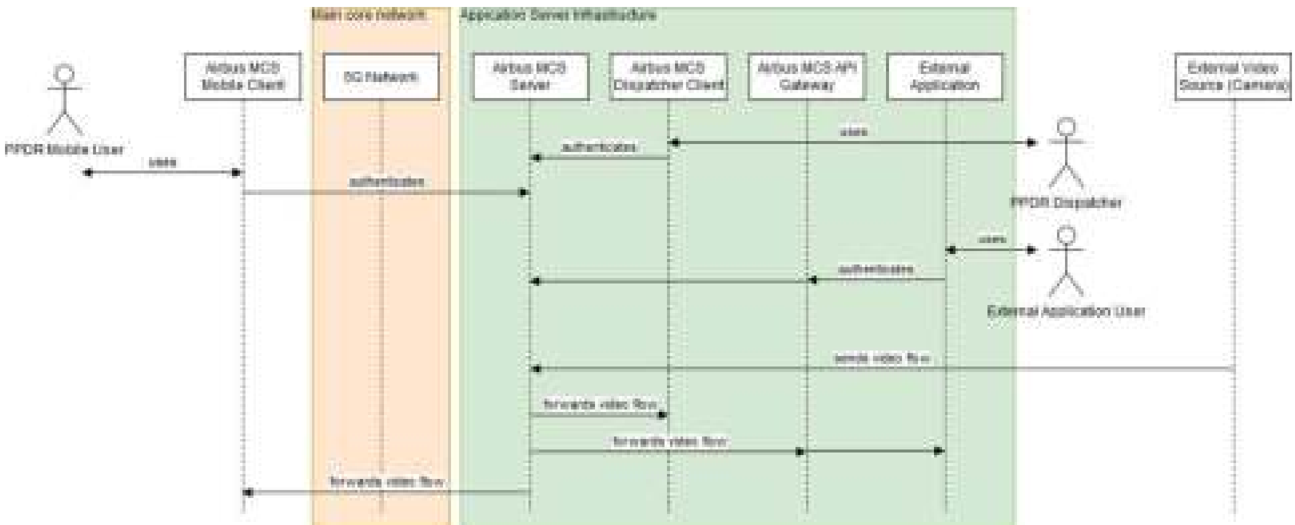

Figure 6: UC1 UML diagram 4.

3.2.4 Use case requirements

The list of functional requirements for UC1 is provided in Table 3 below.

Table 3: UC1 functional requirements.

Req. ID	Use case functional requirements	Description	Related KPI
UC1-F1	Group and individual voice calls.	The MCS Mobile Client, MCS server and applications enabled by the MCS APIs shall support group and individual voice calls.	UC1-K1 UC1-K3
UC1-F2	Group and individual messaging.	The MCS Mobile Client, MCS server and applications enabled by the MCS APIs shall support group and individual messaging.	UC1-K1
UC1-F3	Group and individual multimedia messaging.	The MCS Mobile Client, MCS server and applications enabled by the MCS APIs shall support group and individual multimedia messaging.	UC1-K1
UC1-F4	Individual video calls.	The MCS Mobile Client, MCS server and applications enabled by the MCS APIs shall support individual video calls.	UC1-K1 UC1-K2 UC1-K3
UC1-F5	Emergency calls.	The MCS Mobile Client, MCS server and applications enabled by the MCS APIs shall support emergency calls.	UC1-K1 UC1-K3
UC1-F6	Location and map services.	The MCS Mobile Client, MCS server and applications enabled by the MCS APIs shall support location and map services.	UC1-K4
UC1-F7	Mission Management Application.	A Mission Management Application shall enable collaboration between PPDR users with the exchange of information such as resources, location drawing, document, media files, *etc*.	None
UC1-F8	End-to-end delay.	End-to-end delay ≤ 10 ms.	UC1-K1
UC1-F9	Throughput.	User data rate of 100 Mbps in downlink and 50 Mbps in uplink.	UC1-K2
UC1-F10	Reliability.	A minimum of 99.99999% success probability of transmitting a packet of 32 bytes within 1ms.	UC1-K3
UC1-F11	Location accuracy.	Location accuracy of one meter (1m) in 99% of the cases.	UC1-K4

The list of technical requirements for UC1 is provided in Table 4 below.

Table 4: UC1 technical requirements.

Req. ID	Use case technical requirements	Description	Related KPI
UC1-T1	Demonstrations and KPI validation.	The platform shall provide an MCS and Mission Management systems in order to perform the demonstrations and validate the KPIs.	UC1-K1 UC1-K2 UC1-K3 UC1-K4
UC1-T2	Virtualisation and containerisation.	The MCS and Mission Management applications shall support the virtualisation and/or containerisation technologies available on the targeted testbeds.	None
UC1-T3	API support.	The MCS server shall provide APIs in order to allow first-party (5G-EPICENTRE consortium members) and third-party experimenters to integrate their devices and/or applications.	None
UC1-T4	API methods.	The MCS APIs shall provide methods for: • Group and individual calls. • Group and individual messaging. • Group and individual multimedia messaging. • Individual video calls. • Emergency calls. • User and group management. • External video sources.	None

3.2.5 Use case KPIs

The list of KPIs for UC1 is provided in Table 5 below.

Table 5: UC1 KPI.

KPI ID	Description	Measurement procedure
UC1-K1	The End-to-end delay KPI is the time taken by IP packets for their transmission between the UE and the N6 interface.	The MCS application will be used to measure the time taken to transmit a packet from the MCS client to the MCS Server and from the MCS Server to the MCS Client.
UC1-K2	The Throughput KPI is the User Data Rate between the UE and the N6 interface.	A test application will be used to transmit User Datagram Protocol (UDP) packets in order to measure the data rate for both uplink and downlink.

UC1-K3	The Reliability KPI is the capability of transmitting a given amount of traffic within a predetermined time duration with a high success probability.	A test application will be used to measure the probability of transmitting a small data packet within the required maximum time.
UC1-K4	Location accuracy KPI.	The measurement of this KPI will be defined depending on the 5G NR techniques which will be put in place on the various platforms and on the associated 5G testing tools.

3.2.6 Network services

UC1 will require the instantiation of the following Virtual Network Functions (VNFs):

- ***Airbus MCS Server***: in the context of 5G-EPICENTRE, this VNF contains all the necessary modules for the control and management of voice, video and data communications. This includes an MCS Controlling Server, an MCS Participating Server, an Identity Management Server (IdMS), a Key Management Server (KMS), a Group Management Server (GMS), a Configuration Management Server (CMS), a SIP Core, an HTTP Proxy and an MCS Configuration Server.
- ***Airbus MCS API Gateway*****:** this VNF implements the gateway which manages incoming API requests from external applications and routes them to the right MCS Server module. It also sends the API responses back to the application.
- ***Airbus Map Server*****:** this VNF hosts the map and provides the map elements (tiles) to the MCS clients.
- ***Airbus Mission Management Server***: this VNF enables mobile client to download and install a mobile application for tactical situation awareness which provides geographical information, PPDR resources allocation and instant messaging.
- ***5G System*****:** The 5G System based on 3GPP specifications provides the necessary network elements in order to support the use case communication needs. It consists of the ***5G Access Network***, the ***5G Core Network*** and the User Equipment (UE).
- ***DNS Server*****:** this VNF provides a name server base on the Domain Name System (DNS).
- ***NTP Server*****:** this VNF provides a Network Time Protocol (NTP) based server.

3.3 UC2: Multi-agency and multi-deployment mission critical communications and dynamic service scaling

3.3.1 Use case description

The UC2 (Multi-agency and multi-deployment mission critical communications and dynamic service scaling) aims to provide a common coordination between first responders agencies in an emergency scenario for 3GPP Mission Critical communications (MCPTT for voice, MCData and MCVideo).

Taking advantage of the 5G-EPICENTRE testing platform and infrastructure, the UC2 will consider the provision of the mission critical service in a dynamic multi-Point of Presence (PoP) manner (Figure 7). To do so, it will make use of the intrinsic monitoring and alarm system in 5G-EPICENTRE. As an additional improvement feature, via geo-localisation tools, it will be possible to reduce the service delivery times deploying the service closer to the PPDR agency action point through available edge deployment(s).

Nemergent will provide necessary Mission Critical Services which will fit together with 5G-EPICENTRE testbed to create a PPDR service testing framework focused on multi-agency 3GPP standardised communications.

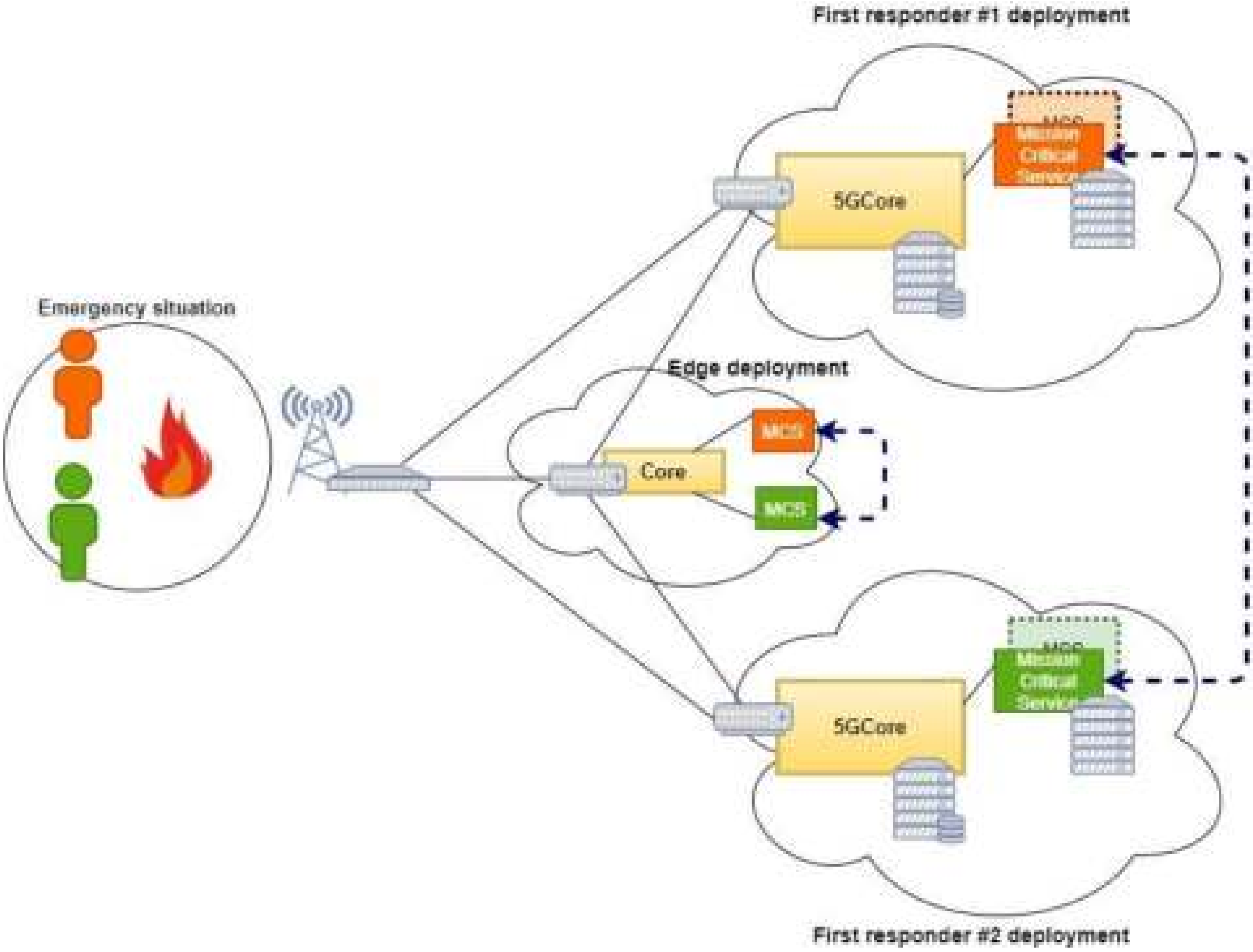

Figure 7: UC2 deployment overview.

3.3.2 Experiment phases or deployment scenarios

3.3.2.1 MCS coordination between first responders

The first scenario targets a common coordination between first responders, each one from a different agency or authority with its own mission critical service, providing an interconnection “MCS Control” VNF/CNF that will seamlessly facilitate merged and temporary talk groups for the various agencies involved during the time the emergency event takes place. Both first responders or authorities will have co-localised agents or members on the field, and when the experiment is launched, each one of the MCS #1, MCS #2 and MCS Control instances will be launched (Figure 8).

- MCS #1 represents the instantiated service of the first agency of PPDR units (orange in the figures).
- MCS #2 represents the instantiated service of the second agency of PPDR units (green in the figures).
- MCS Control represents the instantiated service of a centralized location that will play the role of coordination instance to allow communication of different agencies without peer to peer (p2p) connection and allowing configuration of non-trusted entities between them to preserve privacy and security. The figure below shows in a simplistic way a method to allow communication between agencies, being able to group isolated groups for each entity or agency (Talk group #1 from MCS #1 and Talk group #2 from MCS #2) in a centralised temporary group or supergroup (Talk supergroup involving Talk group #1 and Talk group #2).

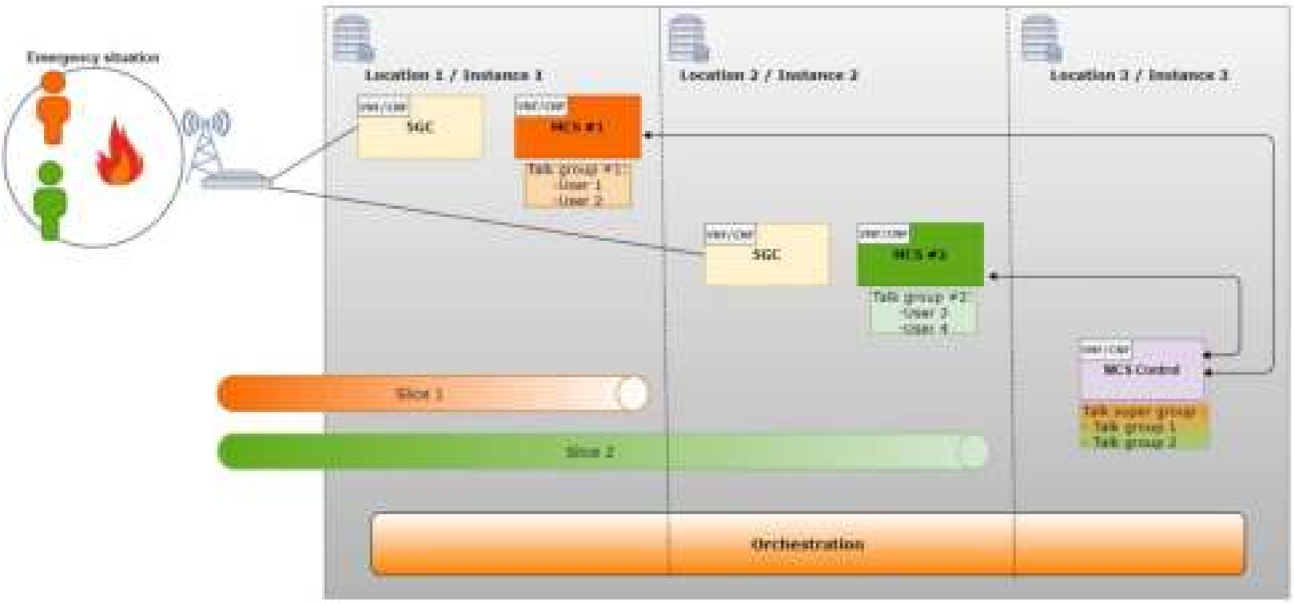

Figure 8: UC2 deployment scenario 1.

End-to-end slicing will be considered in order to allocate the necessary resources across the network and to guarantee a specific QoS for the Mission Critical flows.

3.3.2.2 MCS coordination between first responders based on geo-localisation

The second scenario, as an enhanced first scenario, will make an Edge Mission Critical and 5G Core (5GC) services instantiation (close to the emergency event) via 5G next Generation NodeB (gNB) geo-localisation mechanisms and/or MCS Global Positioning System (GPS) based localisation reports in order to adjust and improve the latency of the first responders attending the emergency event localisation.

Both first responders or authorities will have co-localised agents or members on the field, and when the experiment is launched each one of the MCS #1, MCS #2 and MCS Control instances will be launched. Considering that each of the MCS #1 and MCS #2 are deployed in a different location, and also taking into account that the field location is divided in working areas that are directly related to the most adequate serving PoP, this scenario will re-instantiate one of the instances to co-locate both MCS#1 and MCS#2 in the same PoP. That way, it will resemble the authority location so that the most efficient service could be provided (Figure 9). This is, since we start with disperse instances deployment, the scenario implies a re-instantiation to co-locate MCS #1 and MCS #2 in the service side and map directly to the physical position of the authority members or agents.

