CEF-DIG-2022-5GSMARTCOM-WORKS - 5G for Smart Communities – Works
5G for a Better Tomorrow: Protecting Lives and the Environment in Riga and Turin
Grant Agreement No 101133716

5G4LIVES D2.3 5G4LIVES SERVICES CO-CREATION, FUNCTIONAL SPECIFICATIONS AND REFERENCE ARCHITECTURE (1ST VERSION)

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5G4LIVES
D2.3. 5G4LIVES SERVICES CO-CREATION, FUNCTIONAL SPECIFICATIONS AND REFERENCE ARCHITECTURE (1ST VERSION)

Project Title:	5G for a Better Tomorrow: Protecting Lives and the Environment in Riga and Turin
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Project Coordinator:	RIGAS PILSETAS PASVALDIBA
WP Leader:	RIGAS PILSETAS PASVALDIBA

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REVISION TABLE

Version	Date	Comments
1.0	13.02.2025	Draft table of contents sent for discussion to LMT, ECO (EX VASES), MoT, PoT, Wind3.

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1.1	19.03.2025	Finalised table of contents after discussion with all involved partners
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2.1	09.05.2025	Obtaining information from Italian partners about the Torino use-case and deviations regarding 5G USIM and local private core network integration
2.2	20.05.2025	Obtaining information from LMT and ECO (EX VASES) about the Riga use-case, UAV technological analysis and regulatory barriers
2.3	12.06.2025	Adding information from RCC about the 5G4LIVES concept, scaling opportunities, and future use-case scenarios
3	26.06.2025	Redaction of summary, introduction and conclusion part, formatting work and review.
3.1.	30.06.2025	Final version ready for submission

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5G4LIVES ABSTRACT

In an era where technology is advancing at an unprecedented pace, the project takes centre stage as an initiative committed to harnessing innovation for the greater good. This project unfolds its transformative vision across two distinct geographic clusters, Latvia and Italy. It strategically leverages 5G connectivity alongside cutting-edge technologies such as Unmanned Aerial Vehicles (UAVs or drones) and alternative hydrogen power. With a dual mission of enhancing public safety and environmental health, the project unfolds a narrative where data-driven forecasting and real-time aerial situational awareness become the bedrock of a more secure, efficient, and sustainable future.

At its core, the project seeks to enable optimal emergency management and data-driven forecasting, a mission encompassing the entirety of public safety. Through the dynamic fusion of 5G connectivity and UAVs, this initiative aims to provide real-time aerial situational awareness and automatic vulnerability assessment for at-risk areas. The project's scope extends beyond traditional rescue operations, pushing the boundaries of innovation to safeguard both human lives and the environment.

The project in Latvia involves using drones and 5G technology for monitoring and rescue operations, especially at Vecaku Beach and Kisezers Lake in Riga. This approach aims to enhance police efficiency, particularly in challenging terrains. In Turin, the focus is on developing a 5G-enabled service for situational awareness and vulnerability assessment to counter natural disaster threats. This includes testing anti-drone hacking technology, integrating satellite data, and improving pilot-drone command for better emergency response. The project also includes research in Riga on safety protocols and procedures for urban drone operations and beyond-visual-line-of-sight (BVLOS) flight methodologies with EU-wide relevance. A significant aspect of the project is to engage in extensive communication to inform and educate local, national, and EU networks about these technological solutions.

By leveraging 5G and drones, the project promises quicker and more effective emergency response, addressing staff shortages in law enforcement and expanding their skill set. In Latvia, the use of drones and 5G connectivity will empower law enforcement to intervene more swiftly, addressing staff shortages and expanding the skill set of police officers. In Italy, the project will mitigate the threat of natural disasters and test innovative anti-drone hacking technologies, leading to more efficient emergency responses. Additionally, developing safety protocols and procedures for urban drone flights and validating BVLOS flight methodologies will set new standards for public safety and security. The project emphasises community involvement and knowledge sharing, ensuring that the benefits of these technological advancements extend beyond immediate emergency management to foster a more resilient and informed society.