End-to-end slicing will be considered in order to allocate the necessary resources across the network and to guarantee a specific Quality of Service (QoS) for the Mission Critical flows. Resources' re-allocation will also be considered to accommodate the new instances in their new PoP or Network Function Virtualization Infrastructure (NFVI).

From an End to End (E2E) point of view, the network elements identified in conducting the experiment are the following:

- The UEs for each first responder participating in the use case equipped with the NEM MCS Android Client
- Same Radio Access Network (RAN) access (5G cells and antennas) zone where the simulated emergency event will take place.
- The 5GC hosting all the necessary network services.

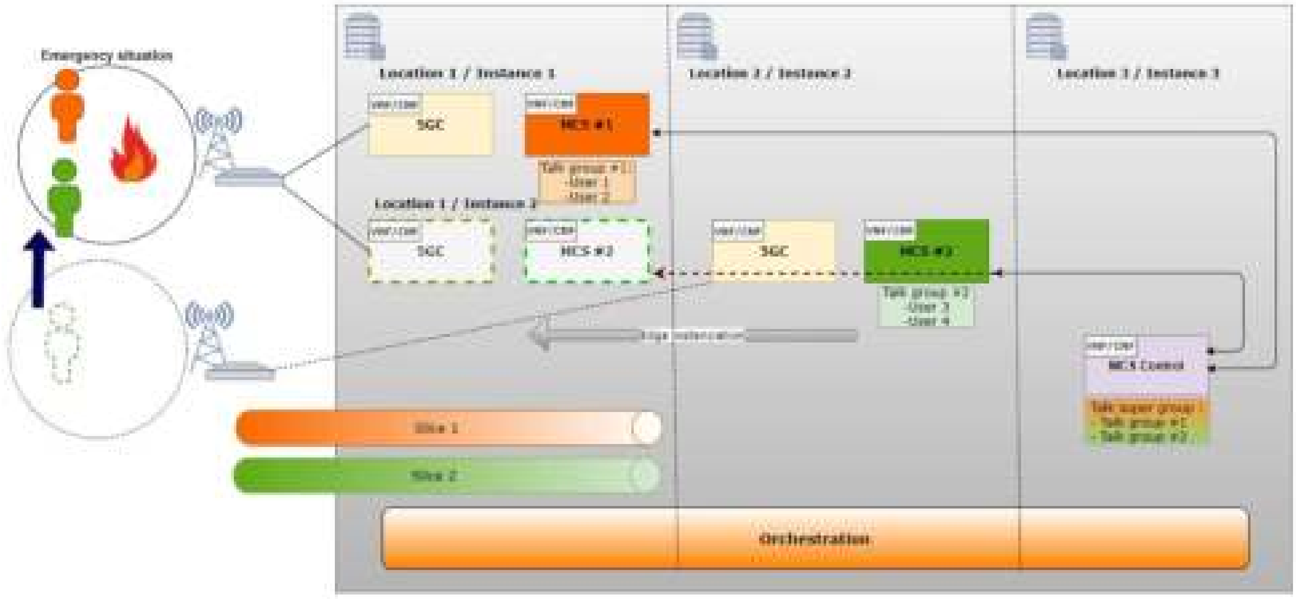

Figure 9: UC2 deployment scenario 2.

- The MCS Application Servers and management servers.

Also, from a services management point of view the elements that will be needed are:

- The experiment lifecycle management support.
- The orchestration system providing management and operation of network services instantiation and network slice creation across technological domains.
- The monitoring system: it involves alarm and detection to notify variations from the expected KPI.

3.3.3 Use case main building blocks

The network elements represented in the Unified Modelling Language (UMLs) for both scenarios (Figure 10 and Figure 11) below are the following ones:

- User 1 and 2: first responders or authorities attending the emergency area, each one being proprietary of its Mission Critical Service.
- 5GC1: 5GC instance for User1.
- 5GC2: 5GC instance for User 2.
- 5GC2_reloc {Scenario 2 specific}: 5GC2 re-instantiation in a location closer to the emergency area.
- MCS1: MCS instance for User1.
- MCS2. MCS instance for User2.
- MCS2_reloc {Scenario 2 specific}: MCS2 re-instantiation in a location closer to the emergency area.
- MCS Common: MCS instance with merged talk groups from MCS1 and MCS2.
- Lifecycle Manager: it will manage VNF/CNFs status and their resources consumption.
- Monitoring: alarm and detection mechanism.
- Orchestrator: management and operation of network services instantiation and slice creation.
- The “Emergency zone coverage area” represents the perimeter in which the event takes place where first responders and authorities will be reunited.

- "Location 1" refers to the server location hosting the services mentioned above.
- "Location 2" refers to the server location hosting the services mentioned above.
- "Location 3" refers to the server location hosting the services mentioned above.

Figure 10 below displays MCS coordination between first responders scenario building block interactions:

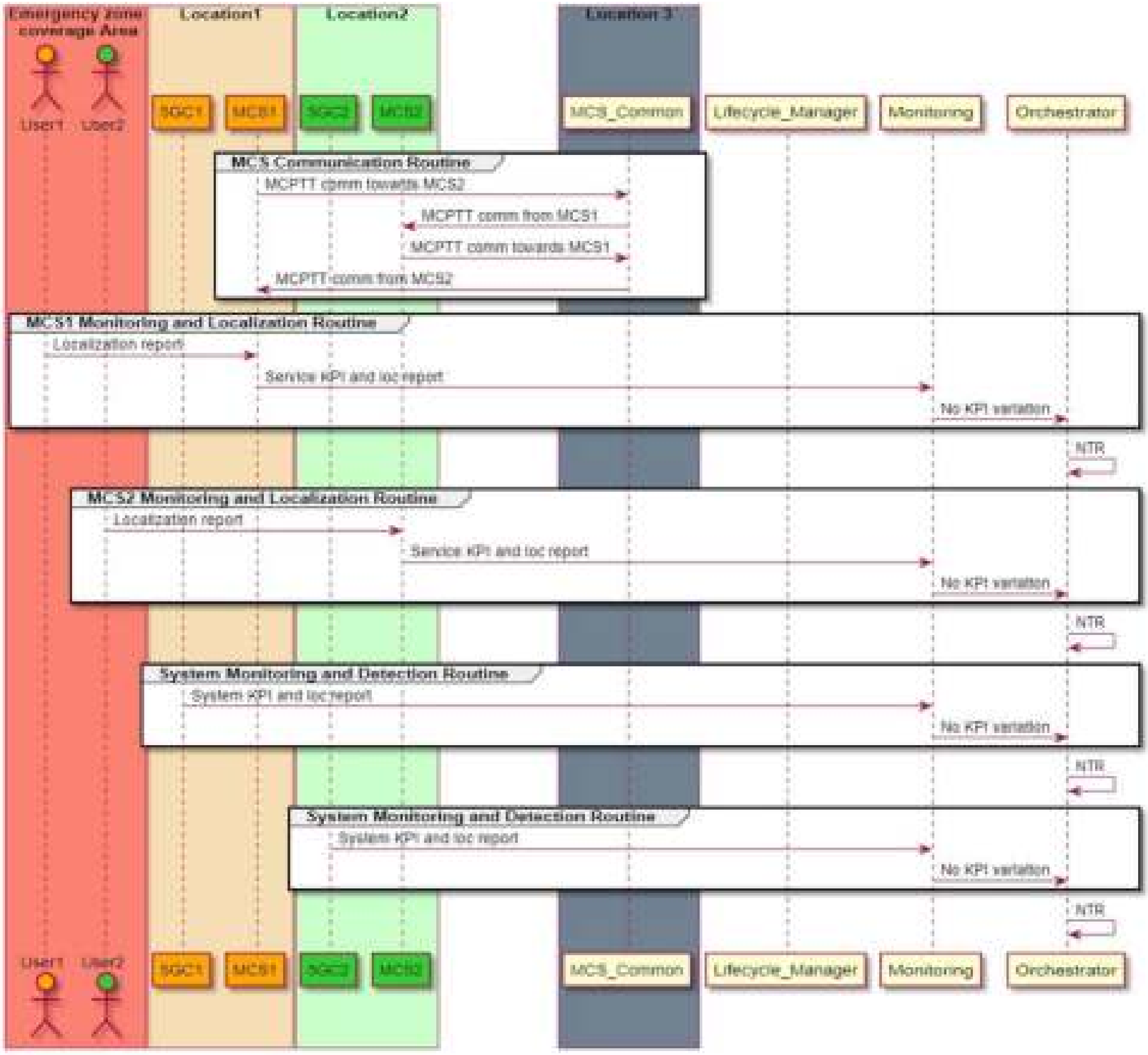

Figure 10: UC2 First scenario building block interactions.

Figure 11 below displays MCS coordination between first responders based on geo-localisation scenario building block interactions:

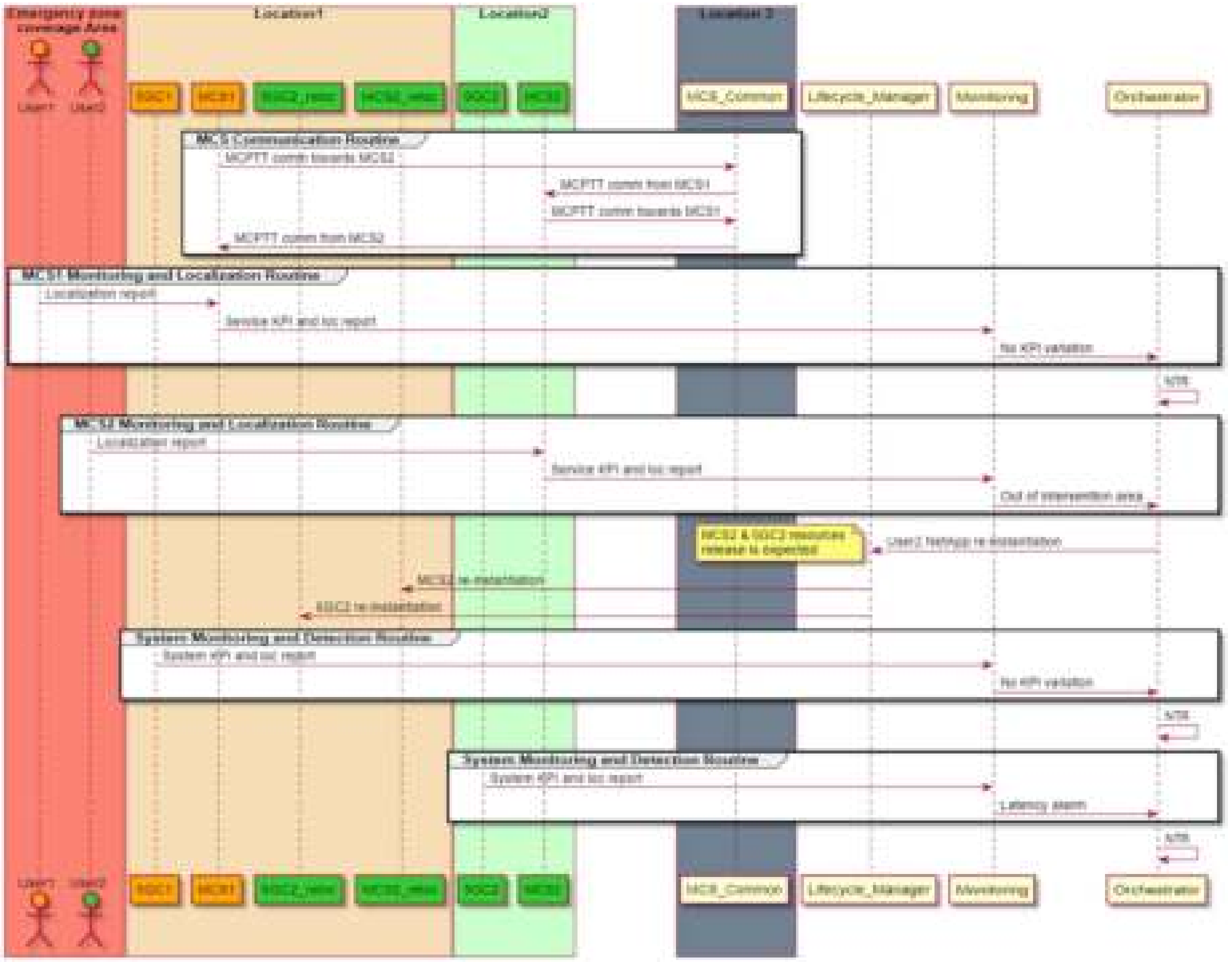

Figure 11: UC2 Second scenario building block interactions.

3.3.4 Use case requirements

The list of functional requirements for UC2 is provided in Table 6 below.

Table 6: UC2 functional requirements.

Req. ID	Use case functional requirements	Description	Related KPI
UC2-F1	Coordination between first responders in diverse geographical areas.	The MCS Service shall provide a way to create merged communication groups between first responders no matter their location.	None
UC2-F2	Mission Critical individual and group calls: voice, video and data transmission	Within the merged communication groups, first responders shall be able to talk via standardised MCPTT, MCVideo and exchange messages.	None

	between first responders.		
UC2-F3	Geo-localisation tools.	The MCS Service and/or the 5G-EPICENTRE platform shall provide location services.	None
UC2-F4	Latency (delay).	End-to-end latency ≤ 10 ms.	UC2-K1
UC2-F5	Service availability.	The (MC) service availability shall be >99%.	UC2-K2
UC2-F6	Alarm triggering.	The alarm triggering time face to an unattended KPI variation or event should be under 30s.	UC2-K3
UC2-F7	Reinstantiation time.	The MC service reinstantiation time shall not exceed 3min.	UC2-K4
UC2-F8	Multi-agency merged talk groups creation.	The merged talk creation and notification time shall be under 1min.	UC2-K5
UC2-F9	Traffic priority and QoS.	Faced with an emergency, communication between first responders shall subscribe a specific QoS and traffic priority.	None

The list of technical requirements for UC2 is provided in Table 7 below.

Table 7: UC2 technical requirements.

Req. ID	Use case technical requirements	Description	Related KPI
UC2-T1	The platform shall provide a Monitoring system/mechanism.	The platform shall monitor the infrastructure and services KPI.	None
UC2-T2	The platform shall support UE geo-localisation.	UE geo-localisation will trigger the required network services re-instantiation.	None
UC2-T3	The platform shall provide Specific QoS support.	MC services require specific QoS.	None
UC2-T4	The platform shall support multiple points of presence.	Service instances might be running in diverse locations.	None
UC2-T5	The system shall provide uninterrupted connection between the	MC service shall have high availability.	UC2-K2

	MC service components.		
UC2-T6	The platform shall support end-to-end slicing.	Adapted QoS and resources reservation across the network shall be supported.	None
UC2-T7	The platform shall support an alternative to deal with latency problems.	V/CNF/NetApp lifecycle management shall provide mechanisms to correct latency problems.	UC2-K3 UC2-K4

3.3.5 Use case KPIs

The list of KPIs for UC2 is provided in Table 8 below.

Table 8: UC2 KPIs.

KPI ID	Description	Measurement procedure
UC2-K1	Latency is the time that it takes to transfer a given piece of information from a source to a destination, from the moment it is transmitted by the source to the moment it reaches the designated destination.	A packet stream is emitted from a source and received by a data sink (destination). The data sink shall acknowledge the correct reception of the data packet back to the sink. The time of the source emitting the packet and receiving the acknowledgement is divided by two in order to obtain the KPI (equal UL and DL paths).
UC2-K2	Service availability is the expected time the service will be in operation over a measurement period.	Service status reports will show the availability of the service.
UC2-K3	Alarm triggering time is the elapsed time from an unattended event detection to the resulting action triggering.	The time elapsed from the triggering point of a predefined action or event (e.g., INVITE messages for the calls) to the point the expected alarm is launched after the detection of the event (e.g., specific call type alarm, number of simultaneous calls, *etc.*).

3.3.6 Network services

The network services involved in the UC2 could be divided in three main categories: Service-specific network services, network-linked network services and generic or supporting baseline services.

3.3.6.1 Service specific network services

The main service-specific network service is related to the MCS VNF or CNF as a whole but divided in different components that depending on the used technology will be divided in Virtual Deployment Units (VDU) in the case of VNF or namespaces in the case of CNF. Inside the MCS network service each component represents a small portion of the network service, having the entity of network service by themselves as conceptually understood with microservices. In the 3GPP MCS definition there are important components that play the role of technology enablers like the Internet Media Services (IMS) core that make registration and call, publish and subscription routing possible. The provided ***IMS core*** is divided in small components that are Proxy-Call Session Control Function (P-CSCF), Controlling-Call Session Control Function (C-CSCF), IMS-Call Session Control Function (I-CSCF) and IMS Home Subscriber Server (HSS). On top of that the MCS VNF/CNF mounts the two most important actors in MCS which are the ***Participating Application Server (PAS)*** and ***Controlling Application Server (CAS)***, the former handling authorisation of users, media and QoS managements and the latter handling call control, floor control and media. The MCS is also supported in the service-specific side with a ***Load Balancer (LB)*** between the IMS Core and the different PAS and CAS that the system may have. Additionally, the system is composed of the management servers divided into ***Identity Management Server (IdMS)*** to handle, among others, the MCS users credentials and access token handling, ***Configuration Management Server (CMS)*** as the central point to handle configuration of each user and each service separately (MCPTT, MCVideo and MCData), ***Group Management Server (GMS)*** to handle group configuration and formation and ***Key Management Server (KMS)*** to handle all the security and encryption related exchanged. Related to these management servers, other components arise like the Orchestration And Management (OAM) and Dispatch position to graphically configure the exposed components and be able to even handle calls from the dispatch or control room (also known as Command and Control Centre –CCC-) position (supported by the additional MCS Enabler component). It is also important to note that the system is supported by storage methods like Redis and PostgreSQL database. Finally, it must be underlined that monitoring and scaling modules are intrinsic to the whole MCS VNF/CNF and possibilities of dividing them as separate components of the system will be explored.

3.3.6.2 Network linked network services

Inside the MCS NetApp requirements there is a big dependency with the components that enable connectivity. This is, the MCS highly depends on the deployment of ***5G Core*** and its deployed configuration so that the management of QoS is provided via Policy Charging Function (PCF) through one of the possible methods in the standard to handle the N5 interface (*e.g.,* exposure of function with Network Exposure Function (NEF), Common API Framework (CAPIF), discovery of methods with Network Repository Function (NRF) or directly with direct communication between Application Function (AF) and PCF). Additionally, the connectivity also involves active participation of the ***5G RAN*** to reach UEs using RAN services with the decided functional split between most commonly mentioned Radio Unit (RU), Distributed Unit (DU) or Centralized Unit (CU).

3.3.6.3 Generic services

Last but not least, depending on the final setup the MCS NetApp may also need additional supporting services like ***network-based load balancer, firewall, DNS server, service-specific IP discovery, topology hiding modules*** and so forth.

3.4 UC3: Ultra-reliable drone navigation and remote control

3.4.1 Use case description

Within the 5G-EPICENTRE project, HHI plans to test an important use-case, which addresses the topic of PPDR. Among the most prominent cases of interest to the Wireless Communications and Networks department at Fraunhofer Institute for Telecommunications is the demonstration of super reliable drone navigation and remote control by utilising the federated testbed resources.

Drones have the potential to improve public safety, as they can, for example, be deployed to fly ahead of first responders and transmit live video of a particular situation at the site. This could be, for example, a fire on company premises. Efficient drone control and localisation, however, remain a challenging task, as drone communications should be characterised by stability, wide availability, low cost and ultra-reliability, even when the drone is out of sight. As modern drones are typically controlled via remote control, their applicability in real-life situations will remain severely limited. In this UC, HHI will experiment with various methods for drone control in different situations, particularly focusing on network overload situations, when the data channels are used in major events or disasters.

A particularly efficient means of controlling drones via Bandwidth-optimised communication protocols in the mobile network will be deployed in the form of VNFs on top of the 5G-EPICENTRE infrastructure, facilitating a two-way communication where commands are transmitted to the device, which in turn responds with information about its position, altitude and battery status.

The mission drone will be using a 5G-Network slice in order to secure ultra-reliability and will be streaming Infrared (IR) and optical video streams of the site.

As a list of indicative VNFs there could be: imaging, positional coordinates extraction, signal translator, coding.

As a list of indicative NetApps there could be: Management and monitoring interface, command and control (CC) link, ultra-reliable and high-resolution video streaming comprising at least two video channels (IR and Optical).

The fire service is to receive a prioritised data link for the use of drones. Video and telemetry data should be able to be displayed on different devices at the same time.

The first step is to realise the CC link to the drone. This involves narrowband data with a high requirement for availability and latency.

In the second step, the live video is to be transmitted via a separate VNF. The video has a high bandwidth requirement but lower latency and availability requirements than the CC link.

Subsequently, the data from CC Link and Video should be able to be displayed in a common graphical user interface (Figure 12).

Figure 12: UC3 Ground control app with integrated video.

3.4.2 Experiment phases or deployment scenarios

The use case is intended to demonstrate the use of a drone as part of a fire rescue service operation.

- The drone connects to the 5G testbed via 5G campus network connection using 100 MHz bandwidth at 3.7 GHz in band n78 for the transmission of telemetry and video data.
- Optionally, the drone can connect to a 5G slice within this band to ensure reliability for mission critical communications.

3.4.2.1 Scenario 1

The control centre launches the drone and sends it to the operation area. The emergency forces who arrive at the scene after the drone can access it and its video data via a tablet or other suitable UE on their way to the site to get an impression of the situation. In order to relieve the emergency services, the monitoring of the drone can be returned to the control centre at any time. The mission operation manager is in control of the drone and the video streams all the time, even on the way to the site.

3.4.2.2 Scenario 2

Optionally and additionally to scenario 1, another drone operator off-site is able to control the drone remotely from the mission control centre. In addition to the drone's automatic flight operation, this gives the maximum control over the drone and helps to guide and advise first responders to the site's special conditions accordingly. This can make all the difference to save valuable time, even if only some crucial minutes, and thereby possibly save lives.

3.4.3 Use case main building blocks

The interaction of the individual components is shown in

Figure 13. The main building blocks consist of the drone with the dual camera and its 5G interface. The 5G network forms the node over which the entire communication runs. The processing of the data is done on an edge server. The access to the data and the control of the drone is done via Internet, the Server and the 5G Network as depicted in the UML diagram (Figure 14).

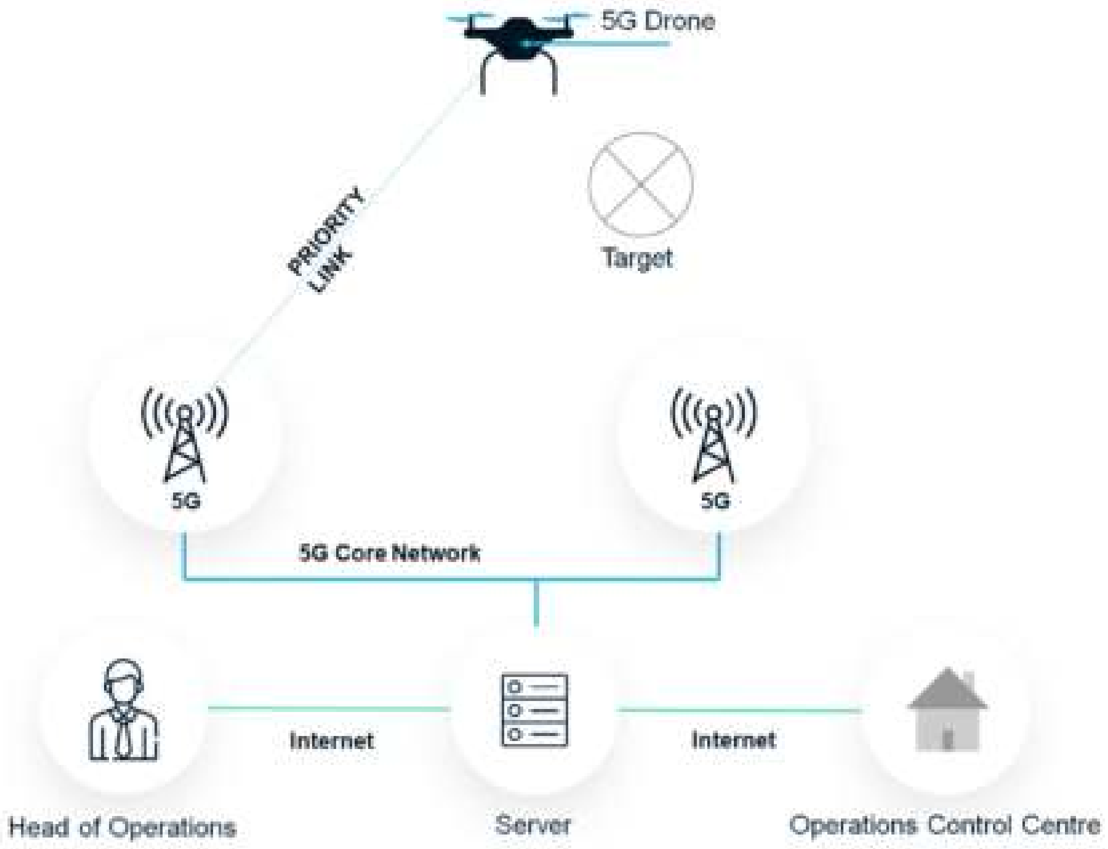

Figure 13: UC3 Interaction of the individual components.

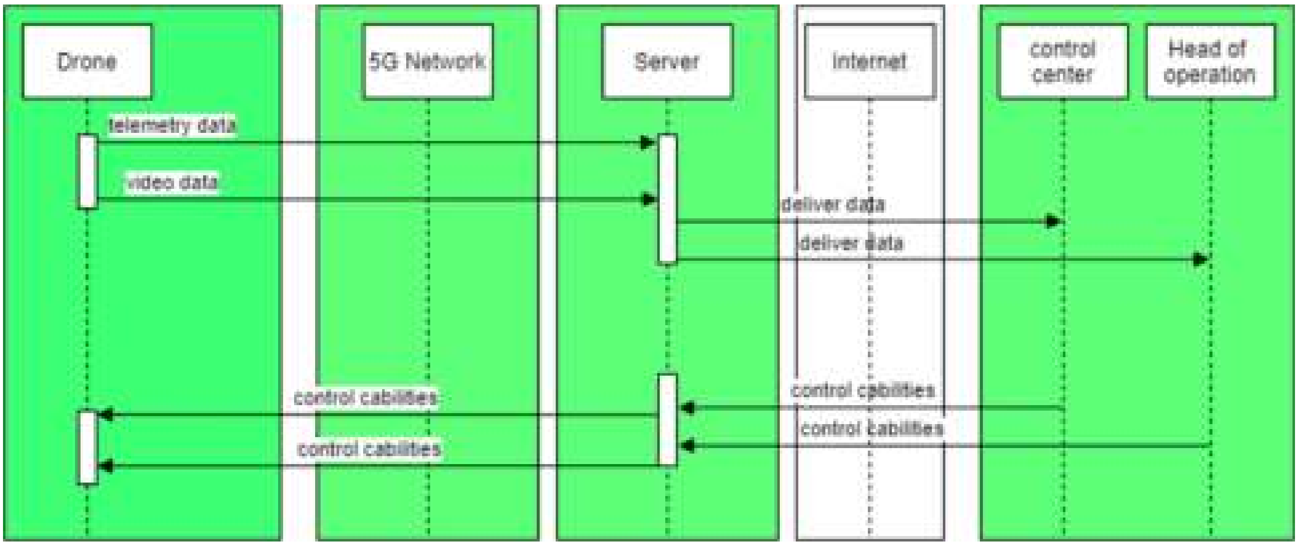

Figure 14: UC3 UML diagram.

3.4.4 Use case requirements

The list of functional requirements for UC3 is provided in Table 9 below.

Table 9: UC3 functional requirements.

Req. ID	Use case functional requirements	Description	Related KPI
UC3-F1	Emergency service case surveillance.	The user/ mission operation manager shall be able to surveil the emergency service case from a remote position in order to improve the on-site service operation planning with first responders/fire fighters accordingly.	UC3-K1 UC3-K2
UC3-F2	Control of the drone and airborne video cameras.	The user/ mission operation manager shall be supported by autonomous drone flight functions in order to focus on the control of the video camera angle and position.	UC3-K2 UC3-K3
UC3-F3	On-site support of the drone and video footage from a bird's eye view.	The user/ the mission operation manager shall be able to use the drone during on-site service mission in order to get a bird's eye view of the scenery to improve the mission.	UC3-K3
UC4-F4	Reliability.	Reliability of connectivity in a defined area shall reach 99.9% (no dead zones).	UC3-K2
UC4-F5	Latency.	Latency between drone and targeted management server < 5ms. Latency between drone and targeted client < 50ms.	UC3-K1

UC-F6	High data rate.	The Uplink (UL) targeted data rate is > 30 Mbps.	UC3-K3

The list of technical requirements for UC3 is provided in Table 10 below.

Table 10: UC3 technical requirements.

Req. ID	Use case technical requirements	Description	Related KPI
UC3-T1	Ultra-reliable transmission of telemetry and video stream data.	The drone connects to the 5G testbed via a 100 MHz bandwidth at 3.7 GHz in band n78 for the transmission of telemetry and video data.	UC3-K1 UC3-K2 UC3-K3
UC3-T2	5G network slicing for priority connection.	The drone uses a 5G slice in the network to get a priority link for the telemetry and/or video data.	UC3-K1 UC3-K2
UC3-T3	Optical and IR live video streaming.	The drone's dual camera can live-stream infrared and also optical video data that can be captured and processed directly.	UC3-K2 UC3-K3

3.4.5 Use case KPIs

The list of KPIs for UC3 is provided in Table 11 below.

Table 11: UC3 KPIs.

KPI ID	Description	Measurement procedure
UC3-K1	Latency is the time elapsed between the time data is transmitted from the drone to the time they are received by the management server / client.	R&S Qualipoc app and ping tests will be used to calculate this KPI.
UC3-K2	Reliability is the capability of transmitting a given amount of traffic within a predetermined time duration with a high success probability	R&S Qualipoc app and ping tests will be used to calculate this KPI.
UC3-K3	Data rate refers to the digital amount of data that is transmitted over a transmission channel within a period of time	R&S Qualipoc app and ping tests and UL datarate stream test will be used to calculate this KPI.

3.4.6 Network services

UC3 will require the implementation of the following VNFs:

- ***Drone communication*** with high bandwidth video streaming over the 5G slice with two video streams (thermal and optical streams): In order to assess the situation on-site, there is a need to transmit high-resolution video data. This requires high bandwidth.

- ***Ground control app*** for the mission control operator: The GroundControl app is used to control the drone (see Figure 12). This is an open-source software that runs on all common platforms (Windows, Linux, Mac OS, Android, iOS). The app can be used to display the position of the drone as well as the live video of the camera.
- ***Unmanned Aerial Vehicles (UAV) Mission Management Server:***
    - *CC Link with the command/mission control centre:* The control of the drone can be accessed from different clients. For example, the on-site commander can take control of the drone and the cameras to get an overview. They can then hand over control to the operations centre. This reduces the effort for the emergency forces on site.
    - *Live Video Server*: The drone's video streams can be shared with various entities via the Mission Management Server. This allows both the forces on-site and the control centre to get an overview of the situation.
- ***5G core:*** The 5G core used in the use case is from ng4T and contains VNFs to modify the core performance and functionality.

3.5 UC4: IoT for improving first responders’ situational awareness and safety

3.5.1 Use case description

The underlying mission of first responders demands central coordination and management. This coordination is greatly improved with situational awareness, which corresponds to the perception of data and behaviour of ongoing situations in the field. Having awareness helps to understand the meaning and significance of data and behaviours, and how processes, actions, and new situations inferred from these data and processes are likely to evolve in the near future. Hence, it will provide additional information to support proactive decisions.

Through the timely retrieval and process of the available data from the field, one may aim to enhance situational awareness and overall safety. Such data can be collected from a variety of sensors, ranging from field deployed sensors to wearable sensors. Using data from those sensors, response actions can be formulated by the fusion of multiple data sources to leverage and enhance central coordination capabilities and support human or automated critical decisions in real time. As missions go on, more data becomes available to support management decisions and actions. The solution to support the improved situational awareness and decision making will be converted into Containerised Network Functions (CNFs) and VNFs to be deployed using the orchestration environment of the 5G-EPICENTRE testbeds.

For this experiment, the **Mobitrust** situational awareness platform, depicted in Figure 15, will be used in order to meet the pre-set goal of aiding Command and Control Centres (CCC) to obtain a full situational awareness of field operations. This includes monitoring of agents in the field through a set of geographical/indoor positioning, environmental and wearable biological sensors, as well as real-time text, audio and video transmissions. Data is then relayed over 5G and processed in the Command and Control Centre to be displayed in the platform frontend at the operator’s request, together with alerts triggered by Artificial Intelligence (AI)/Machine Learning (ML) algorithms to detect man-down situations and other critical looming situations (*e.g.*, gunshots, environmental hazards, physical threats, *etc*.). For every alert, the platform will recommend proactive actions to mitigate the effects it may cause.

The situational awareness platform will monitor, retrieve, and collect data from different types of devices, including:

- Wearable sensors (*e.g.*, electrocardiogram (ECG), O_2 saturation (SpO2), respiration rate, *etc*.).
- Field stations (*e.g.*, fixed deployments).
- Vehicles (*e.g.*, ambulances, drones, *etc*.).