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ABBREVIATIONS AND ACRONYMS

RF	Radio Frequency
UAVs	Unmanned Aerial Vehicles
IMT	International Mobile Telecommunications
UE	User equipment
ECC	Electronic Communications Committee
MFCN	Mobile/Fixed Communications Network
OOBE	Out-of-band emission
ETSI	European Telecommunications Standards Institute
NTZ	no-transmit zones
BVLOS	Beyond Visual Line of Sight
VLOS	Visual Line of Sight
WG SE	Working Group Spectrum Engineering
WG FM	Working Group Frequency Management
MEC	Multi-Access Edge Computing
WP	Work Package

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EXECUTIVE SUMMARY

The present document is deliverable D2.3 5G4LIVES services co-creation, functional specifications and reference architecture (1st version) that is the last report under WP2 and will be finalised in report D2.4 - (Final version) of 5G4LIVES services co-creation, functional specifications and reference architecture. D2.3 is the result of work carried out directly within Tasks 2.5, 2.6, and 2.7. and previous Deliverables. Task 2.5 - Novel model for public health and life protection involves identifying existing opportunities, future use-case scenarios for the 5G4LIVES concept and potential barriers. Task 2.6 - Use cases technological architecture design benefits from T2.1 and T2.2, and thus the description of the use case and identification of end-user requirements collection, leading to the System Architecture Design Technical Report that describes the technologies needed to implement and test the novel 5G-enabled emergency management and prevention service. Finally, Task 2.7 - Assessment of technical, societal, regulatory barriers aims to assess and identify technical, societal, and regulatory barriers that may impede the implementation and deployment of the 5G4LIVES concept. The D2.3 also contributes from work done in D3.1. - 5G4LIVES technologies integration concept and D3.2 - Technologies implementation

The document presents the tools and architecture of centre systems, UAV technologies and solutions, system flexibility and the identification of operational requirements for the most appropriate technologies. Additionally, this document identifies societal, technical and regulatory factors important for successful 5G4LIVES concept implementation and existing and future use-case scenarios for scaling the 5G4LIVES concept.

The document consists of three main parts:

1. **Technological Elements for Implementation and Testing (System Architecture Design Technical Report)** describing Mobile Site Station Components and deviations related to USIMs Integration in Drones, Local Private Core Network, and Multi Access Edge Computing (MEC) Node

2. **Use case further description** describing technical capabilities of the technologies for Turino and Riga use-cases, Analysis of existing and future single use-case scenarios, as well as Scaling opportunities of the 5G4lives concept

3. **Barriers for the 5G4lives concept** describing Societal impact and constraints, and Regulatory barriers and challenges

To sum up **D2.3. 5G4LIVES services co-creation, functional specifications and reference architecture (1st version)** lay the groundwork for D2.4 as the final Deliverable in the WP2 that plays a critical role in establishing the foundation for the 5G4LIVES project, defining the baseline criteria and challenges that need to be addressed from a technological, regulatory and societal perspective

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1. INTRODUCTION

Deliverable D2.3 - **5G4LIVES Services Co-creation, Functional Specifications and Reference Architecture (1st version)** - represents a key milestone in the 5G4LIVES project, developed under Work Package 2.

The primary objective of D2.3 is to define and structure the co-creation process of 5G-enabled emergency and public health services, establish the system's functional and technical specifications, and present the initial version of the 5G4LIVES reference architecture. It aims to align user needs, technological capabilities, and deployment conditions in diverse operational environments.

The scope of the deliverables includes identifying current and future use-case scenarios, specifying system architecture elements, and analysing implementation feasibility for pilot locations in Turin and Riga to ensure task 2.5. novel model usage. In the Turin use case, the focus is on the main system architecture adopted for UAV-supported emergency services, with a key update being the reallocation of mission management software components to the cloud, improving flexibility and centralised control.

For the Riga use-case, the deliverable describes the 5G-enabled remote drone operation system, supported by the Remote Operation Control Centre, which functions as the central hub for UAV mission planning and monitoring. Additionally, it presents the latest updates on mobile site components in Riga, which now utilise the 5G NR n78 frequency band, capable of operating in both Standalone (SA) and Non-Standalone (NSA) modes.