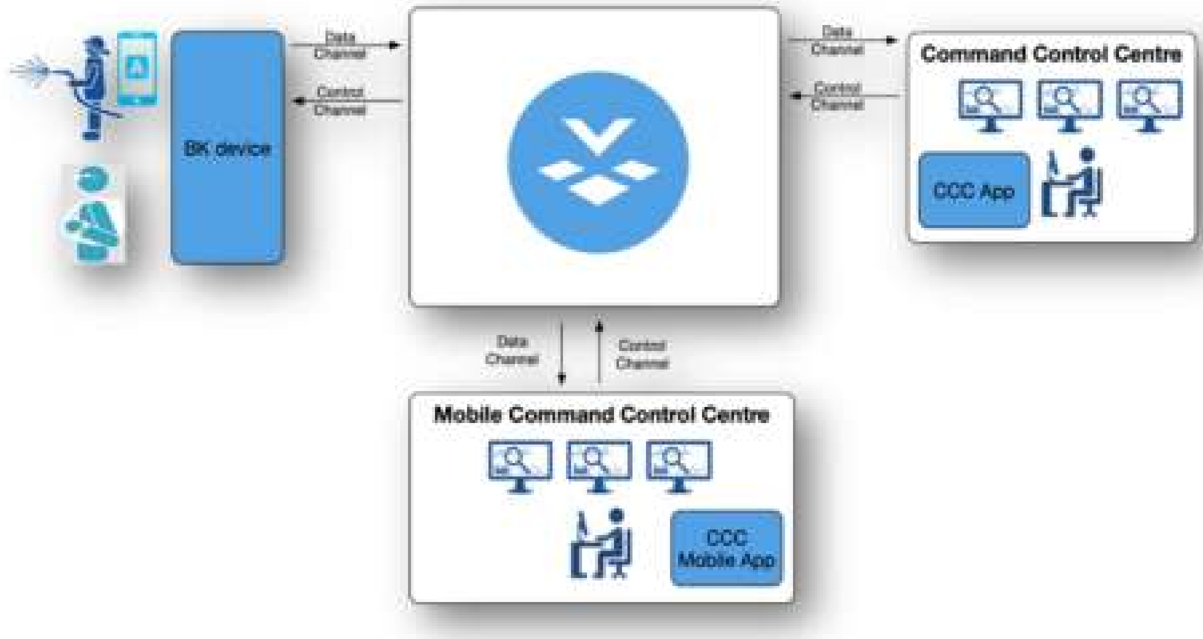

Figure 15: UC4 Mobitrust Platform Architecture.

3.5.2 Experiment phases or deployment scenarios

This use case comprises the following scenarios: "Situational Awareness", "On-demand Live High Definition (HD) Multimedia", and "Response Actions".

3.5.2.1 Situational Awareness

This scenario aims to demonstrate how CCC Operator and CCC Mobile Operator will be aware of the situation on the field. The acquired data will enhance the operator´s capabilities for supporting management and coordination activities and execution of the ongoing activities to achieve mission objectives. That evolving scenario in the field requires dynamic response actions by continuously assessing and assigning the most appropriate tasks to the Users with a Bag pack Kit (BK) Device.

After a BK Device is authenticated, Sensor Data and Standard Definition (SD) Multimedia start to deliver data into Mobitrust to be continuously collected. The Mobitrust platform will monitor Sensor Data and SD Multimedia to identify incidents. After an incident has been identified, the User with BK Device, CCC Mobile Operator and CCC Operator are notified with Alerts.

3.5.2.2 On-demand Live HD Multimedia

This scenario aims to describe the Mobitrust platform capabilities to support on-demand live HD Multimedia from CCC Operator or CCC Mobile Operator to be aware of specific situations in the field. CCC Operator or CCC Mobile Operator can select the specific set of User with BK Device and demand live HD Multimedia at the same time as they receive the situational awareness. Mobitrust platform will request the appropriate Quality of Service (QoS) from 5GC to guarantee real-time and fluent HD Multimedia.

3.5.2.3 Response Actions

This scenario aims to demonstrate how the Mobitrust platform manages response actions in case of real-time incidents (*e.g.*, man down, an SOS request). Those responses will contribute to central decisions and to achieving the best remediation actions in the shorter possible time frame. The CCC operator assigns a set of response actions to incidents and defines if they require human supervision or can be automated. A previously authenticated CCC Operator will be able to define which response actions should be taken (*e.g.*, call, SMS, process).

3.5.3 Use case main building blocks

This section presents the network elements, actions, and flows for this UC.

3.5.3.1 Network Elements

The Network Elements of this UC are the components, actors and locations where this UC occurs.

Mobitrust platform is the core component providing cloud and edge computing resources supporting real-time interaction, ensuring low latency to support delay-sensitive applications and services. It collects Sensor Data, SD Multimedia and HD Multimedia from the User with BK Device. Incidents are identified from Sensor Data and Multimedia. CCC operator, CCC Mobile Operator and User with BK Device are notified with alerts. The Mobitrust platform also provides streaming capabilities supporting real-time on-demand HD Multimedia from BK devices and the interface for maintaining logical behaviour.

The actors for this use case comprise User with BK Device, CCC Mobile Operator and CCC Operator, that should be previously authenticated to access the available features.

Network Elements are distributed at different locations, such as Emergency Zone, Non-Emergency Zone and 5G Network. At Non-Emergency Zones, we will have the network elements for the User with BK Device and CCC Mobile Operator. User with BK Device and CCC Mobile Operator are located at the Emergency Zone communicating to Mobitrust platform through the 5G Network. This zone corresponds to the geographical area where the event pertaining to the mission occurs.

3.5.3.2 Actions

- Sensor Data: data from sensors in the BK Device are delivered to the Mobitrust Platform. That data will help to support processes to identify incidents.
- SD Multimedia Live audio and video demanded from the CCC Operator or CCC Mobile Operator from the User with BK Device. Provides support to identify incidents.
- HD Multimedia High-definition video and audio available on CCC Operator and CCC Mobile Operator requests. Provides support to identify incidents.
- Response Actions Triggered actions as soon the incidents are identified.
- Alerts Triggered: alerts in the case incidents are identified.
- Visualisation CCC Operator requires to know situational awareness including Sensor Data, SD Multimedia and Alerts.
- QoS Request Mobitrust platform requests QoS from 5GC to guarantee on-demand live HD Multimedia.
- QoS Setting 5GC sets up QoS accordingly to QoS Request.

3.5.3.3 Flows

As presented in Figure 16, the following list includes the sequence steps describing the use case scenarios:

1. Sensor Data and SD Multimedia are continuously delivered from User with BK Device to the Mobitrust platform.
2. In case an Incident is identified, Response Actions might be taken.
3. Alerts are triggered in consequence of Incident to the User with BK Device, CCC Operator or CCC Mobile Operator.
4. CCC Operator or CCC Mobile Operator demand Visualization from Mobitrust platform to contribute to the Situational Awareness.
5. CCC Operator or CCC Mobile Operator demands HD Multimedia from the Mobitrust platform.

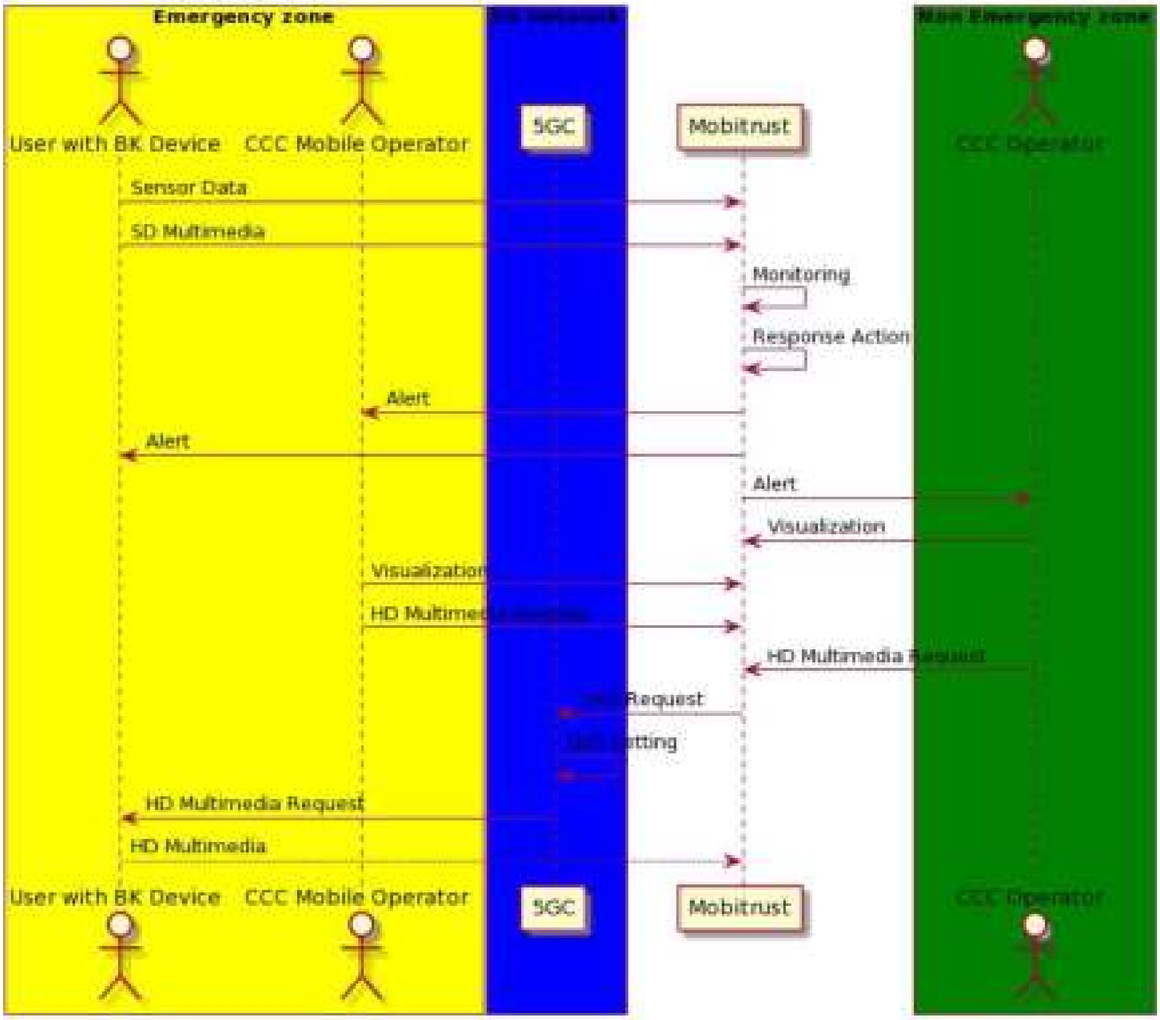

Figure 16: UC4 sequence diagram.

6. Mobitrust requests 5GC for a specific QoS (QoS Request).
7. 5GC set ups the QoS (QoS Setting) according to the QoS Request.
8. 5GC forwards the HD Multimedia request to the User with BK Device.
9. User with BK Device delivers HD Multimedia to the Mobitrust platform.

3.5.4 Use case requirements

The list of functional requirements for UC4 is provided in Table 12 below.

Table 12: UC4 functional requirements.

Req. ID	Use case functional requirements	Description	Related KPI
UC4-F1	Incident notifications.	After an incident has been identified, the User with BK Device, CCC Mobile Operator and CCC Operator shall be notified.	UC4-K1

UC4-F2	On-demand Live HD Multimedia.	CCC Operator or CCC Mobile Operator shall be able to select the specific User with BK Device to demand live HD Multimedia.	UC4-K2 UC4-K3
UC4-F3	Alert Notification List.	CCC Operator shall be able to assign a notification list to an Incident.	None
UC4-F4	Response Actions Management.	CCC Operator shall be able to manage the Response Actions to Incidents.	UC4-K4
UC4-F5	Good User Experience.	Mobitrust platform should provide a good user experience to CCC Operator and CCC Mobile Operator.	UC4-K5 UC4-K6

The list of technical requirements for UC4 is provided in Table 13 below.

Table 13: UC4 technical requirements.

Req. ID	Use case technical requirements	Description	Related KPI
UC4-T1	Incidents Identification.	Sensor Data and SD Multimedia are permanently monitored by Mobitrust platform to identify incidents.	UC4-K7 UC4-K8
UC4-T2	Proactive Actions Notifications.	Proactive actions shall be triggered in consequence of the identification of specific incidents.	None
UC4-T3	Continuous Sensor Data Collection.	Live Sensor Data and SD Multimedia from BK Devices shall be continuously collected from BK Device to the CCC.	UC4-K9
UC4-T4	CCC Operator and CCC Mobile Operator Authentication.	CCC Operator and CCC Mobile Operator shall be authenticated to be aware and interact with the Mobitrust platform.	None
UC4-T5	BK Device Authentication.	BK Device shall be authenticated when turned on.	UC4-K10
UC4-T6	BK Device Sensor Data.	After BK Device has been authenticated, it should start delivering Sensor Data and SD Multimedia to the Mobitrust platform.	None
UC4-T7	External Encrypted Communication.	CCC Operator and CCC Mobile Operator shall provide Encrypted Communication.	None

3.5.5 Use case KPIs

The list of KPIs for UC4 is provided in Table 14 below.

Table 14: UC4 KPIs.

KPI ID	Description	Measurement procedure
UC4-K1	Incident Notification time is the elapsed time from the moment the incident is identified (TS1) until the moment the users receive the notification (TS2).	The identification, the content of the message and TS1 and TS2 timestamps will be logged into a KPI pool.
UC4-K2	End-to-End HD Multimedia Latency is the elapsed time from the moment HD Multimedia is requested (TS1) by the CCC Operator or CCC Mobile Operator until the multimedia is displayed at the operator screen (TS2).	The identification, the content of the message and TS1 and TS2 timestamps will be logged into a KPI pool.
UC4-K3	HD Multimedia Quality of Experience (QoE) represents the user satisfaction feedback by evaluating the responses to the question "How satisfied are you with multimedia experience" on a 0 a 5 scale (Very dissatisfied, Dissatisfied, Neutral, Satisfied, Very satisfied).	The identification, HD Multimedia QoE type, and response to the satisfaction inquiry will be logged into a KPI pool.
UC4-K4	Incident Response Action Time is the elapsed time from the moment the incident was identified (TS1) until the moment the response action is initiated (TS2).	The identification, the content of the message and TS1 and TS2 timestamps will be logged into a KPI pool.
UC4-K5	End-to-End SD Multimedia Latency is the elapsed time from the moment the User with BK Device starts delivering SD Multimedia (TS1) until it is displayed at the CCC Operator or CCC Mobile Operator screen (TS2).	The identification, the content of the message and TS1 and TS2 timestamps will be logged into a KPI pool.
UC4-K6	Mobitrust Platform QoE represents the user satisfaction feedback by evaluating the responses to the question "How satisfied are you with MOBITRUST platform" in a 0 a 5 scale (Very dissatisfied, Dissatisfied, Neutral, Satisfied, Very satisfied).	The identification, platform QoE type, and response to the satisfaction inquiry will be logged into a KPI pool.
UC4-K7	Incident Prediction Precision is when an incident is detected, the CCC Operator or CCC Mobile Operator	Precision is computed between the ratio of the number of True Positives (TPs) and the total of TPs with False Positives (FPs), according to the formula: Precision=TP/(TP+FP).

	classifies them as "True" or "False" Incidents.	The identification of the incident, the type of incident and the Precision will be logged into a KPI pool.
UC4-K8	Incident Detection Time is the moment the incident has started (TS1), defined by the CCC Operator or CCC Mobile Operator. The elapsed time corresponds to the difference between TS1 and the moment the Mobitrust platform classifies that event (TS2).	The identification, the content of the message and TS1 and TS2 timestamps will be logged into a KPI pool.
UC4-K9	Sensor Data Latency is the elapsed time between the timestamps of the messages since they are delivered from the BK Device (TS1) until the moment they are received by the CCC Operator or CCC Mobile Operator (TS2).	The identification, the content of the message and TS1 and TS2 timestamps will be logged into a KPI pool.
UC4-K10	BK Device Authentication time is the elapsed time from the moment the BK Device is turned on (TS1) until the moment it receives the authentication confirmation (TS2).	The identification, the content of the message and TS1 and TS2 timestamps will be logged into a KPI pool.

3.5.6 Network services

This UC4 will depend on internal and external services.

The ***Mobitrust*** platform encompasses a set of containerised internal network services. A ***Message Broker*** (MB) component enables the cluster internal and external communication. ***Back-End Server*** (BES) provides the key features to attend to MB messages. BES manages the ***Database Server*** (DBS) and ***Time Series Server*** (TSS) internal network services. The ***Front-End Server*** (FES) hosts the user interface application capabilities to the CCC Operators. Moreover, a ***Multimedia Server*** (MS) provides the multimedia capabilities to cope with streams delivered from BK devices.

The UC4 also depends on external services. The ***Orchestrator*** will manage the containerised internal services. Storage is required from DBS, TSS and MS internal services. MB and MS internal services will be exposed to external services through a Proxy routing traffic and a ***Load Balancer (LB)*** distributing workloads. BK Devices and CCC Mobile Operators UEs are placed on the field, connecting to ***5G RAN*** base stations to have access to the Mobitrust platform MB and MS internal services. CCC Operators will be able to request HD Multimedia from BK Devices. To achieve this goal, the Mobitrust platform will request a specific QoS for the flow from the ***5G Core***.

Additional general network services may be involved, including a ***Firewall***, ***Policy Manager***, and ***WAN optimizer***.

3.6 UC5: Wearable, mobile, point-of-view, wireless video service delivery

3.6.1 Use case description

For this use case, RedZinc provides wearable video for mobile telemedicine applications. BlueEye Handsfree is a wearable video solution for paramedics (Figure 17) and nurses (Figure 18). A video camera is worn on an ergonomically designed headset. This camera sends live point of view video to a remote doctor. The doctor could be at a helpdesk, different part of the hospital, or at home at night. Real-time video of emergencies can benefit both patients and first responders. When the video is relayed to the emergency doctor at the hospital, the doctor can help with diagnosis, treatment and oversight before the patient reaches a hospital. For a stroke patient 'time is brain tissue' and for a heart attack patient 'time is heart muscle'. Using point of view video from the paramedic to 'immerse' the hospital-bound doctor in the remote scene allows for quicker delivery of, for example, clot busting drugs, which can benefit patient outcome.

RedZinc also has come up with wearable video for educational and training set-up (Figure 19). The medical professional gives a live demonstration of a medical procedure to students in remote locations such as students at home. The professor or medical professional wears the hands-free headset through which the live video and audio feed are transmitted to the students who are in remote locations. The students log in to the BlueEye portal using a laptop or smartphone and access the real-time video and audio feed.

Figure 17 below depicts Blue Eye Handsfree Regular for Paramedics:

Figure 17: UC5 Blue Eye Handsfree Regular for Paramedics.

Figure 18 below depicts Blue Eye Handsfree Regular for Nurses:

Figure 18: UC5 Blue Eye Handsfree Regular for Nurses.

Figure 19 below depicts Blue Eye Handsfree Classroom:

Figure 19: UC5 Blue Eye Handsfree Regular for Nurses.

3.6.2 Experiment phases or deployment scenarios

3.6.2.1 UMA Nursing School for medical emergency training Inside Simulation room Campus 5G

The deployment scenario in the UMA nursing home is the BlueEye Handsfree Classroom. In this scenario, a medical professional or professor who is inside a simulation room on the 5G campus provides online emergency medical demonstrations to the junior doctors or trainees located remotely. The medical professional or professor wears the BlueEye hands-free headset. The hands-free app transmits the live audio and video feed to the students. The students log in to the BlueEye portal using their laptop or smartphone for accessing the real-time video and audio feeds. For security, each student has a unique Personal Identification Number (PIN) for accessing the portal. The administration of the session is done by the moderator. This allows the professor or the medical professional to focus on the medical procedures rather than management of the session.

3.6.2.2 Andalucía Ambulance for Paramedic support in wide area 5G in public spaces

The scenario with Andalucía Ambulance focuses on the BlueEye Handsfree for paramedic support. The paramedic wears a headset camera connected to the BlueEye Handsfree app in the smartphone. The smartphone is connected to the 5G network in a public space. The paramedic is in a wide area and attends the patient. The headset camera sends a live point of view video feed to a remote doctor for medical consultations before the patient is taken to a hospital. The remote doctor logs in to the hot desk using unique login credentials. Hot desk is accessed from a laptop using browsers such as Firefox, Chrome or Safari. The hot desk also provides the GPS location of the paramedic at a given time. For expertised medical consultation, another doctor logins to the hot desk using unique login credentials to the see video feed as seen by the first remote doctor. Both doctors and the paramedics evaluate the current scenario with the help of hands-free device.

3.6.2.3 Medical applications in Aveiro search and rescue in wide area 5G in public spaces

The deployment scenario in Aveiro is related to search and rescue by a paramedic in a wide area in a public space. In this scenario, the paramedic wears the hands-free camera and goes to a wide area looking for the patient and triaging the condition of the patient with the doctor located away from the search and rescue area. The headset camera sends a live point of view video feed to a remote doctor for medical consultations before the patient is taken to a hospital.

3.6.2.4 Medical applications in Barcelona in wide area 5G in public spaces

The deployment scenario in Barcelona is similar to the deployment scenario in Andalucía Ambulance.

3.6.3 Use case main building blocks

The following figures show the main building blocks for BlueEye Handsfree.

- **Direct Connection** (Figure 20): Direct connection is established between the BlueEye app and the Hot Desk. This connection does not need any intermediate relay servers between the app and the Hot Desk. Media connections get established with the video server for unidirectional video, sent from the app and received in the hot desk. Media connections are also established with a video server **for the bidirectional audio and bidirectional data which are sent and received on both ends.**
- **Connections through Relays** (Figure 21): In case a direct connection is not established between the BlueEye app and the Hot Desk, the connection is established with the help of intermediate relay servers Traversal Using Relay NAT (TURN) between the app, video region and the hot desk. The TURN servers can be put either between app and the video region or between the video region and the hot desk or between app, video region and hot desk. The media connections get established with the video server for unidirectional video, sent from the app and received in the hot desk. Media connections are also established with a video server for the bidirectional audio and bidirectional data which are sent and

Figure 20: UC5 Direct Connection building blocks.

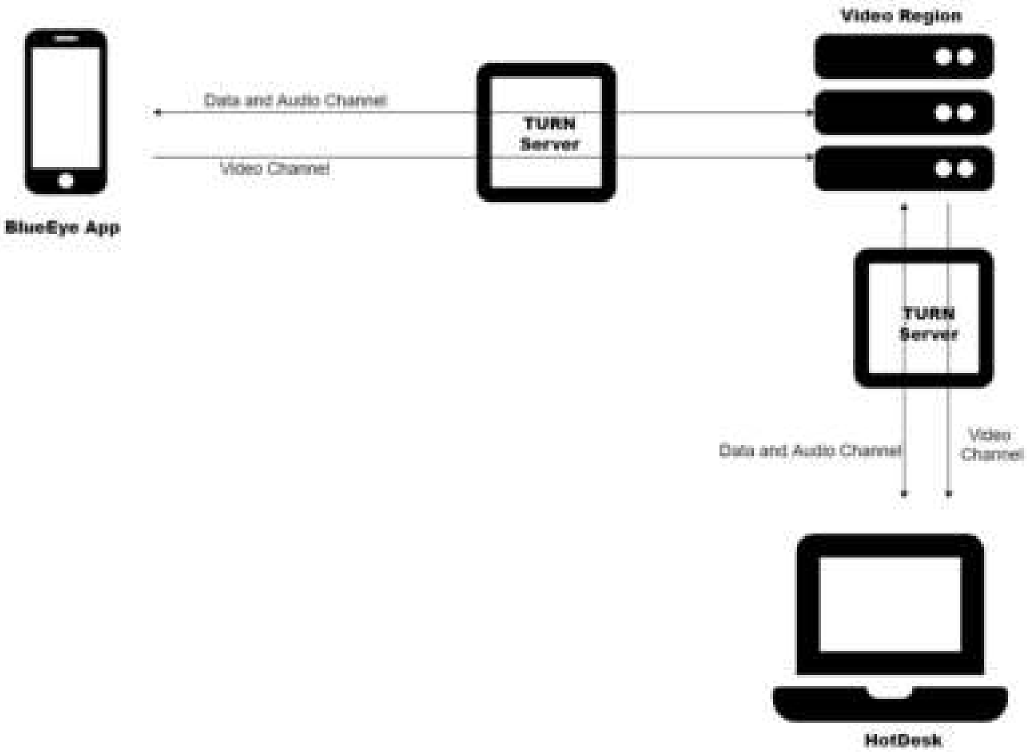

Figure 21: UC5 Through Relays Connection building blocks.

received on both ends. These media connections go through the TURN servers based on where these are put as mentioned above.

3.6.4 Use case requirements

The list of functional requirements for UC5 is provided in Table 15 below.

Table 15: UC5 functional requirements.

Req. ID	Use case functional requirements	Description	Related KPI
UC5-F1	Remote doctors/ students receive video and audio feeds.	The remote doctor and the students should receive the live video and audio feeds.	UC5-K1 UC5-K3 UC5-K5 UC5-K6
UC5-F2	1MP, 2MP and 5MP video feeds with negligible image impairments.	The video feed received by the remote doctor and students should not have poor quality frames.	UC5-K2
UC5-F3	Multiple medical endpoints receive audio and video.	Multiple remote doctors receive audio and video feeds.	UC5-K1

The list of technical requirements for UC5 is provided in Table 16 below.

Table 16: UC5 technical requirements.

Req. ID	Use case technical requirements	Description	Related KPI
UC5-T1	Firewall not blocking video feed.	The firewall rules should allow video feed to be transmitted to the remote doctor.	UC5-K1
UC5-T2	Bounded data packet loss.	The smartphone and the hot desk should be connected to a stable data network connection.	UC5-K2
UC5-T3	1MP, 2MP and 5MP video feeds with negligible image impairments.	Network has a virtual network function for Network Address Translation (NAT) management and for video distribution.	UC5-K4

3.6.5 Use case KPIs

The list of KPIs for UC5 is provided in Table 17 below.

Table 17: UC5 KPIs.

KPI ID	Description	Measurement procedure

UC5-K1	Live video feed from paramedic/nurse/medical professional to the remote doctor/students.	In case the remote doctor or students does not get the video feed, the hot desk will show a blank screen with an error message “No remote video”.
UC5-K2	Video feed quality because of packet loss.	Nuttcp[4] will be used to measure data packet loss.
UC5-K3	No impact on audio feeds from paramedic/nurse to remote doctor and vice-versa.	No audio verification at either or both ends.
UC5-K4	Functional testing of video.	Enable/disable ports to check whether video goes through from paramedic’s end to remote doctor’s end.
UC5-K5	Video quality perceived by the end user.	Mean Opinion Score (MOS) will be used to calculate video quality.
UC5-K6	Audio quality perceived by the end user.	MOS will be used to calculate audio quality.

3.6.6 Network services

The BlueEye Handsfree application is a cloud-based service application. It mainly consists of the BlueEye application management and the video region. The network diagram below (Figure 22) shows the Málaga video region.

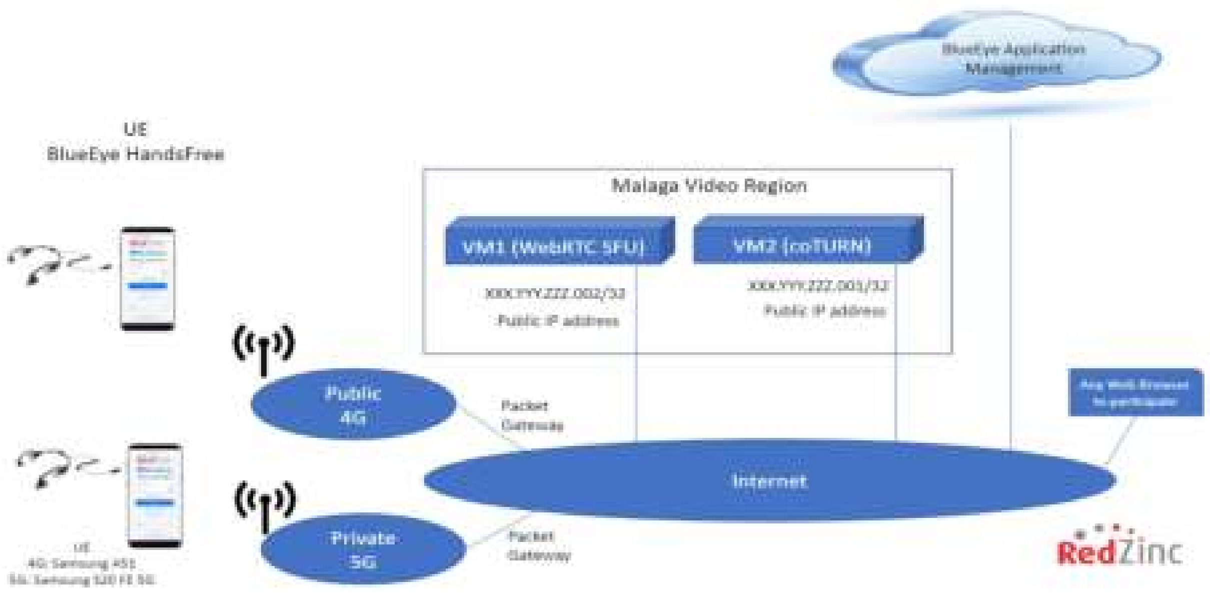

Figure 22: UC5 Network Services overview.

[4] https://www.nuttcp.net/

The BlueEye Application Management contains the software code which is hosted in the cloud. The BlueEye app on the smartphone and the hotdesk access the application management through ***WiFi/4G/5G networks***. The user at the hotdesk logs in to the BlueEye portal over the internet through a laptop or smartphone using regular web browsers such as Chrome, Firefox on Windows and Android machines and Safari on Mac machines.

The app sends the video feed captured from the camera and the audio feed via a media channel established between the app and the video region. The video region consists of virtual machines for WebRTC SFU and coTURN. The video region establishes a media connection with the hotdesk over the internet. Three media connections are established. These are unidirectional video streams from app to video region to the hotdesk and two bidirectional streams (one for audio and second for data) between the app and the hotdesk via the video region. The user equipment in use for the handsfree app are Samsung A51 4G version and Samsung S20 FE 5G version.

3.7 UC6: Fast situational awareness and near real-time disaster mapping

3.7.1 Use case description

OPTO intends to perform various Tests on the 5G-Infrastructure with an AI/AR-based software-system for a PPDR Use-Case in UC6: Fast situational awareness and near real-time disaster mapping.

Our Goal is to create an app and the associated hardware for using the 5G infrastructure via APIs to be defined. For this purpose, image data will be transferred from a camera system on a drone in a format to be defined to a request-reply connection in order to be received at a ground-station Emergency Control Centre (ECC).

The ground station will receive both image data and metadata. The former is to be stored in a file system and displayed on a Graphical User Interface (GUI) while the latter will be stored in a database. The storage of the annotated data is expected to enable evaluation and processing, adapted to a wide range of application areas.

In addition to managing the user data, the ground station will take on the task of controlling the aircraft, which will carry the optics and send the image data (Figure 23). The ground station will also be able to transfer the processed data (image and metadata) to other stations, for example, mobile units, to send and to receive commands from these stations in order to implement them for the imaging unit.

Overall, this UC will experiment with the complete solution path from imaging to processing and proceed with its evaluation over a 5G network, which in this case will be considered to be transparent.

In this UC, we are focusing on Video and Image Data to be transferred over the 5G network. The analytics focuses on AI-based algorithms to detect hazards (*e.g.*, fire). This allows to mark these hazards on an AR-based visualisation device. With this the first responders are able to use these data to expand their knowledge of the situation and to react faster.

Interfaces to the 5G network are realised by standard market devices like the most recent Apple iPhone 12 and iPad Pro.

In this UC, the drone is handled just as a vehicle to carry the information delivery systems. We are not focusing on autonomous flight situations. Therefore, the drone will automatically start and flight to a disaster location by a piloting person.

3.7.2 Experiment phases or deployment scenarios

The experiment utilises the following phases to be completed:

1. Determining the capabilities at the edge computing network services and the services provided by the testbed providers to best fit the use case hardware and software requirements.

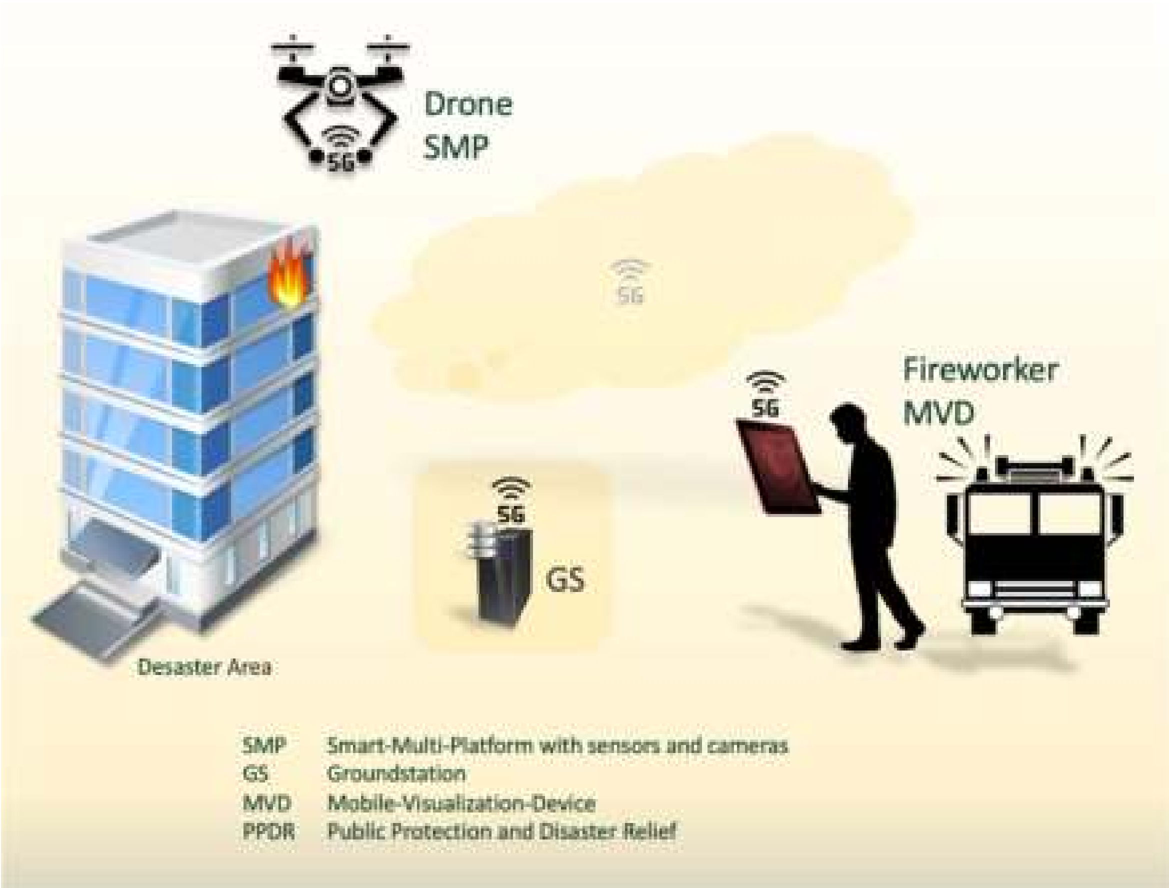

Figure 23: UC6 functional overview.

2. Develop the Drone as a vehicle and develop hardware and software parts to connect to the 5G network for image and data transfer.
3. Develop the ground station and the APIs to fit the requirements of the Drone System.
4. Determine performance issues and make optimisations to best fit the given environment.
5. Optimise latency behaviour to achieve high-quality user experience.
6. Fulfil KPIs for this UC in reducing reaction time by 20%, deliver information in <1000ms and automatic start and flight to disaster location.

This experiment can demonstrate the added value in case of reliability, end-to-end latency behaviour and the behaviour under heavy network load.

In one possible deployment scenario a responsible party of the disaster handling organisation can have a view to the current disaster area information and image material by several visualisation devices. The first responders at the disaster area are able to point a drone with the camera system to several points of interest.

The deployment of the UC itself is done by starting the drone with the camera system and have the information and image material displayed on the visualisation. All devices communicate with each other by 5G network-connections.

3.7.3 Use case main building blocks

The Main building blocks are: the drone including the camera system, the ground station (AI/AR component) and the visualisation device. The 5G network is the basis for the system. All building blocks communicate with each other by several 5G-network connections (Figure 24).

The data and media that the 5G-network has to transport consist of unidirectional communication for large image/video files and bi-directional communication for the smaller metadata and control data.

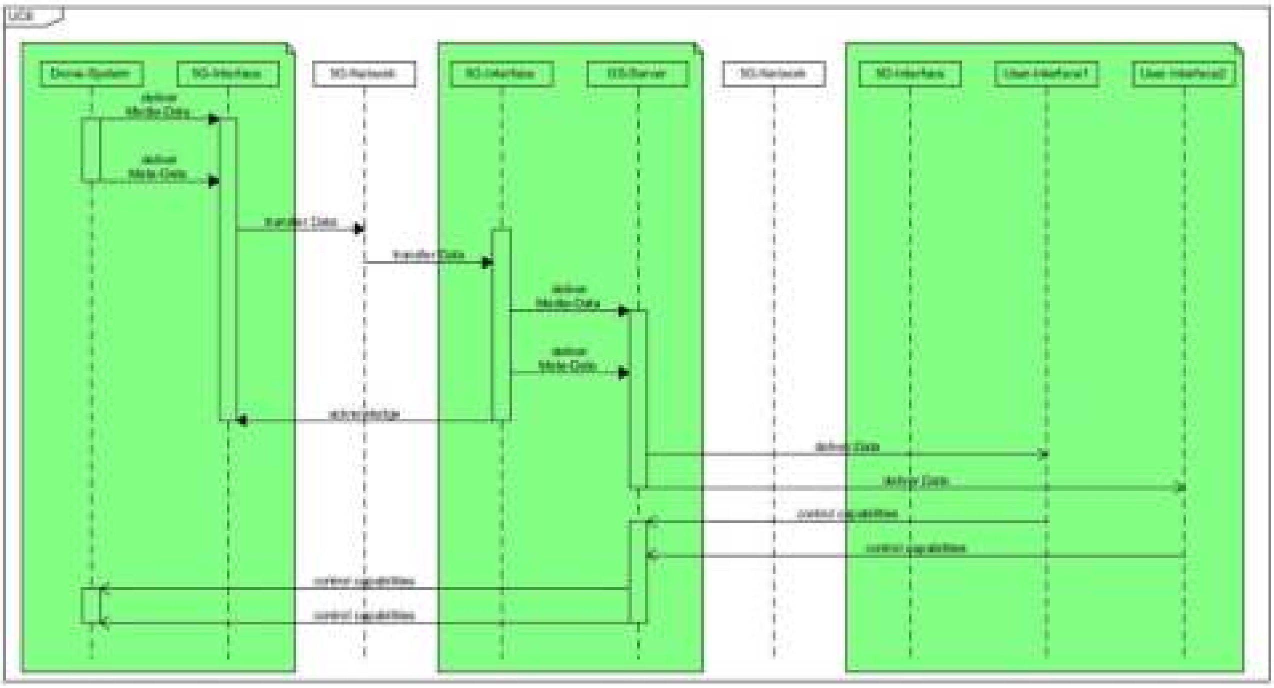

Figure 24: UC6 Main building blocks sequence diagram.

3.7.4 Use case requirements

The list of functional requirements for UC6 is provided in Table 18 below.

Table 18: UC6 functional requirements.

Req. ID	Use case functional requirements	Description	Related KPI
UC6-F1	User story for emergency handling.	The first responder and the emergency manager can surveil the disaster area. The planning site has the same information as the on-site personnel. That helps to reduce reaction time.	UC6-K1 UC6-K2
UC6-F2	Automatic start and flight to disaster area.	The first responder shall be able to control the drone and the drone's camera system on-site. The first responder shall be able to pilot the drone with the camera system to points of interest in the disaster area.	UC6-K1 UC6-K2

UC6-F3	Reaction time.	The aim is to reduce the communication time and optimise communication flow for the first responder and the operation management.	UC6-K1
UC6-F4	Information delivery.	The delivered views from the drone's camera systems shall have a low latency not greater than 1000ms.	UC6-K2

The list of technical requirements for UC6 is provided in Table 19 below.

Table 19: UC6 technical requirements.

Req. ID	Use case technical requirements	Description	Related KPI
UC6-T1	Reliable and fast network connection to transfer image data and metadata to the first responder device or ground station.	The drone's camera system connects to the 5G network to transmit image data and metadata and receives control codes to set camera parameters.	UC6-K1 UC6-K2
UC6-T2	5G Network Services NTP and DNS.	The drone's camera system needs to know the correct date/ time to annotate image data and metadata and get all devices synced.	None
UC6-T3	Device Connections.	Devices that must be used to connect to the 5G network eMBB Service: • Apple iPhone 12 Pro Plus • Apple iPad Pro	None

3.7.5 Use case KPIs

The list of KPIs for UC6 is provided in Table 20 below.

Table 20: UC6 KPIs.

KPI ID	Description	Measurement procedure
UC6-K1	Reaction time is the communication time between the first responder and the operation management to make a decision.	The starting point for measuring is defined by sending the first image of the disaster area by the camera system. Endpoint is defined by transmitting the image and/or information from the operation management to the first responder. All images are annotated with sent and received timestamps, so the time difference can be calculated.
UC6-K2	Information delivery time is the time elapsed between the transportation of big data from the camera system and	Measurement is done by calculating the time difference between the time an image is sent by the

	the processed information delivery to the visualisation devices.	camera system and the time the image is received by the first responder. All images are annotated with sent and received timestamps, so the time difference can be calculated.

3.7.6 Network services

UC6 will require the instantiation of the following VNFs:

- Support ***Drone Camera System*** to deliver Media- and Meta-Data:
  - ***5G-network*** has to transport big media data with low latency from the camera-system to ground station and visualisation devices.
  - 5G-network has to transport small metadata with low latency to and from the camera system to ground station and visualisation devices.
- Support ***Ground station*** to deliver processed data:
  - 5G-network has to transport processed big media-data with low latency from the ground-station to visualization devices.
  - 5G-network has to transport small meta-data with low latency to and from the ground-station to visualization devices.
- Support ***Visualisation-Devices*** to display the processed data and to send control messages:
  - 5G network has to transport small metadata with low latency to the ground station or/and to the camera system.
- Provide Network-Service ***NTP***: to sync all devices a global network time is required.
- Provide Network-Service ***DNS***: to name and find all devices a global name service is required.

3.8 UC7: AR and AI wearable electronics for PPDR

3.8.1 Use case description

YBQ is the manufacturer of the "Talens" Smart Glasses, a wearable computer equipped with augmented reality and artificial intelligence features. Coming off a successful record of accomplishment with the manufacturing industry, the Smart Glasses come equipped with Smart Personal Assistant and Video Conference software, which YBQ plans to integrate into the rescue and operations environment. In this UC, YBQ aims to experiment with its Talens Holo Smart Glasses in 5G network conditions, targeting two cases of interest to the PPDR domain:

*Real-time semantic segmentation (*Figure 25*),* instance segmentation and edge detection will be used to overlay useful information directly on top of the real world through the optical see-through display worn by police officers who patrol or operate in a designated area. For the realisation of this scenario, low latency edge devices interconnection is a requirement so that ML processes dealing with costly, AI-driven semantic segmentation procedures can run efficiently in order to provide real-time view annotation. The overall SA mechanism for the officers will be complemented by data interchanged between the operation site and the CCC. Finally, if drones are available on-site, ML elaborated info coming from their cameras can be shown on the AR layer such as number of people injured, fires placement, public forces on the field and so on.

*Real-time first aid assistance (*Figure 26*),* an AR-based remote medical assistance application will allow first responders to stream real-time video of a patient to a remote terminal and remote practitioners. Through the remote terminal, a doctor can provide the necessary medical information and guidance on the actions that the first responder should carry out to address the patient's needs. Furthermore, with the use of AR glasses, the remote medical assistant will be able to annotate on the patient's image specific areas of interest that need the immediate responder's enactment, as well as relevant animations exemplifying what needs to be done.

3.8.2 Experiment phases or deployment scenarios

3.8.2.1 Scenario 1 – Police officers

A set of police officers wearing Smart Glasses are able to see AR info on the disaster scene. The AR layer is composed of information locally elaborated into the wearable processing unit together with information remotely elaborated by ML algorithms in the CCC. The Smart Glasses worn by the police officer send an audio/video stream to the CCC for ML SA evaluation. In the CCC a set of views can be developed in order to analyse the different information coming from the disaster field, segmented by its meaning, i.e., a heat map to highlight the movements of police officers onto the field. All the police officers wearing the Smart Glasses can start an audio/video call with the remote CCC.

3.8.2.2 Scenario 2 – Medical doctors

An audio/video stream connection using the Smart Glasses is established between a medical practitioner on the disaster field and a medical doctor (or a staff member) remotely connected via the 5G-EPICENTRE web platform. Both are able to talk as a classic audio/video call, but the AR layer can enable the practitioner to receive information from the remote medical staff as AR information superimposed on the real scene, i.e., the patient to be treated. For this, the remote medical staff can use the web application to select items on the video stream or design something on his/her screen that will be presented in real time onto the Smart Glasses display.

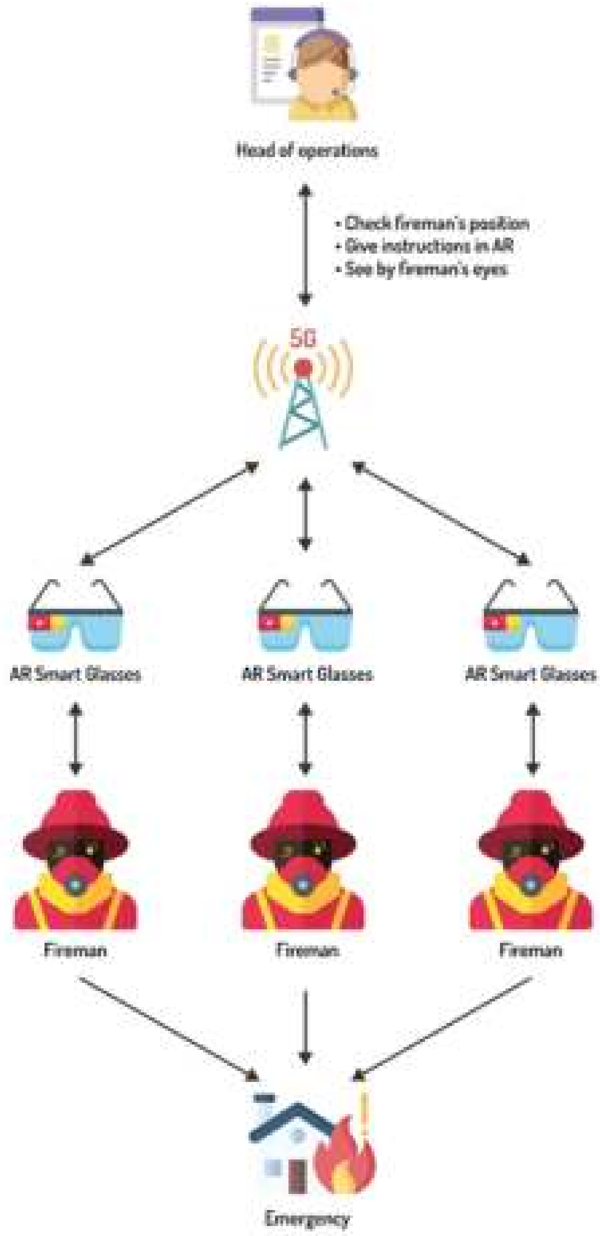

Figure 25: UC7 real-time semantic segmentation.

What the two scenarios have in common is the use of 5G controlled drones. The drones could be sent on the disaster field prior to the arrival of firefighters and doctors. Drones' cameras can map the scene, theirs images can be shared with the CCC and this info can be useful for the people wearing Smart Glasses sent to the field before they arrive.

Moreover, during the action, people wearing Smart Glasses can receive elaborated real-time info from the video flow acquired by drones. Using the fast 5G connection, the drones' video flow can be sent from the drones to the CCC, can be elaborated with ML algorithms and then sent to the Smart Glasses to have a complete awareness of the situation.

From a technological point of view, different mobile applications have to be designed and developed for the Android platform (the OS of the Smart Glasses) and to manage the drones' communication. In the AR field, there are different AR engines available; the first tests done using the Unity Framework are promising and suggested.

Endpoints identification:

- On-the-field users wearing the Smart Glasses: these users receive information in AR mode to quickly act for rescue (police officer or firefighters) or for medical services (doctors).
- Drones for the monitoring of the field activities.
- MCS Server: the MCS Server provides the control and management of voice, video and data communications for audio/video calls. It includes the MCS Controlling Server, the MCS Participating Server, the API gateway, the Identity Management Server (IdMS), the Key Management Server (KMS), the Group Management Server (GMS), the Configuration Management Server (CMS), the SIP Core, the HTTP Proxy and the MCS Configuration Server.
- Map Server for delivering map static tiles in real time to MCS mobile user and dispatcher applications.
- Mission Management Application Server.
- Mission Management Application Clients.
- Mobile PPDR users.
- 5G network elements.
- PPDR Dispatchers/Control room application users.
- Command & Control: the information-gathering centre will receive video streams from the field and manage to coordinate forces; for the medical staff, specialised medical doctors can be involved in order to establish a Mixed Reality video call.

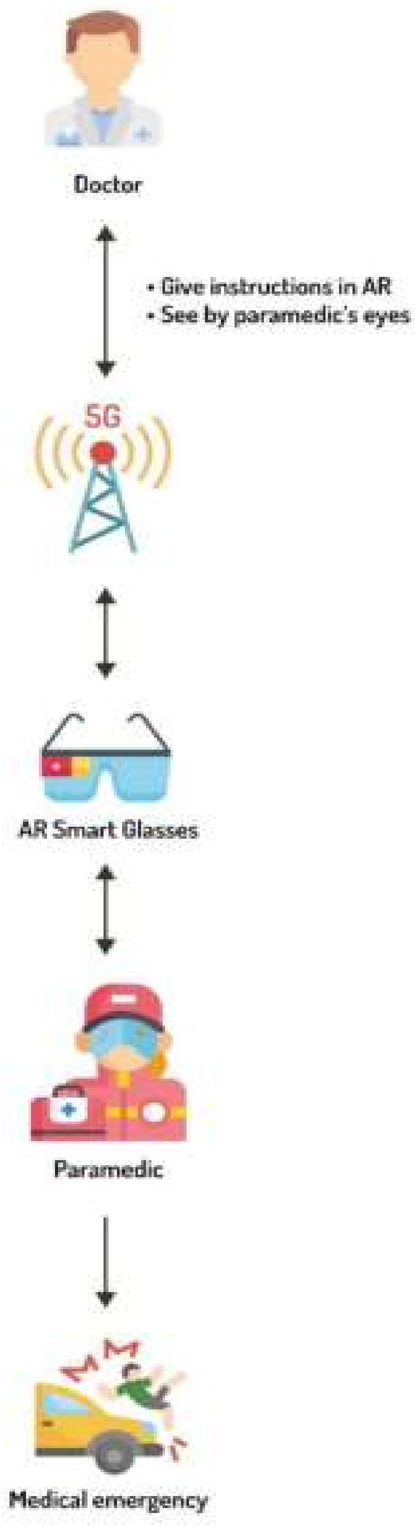

Figure 26: UC7 real-time first aid assistance.

3.8.3 Use case main building blocks

In Figure 27 the data flow from the PPDR user and the CCC is represented.

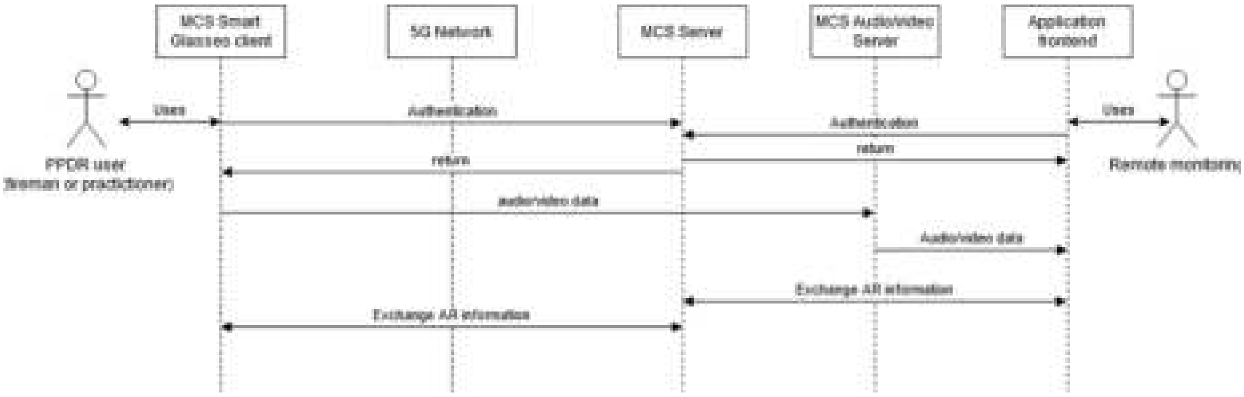

Figure 27: UC7 building blocks interaction.

3.8.4 Use case requirements

The list of functional requirements for UC7 is provided in Table 21 below.

Table 21: UC7 functional requirements.

Req. ID	Use case functional requirements	Description	Related KPI
UC7-F1	Field situation awareness.	The user shall be aware of the current field situation in order to manage and coordinate.	UC7-K1
UC7-F2	Remediation of a threat.	The user shall be aware of the current field situation in order to remediate.	UC7-K2
UC7-F3	Visualisation of context-related AR information.	The user shall visualise AR information related to the context in which he is involved.	UC7-K3

The list of technical requirements for UC7 is provided in Table 22 below.

Table 22: UC7 technical requirements.

Req. ID	Use case technical requirements	Description	Related KPI
UC7-T1	Data collection and monitoring.	In order to identify the incidents and trigger the required actions, data collection and monitoring shall occur.	UC7-K1
UC7-T2	Data collection and monitoring.	In order to apply the required actions, data collection and monitoring shall occur.	UC7-K2

UC7-T3	Audio/Video streaming and data flow communication.	Audio and video shall be sent from the Smart Glasses to the CCC. There, ML algorithms shall evaluate the context and send the info to the Smart Glasses to be represented in the AR layer.	UC7-K3

3.8.5 Use case KPIs

The list of KPIs for UC7 is provided in Table 23 below.

Table 23: UC7 KPIs.

KPI ID	Description	Measurement procedure
UC7-K1	Issue detection time: is the time elapsed from the start of the disaster event to the instant in which the user takes charge of it.	To measure this KPI, the system shall log messages exchanged on the platform; the elapsed time from the start of the incident to the first messages coming from the field, in which the user confirms the intervention, shall be calculated. This “time to detect”, in average, shall be 30% less than the usual case carried out without 5G-EPICENTRE.
UC7-K2	Intervention evaluation time: is the time elapsed from the instant in which the user takes charge of the disaster event to the instant in which the user mark it as solved.	To measure this KPI, the system shall log messages exchanged on the platform; the elapsed time from the start to the end of the intervention shall be calculated. This “time to resolve”, in average, shall be 20% less than the usual case carried out without 5G-EPICENTRE.
UC7-K3	Information flow time: is the time elapsed from the start of the audio/video streaming coming from the user onto the field to the AR information shown onto the Smart Glasses display.	To measure this KPI, the system shall log the timing of the information flow exchanged on the platform; the elapsed time from the start of the audio/video stream to the AR information representation shall be calculated. This “time to present”, on average, shall be less than 1000 ms.

3.8.6 Network services

UC7 will require the instantiation of the following VNFs:

- ***Drone communication to deliver Media Data***: drones are employed on the field to acquire video information before and during the PPDR user interventions. This VNF allows the video stream to be sent to the CCC in order to be evaluated by the remote operators, or even automatically.
- ***5G core with GPS positioning***: this VNF manages the GPS positioning of PPDR users on the field; the GPS position is used to have a complete and real-time knowledge of users’ positions and dislocations.
- ***MCS Server***: this VNF contains all the necessary modules for the control and management of voice, video and data communications.
- ***MCS API Gateway***: this VNF implements the gateway which manages incoming API requests from external applications and routes them to the right MCS Server module.
- ***Map Server***: this VNF hosts the map and provides the map elements (tiles) to the MCS clients.

- ***Mission Management Server***: this VNF enables mobile client to download and install a mobile application for tactical situation awareness which provides geographical information, PPDR resources allocation and instant messaging.
- ***DNS Server***: this VNF provides a name server based on the Domain Name System (DNS).
- ***NTP Server***: this VNF provides a Network Time Protocol (NTP) based server.

3.9 UC8: AR-assisted emergency surgical care

3.9.1 Use case description

ORAMA will employ its know-how to perform various tests on the 5G infrastructure via an AR-assisted surgical care application for PPDR. In these experiments, we aim to overlay deformable medical models directly on top of the patient body parts, effectively enabling surgeons to see inside (visualising bones, blood vessels *etc*.) and perform surgical actions following step-by-step instructions (Figure 28). This use case ultimately aims to provide first aid responders on the PPDR scene with a powerful tool that will help save lives in peril. Using untethered lightweight AR head-mounted displays (HMDs), the responders will be able to visualise various deformable, internal body parts on top of the patient as if they had super-human vision. Furthermore, an instruction set will allow them to perform various operations with the possibility of remote guidance from a medical expert.

The current state-of-the-art, driven, among others, by ORAMA's innovative VR Engine *MAGES*, allows the usage of tethered VR HMDs to perform similar tasks such as perform VR surgeries. In the particular set-up, HMDs have to be connected (wirelessly or with a cable) to a VR-ready local computer (high performance GPU/CPU) to create a high Frames-per-Second (FPS) VR scene. Within the 5G-EPICENTRE project, ORAMA aims to bring the power of *MAGES* to untethered AR HMDs. Moving the processor-heavy rendering operations to the edge/cloud services

Figure 28: UC8 The PPDR responder uses the AR HMD to see overlayed info and deformable objects on top of the patient.

provided by the 5G-infrastructure, we aim to use AR HMDs to mostly receive the rendered scenes and only broadcast the necessary information back to the cloud via a 5G connection. Since the heavy processing will not be performed on the device, we expect a significant decrease in the HMD's energy consumption while the use of inexpensive, light-weight HMDs will now become a possibility. As the PPDR first responder may be located outdoors at any incident site, the increased energy autonomy of the portable device will reduce environmental impact and enable greater portability of the whole project.

3.9.2 Experiment phases or deployment scenarios

The experiment is expected to be performed in the following phases:

- Identify the capabilities of the 5G network architectures and services provided by the testbed providers as well as the edge computing network services.
- Create a suitable version of an AR application, which will run on the edge.
- Develop the necessary VNFs to manage data-intensive services (*e.g.*, prerendering, caching, compression), exploiting available network resources and multi-access edge computing (MEC) support provided by 5G-EPICENTRE.
- Determine potential performance bottlenecks of operating a monolithic AR application and suggest offloading of the software architecture through microservices without adding excessive inter-services latency.
- Fine tune the AR application to fully exploit available network resources and MEC support provided by 5G-EPICENTRE.
- Fulfil our KPIs regarding bandwidth usage and latency, as well as device energy consumption.
- Compile a list of insights towards a better understanding of the 5G network utilisation in conjunction with state-of-the-art AR applications and present the tools that were used throughout the experimentation.

Various tests that may be used to demonstrate the added value of the experiment:

- Measurement of end-to-end latency using different configurations of data compression.
- Conduct load testing to determine the optimal number of users that the network allows within the latency threshold.
- Conduct stress testing to determine the number of users that the network can accommodate without inducing network congestion while preserving QoE.
- Experiment with possible state-of-the-art patient and object recognition methodologies to provide better data overlay.
- Examine different user interfaces in search of the optimal solution that provides a smooth user experience while visualising the proper amount of information streamed from the edge.

Certain scenarios are described in section 3.9.3 below: Start App, Create Session and Join Session.

3.9.3 Use case main building blocks

- Entire computing part of the application is offloaded to the edge, leaving the HMD responsible for UI, input/output.
- The HMD is responsible for:
    - Reconstruction and transmission of the physical scene mesh.
    - Transmitting user input for event handling.
    - Decoding the received rendered frame before being displayed on the HMD.
- The computational node resides on the edge and supports:
    - All related processing from the MAGES SDK and the game engine,
    - Storing data assets.

   - Recognising the physical scene.
   - Computing deformable objects to be overlayed.
   - Rendering the appropriate images to be overlayed.
- Encoding the frames before transmitting to the HMD.
- In a multi-user session, one instance of the application is instantiated per HMD.
- Each instance communicates with other instances through a relay server.

The steps above are summarised in Figure 29 .

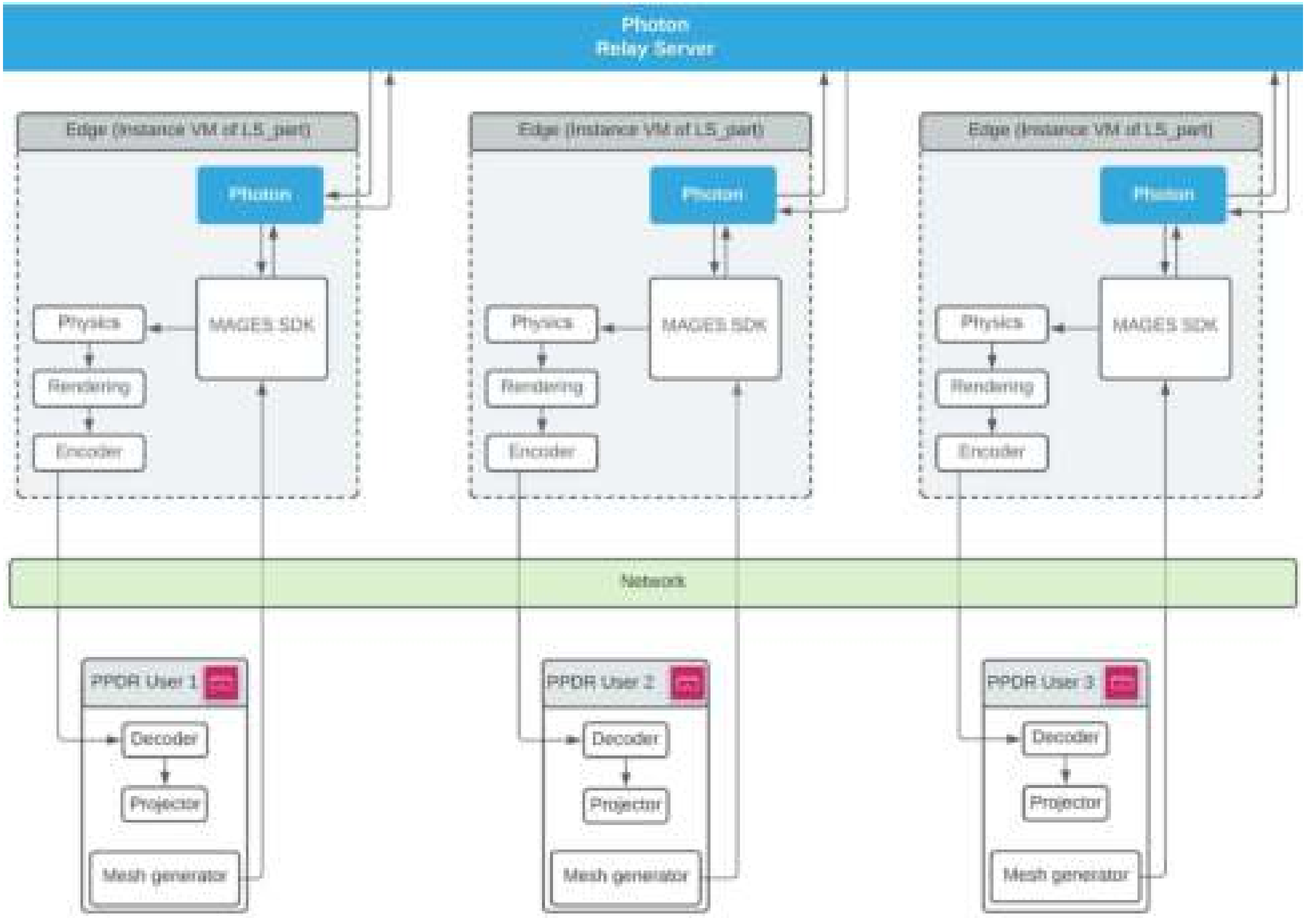

Figure 29: UC8 Conceptual architecture.

In the sequence diagrams below the different use case scenarios are depicted: Start App, Create Session and Join Session.

Start App (Figure 30): The headset (local) application upon launch will communicate with the 5G-EPICENTRE platform and demand to deploy a dedicated (remote) application instance on the Edge. After deployment on the edge, the IPs of both signalling server instance and the local system (LS) instance are sent to the 5G platform. Acknowledge data that a communication between these two parts was successful will also be sent to the 5G platform. All these details will be broadcast to the application running locally on the headset, and after the handshake of the local and remote instance, the deployment procedure is complete.

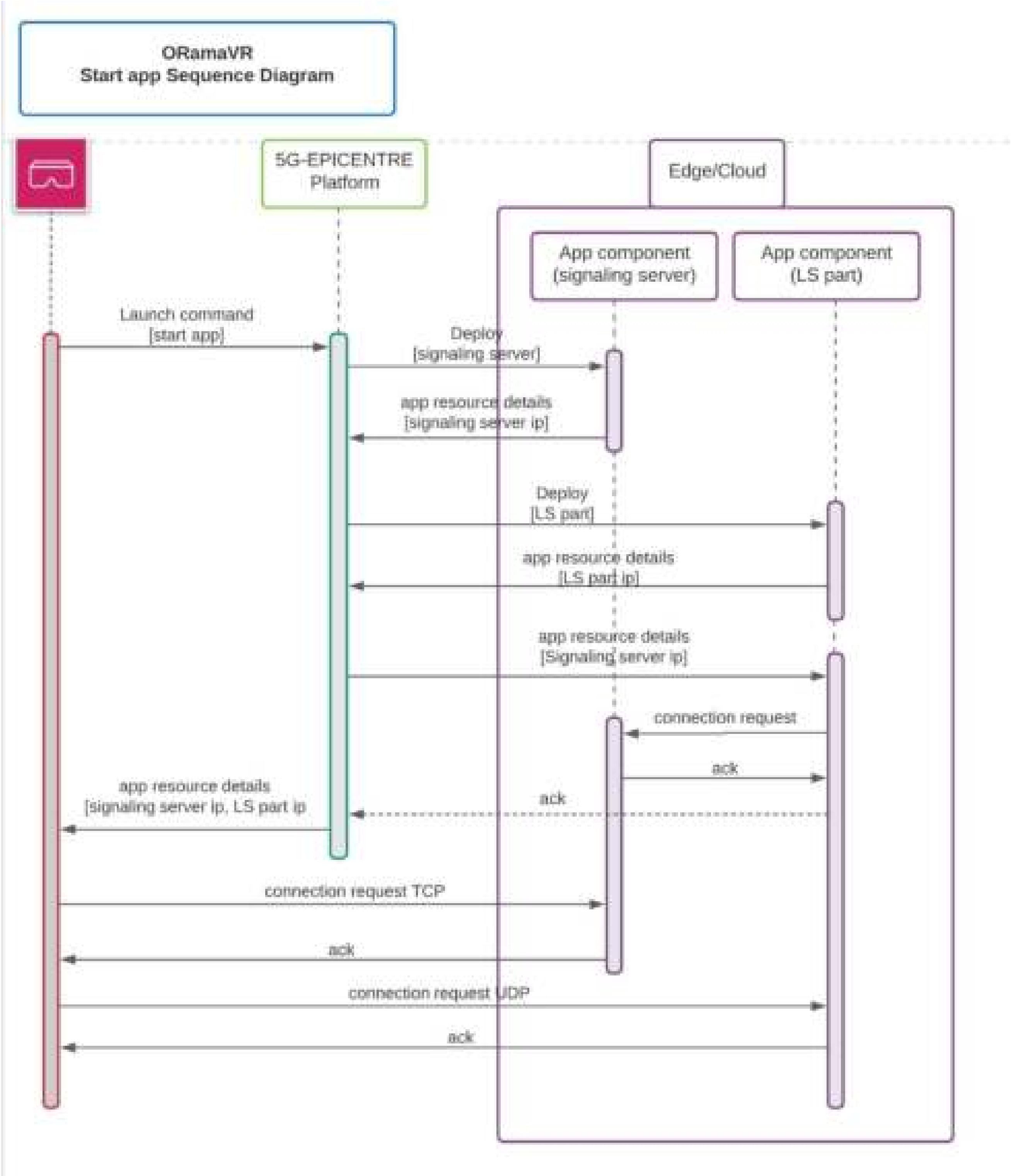

Figure 30: UC8 ORamaVR Start app sequence diagram.

Create Session (Figure 31) & **Join Session** (Figure 32): After the edge instance is created and assigned to the local

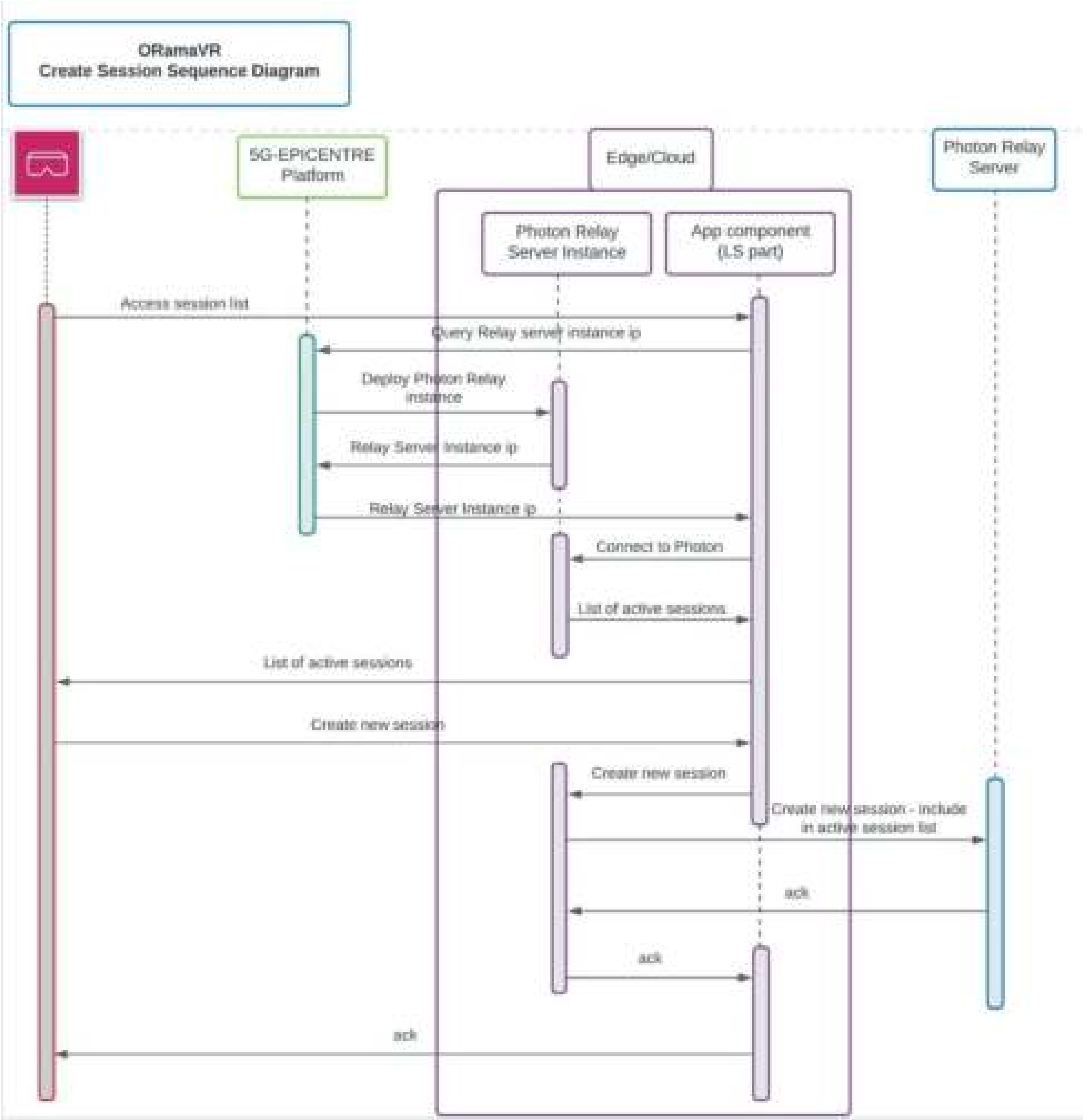

Figure 31: UC8 ORamaVR Create Session sequence diagram.

application, the user may choose to create or join an AR session. The corresponding VNF will relay relevant information (*e.g.*, IP, capacity, network bandwidth status, geo-location) regarding the newly created or existing session(s) and establish necessary connections between the LS part instance, the photon relay server and the user headset.

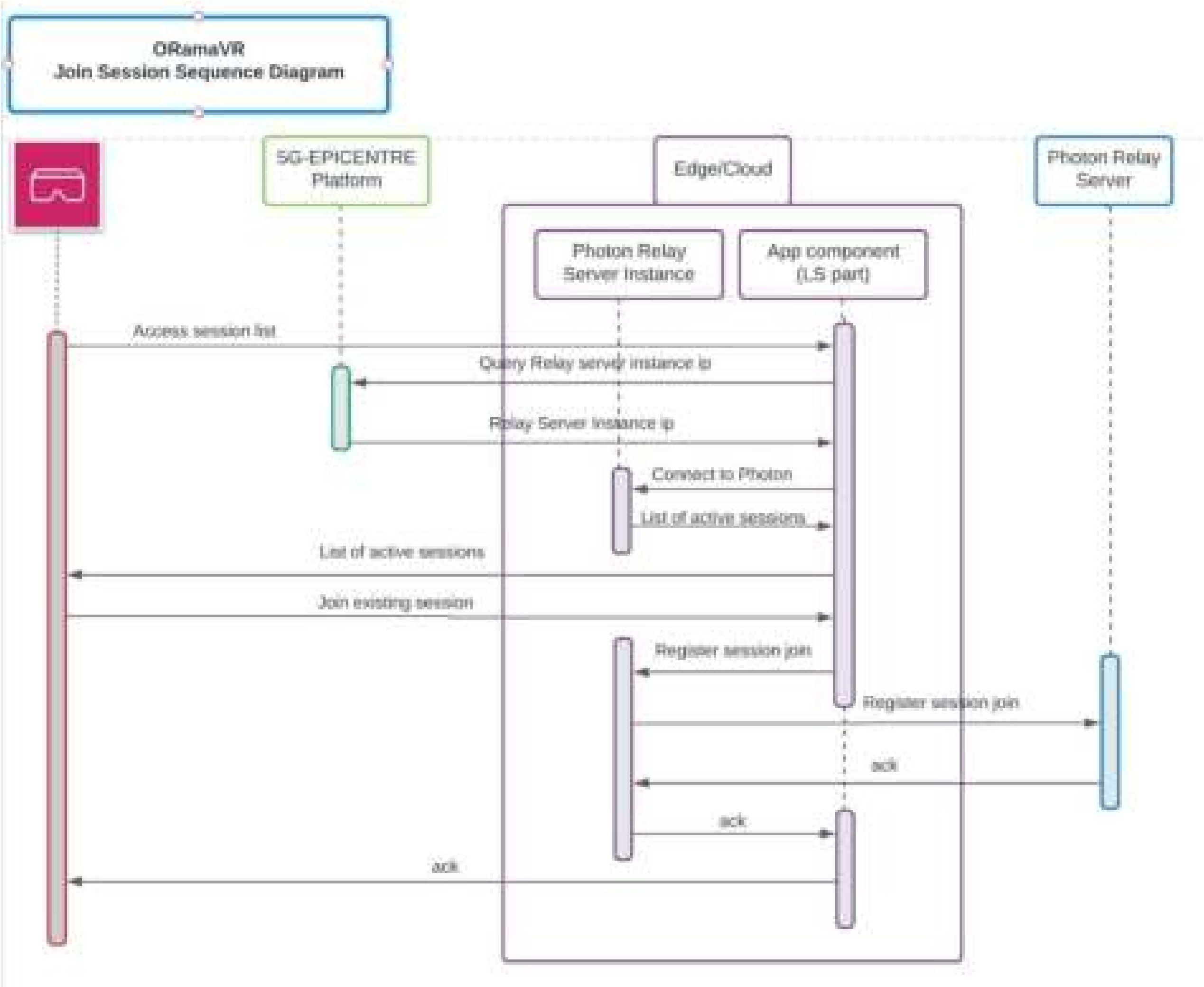

Figure 32: UC8 ORamaVR Join Session sequence diagram.

3.9.4 Use case requirements

The list of functional requirements for UC8 is provided in Table 24 below.

Table 24: UC8 functional requirements.

Req. ID	Use case functional requirements	Description	Related KPI
UC8-F1	Join/Create Session.	First Aid Responder must be able to create session or select an existing session from the application on the HMD based on credentials.	None
UC8-F2	Display Analytics.	First Aid Responder and/or Head-of-operation must be able to visualise performance analytics on the HMD and obtain a report on them after the operation.	UC8-K1 UC8-K2 UC8-K3

UC8-F3	APK Repo.	Head of Operation must be able to install and update the Application on the HMD through a cloud-based repository.	None
UC8-F4	APP Accessibility.	First Aid Responder must be able to open and log in to ORAMA AR application when connected to a 5G network without any additional system configuration (provided with the suitable credentials).	None
UC8-F5	Voice Communication.	First Aid Responder and Head-of-operation must be able to communicate with each other via voice.	UC8-K2
UC8-F6	Real-Time Interaction.	First Aid Responder must be able to choose menus, charts and items to be displayed by the HMD in real time.	UC8-K1 UC8-K2
UC8-F7	Show Deformable Objects.	First Aid Responder must be able to choose via a context menu to visualise deformable models of internal organs, tissues, vessels, bones, *etc.*, overlayed on top of the patient.	None
UC8-F8	Show Step-by-Step Instructions.	First Aid Responder must be able to choose and view, via a context menu, step-by-step instructions of a chosen medical operation.	None
UC8-F9	Object – Menus Real-Time Interaction.	First Aid Responder must be able to interact with projected deformable objects and menus with controllers in real-time.	UC8-K1
UC8-F10	Warnings.	First Aid Responder must be warned if there is a fluctuation on the network that may cause delay.	UC8-K1

The list of technical requirements for UC8 is provided in Table 25 below.

Table 25: UC8 technical requirements.

Req. ID	Use case technical requirements	Description	Related KPI
UC8-T1	HMD sensors & Controllers' monitoring.	The data from the HMD sensors and its controllers are monitored and uploaded to the cloud.	UC8-K1
UC8-T2	HMD Network monitoring.	The network signal, data rates and data size are logged and uploaded to the cloud.	UC8-K1 UC8-K2
UC8-T3	HMD Battery monitoring.	The battery level of the HMD is logged and uploaded to the cloud.	UC8-K3

UC8-T4	IP / Geolocation tracking.	The IP address and geolocation of the HMD is uploaded to the cloud in order for the closest edge node to be selected to run the AR application instance.	UC8-K1
UC8-T5	HMD specs identification.	The type and specs of the HMD are broadcasted to the app instance on the edge, to allow for the best suited resolution of deformable objects and menus to be retrieved from the edge.	UC8-K2 UC8-K3
UC8-T6	Video Streaming.	The edge node must be able to stream the video output of the AR application at an efficient fps rate to the HMD.	None
UC8-T7	Voice Streaming.	The HMD must be able to send and receive voice streaming from the AR app on the edge.	None
UC8-T8	Data Logging	The HMD must be able to keep data regarding the user preferences and current state, as well as their user-id.	None

3.9.5 Use case KPIs

The list of for UC8 is provided in Table 26 below.

Table 26: UC8 KPIs

KPI ID	Description	Measurement procedure
UC8-K1	The time (referred to as E2E latency) it takes for an action/trigger to be transmitted from the HMD to the edge instance must be less than 7ms. The same term also refers to the time it takes for a frame rendered on the Edge to be transmitted to the HMD.	RTT measurements from the app instance on the edge.
UC8-K2	The receiving/transmitting data rate from the HMD to the edge should be at least 0.7Gb/s.	Continuous network metering reports for package transfer and losses from the app instance on the edge.
UC8-K3	The HMD energy consumption should be at least 30% lower compared to the case where all heavy-duty processes (rendering / physics) are processed on the untethered HMD.	Periodic Battery status measurements transferred from the HMD to the app instance on the edge.

3.9.6 Network services

ORAMA’s AR application uses internally the following network services:

- ***Image Streaming Service (WebRTC):*** A service used to stream rendered AR content from the edge instance to the HMDs.
- ***Relay Server (Photon):*** A service used to relay actions and triggers from the HMDs to the edge instance and also between instances for collaborative gaming.

Additional network services, apart from ORAMA's AR application, are:

- ***Radio Access:*** A service that will allow the connection of the HMDs with the 5G network.
- ***5G-EPICENTRE Communication:*** A service that will allow the communication of the HMDs with the 5G-EPICENTRE portal and edge-based services.
- ***Load Balancing Service:*** A service used to allocate resources to multiple edge instances of the ORAMA's AR application to optimize performance.
- ***Orchestrator Service:*** A service that automates the configuration, coordination, and management of the various microservices and containerised edge-instances.
- ***Linked network Service:*** A service that will allow the discovery of users and sessions that are already logged in and running respectively.

4 Conclusions

The purpose of the current deliverable is to provide a preliminary and common vision about the first party PPDR oriented experimentations conducted during the project lifetime. The content of the document has been elaborated with the contributions provided by the use case leaders and formulated for heterogeneous audiences, including audiences not familiar with the PPDR sector.

Associated with “Task 1.1: Pilot Experiments Formulation”, its objective has been to present an overall description of the experiments, as well as a more detailed vision of the basic network architecture, specific requirements and KPI and necessary network services to run the use cases.

In order to collect and homogenise the above-mentioned descriptions, several format iterations have been considered in order to satisfactorily respond to the required outputs for this document, i.e., to provide a thorough experiment descriptions and to identify the network services that should be instantiated for the successful deployment over the 5G-EPICENTRE platform.

With respect to the experiments, different PPDR scenarios have been presented, covering numerous declensions: mission critical communications, drone navigation, coordination and management platforms, wearable video systems and AR for various purposes. Each one with its respective requirements have mostly converged to highlight the importance of the availability of the provided service, the end-to-end latency times and the specific actions triggering time face to sudden emergency and critical situations.

In the updated version of this document, delivered in M22, the intention is to provide a final description of the first party use cases and the eventual mapping into the testbeds shaping the 5G-EPICENTRE platform, helped by the maturity of other project’s tasks as well as the continuous work carried out in T1.1.