The deliverable also highlights technical deviations from the initial architectural design, particularly regarding the deployment of drones equipped with integrated 5G USIM cards, supported by a local private core network and MEC infrastructure. Furthermore, it provides an in-depth look at the technical capabilities of the UAV technologies and the Remote Operation Control Centre, focusing on their architecture, processes, and operational workflows.

Finally, D2.3 explores the scaling potential of the 5G4LIVES concept across new scenarios, and identifies key barriers - technical, societal, and regulatory that may affect broader adoption to finalise the concepts formed from task 2.7.

The approach taken in D2.3 builds on both bottom-up (use-case-driven) and top-down (system-level) perspectives. It combines end-user requirement analysis, technical system modelling, and multi-dimensional barrier assessment. This initial work guides the next development phase and supports the refinement of architectural and service design decisions to be described in the upcoming and final Deliverable D2.4 under Work Package 2.

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2. TECHNOLOGICAL ELEMENTS FOR IMPLEMENTATION AND TESTING (SYSTEM ARCHITECTURE DESIGN TECHNICAL REPORT)

This chapter outlines the integrated system architecture that combines 5G connectivity, UAV capabilities, and process flows, consisting of information updated from the D2.1 submittal earlier in 2024 and D.3.1 submittal earlier in 2025. It describes the principles of organizing lifeguard operations powered by technology and details the general design of the platform that enables this advanced rescue system. In essence, this platform serves as an all-in-one command-and-control center: it allows for flight mission planning (including the option of fully automated UAV missions under approved scenarios). The section also presents how the platform is set up and functions within an operational lifeguard system. It covers the hardware and software components that form the lifeguard station, detailing how UAVs, control centers, and user interfaces are connected.

2.1 Torino Use Case

At present, the architecture has remained largely unchanged, except for some details regarding the allocation of the drone mission management and monitoring software, as well as the tool for BVLOS mission planning, validation, and monitoring. The updated architecture is depicted in Figures 1 and 2 for the Turin Use Case 1 and Turin Use Case 2, respectively.

First use case: quadcopter drone for real-time video streaming of an emergency in BVLOS and/or EVLOS.

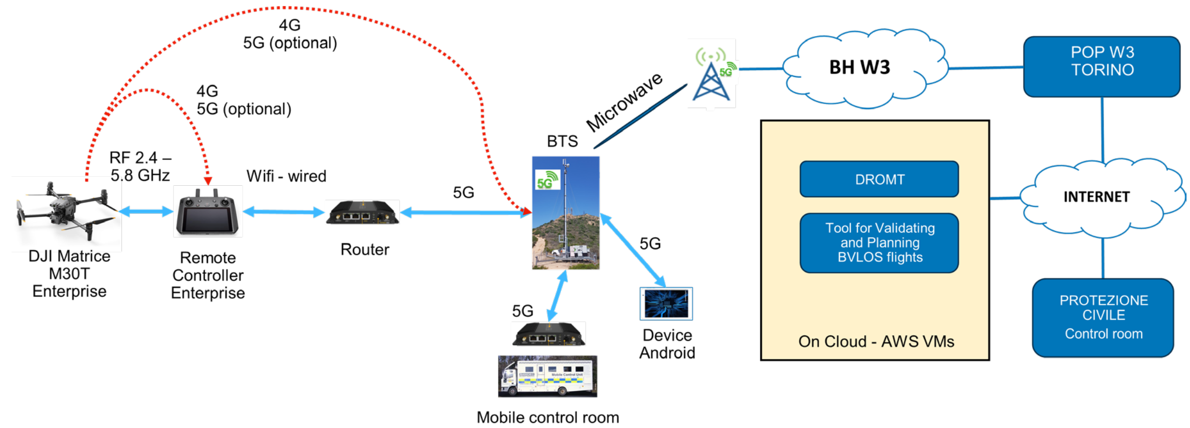

FIGURE 1. THE MAIN SYSTEM ARCHITECTURE ADOPTED WITHIN THE TORINO USE CASE 1

Second use case: BVLOS flight of a fixed-wing drone for monitoring and risk assessment.

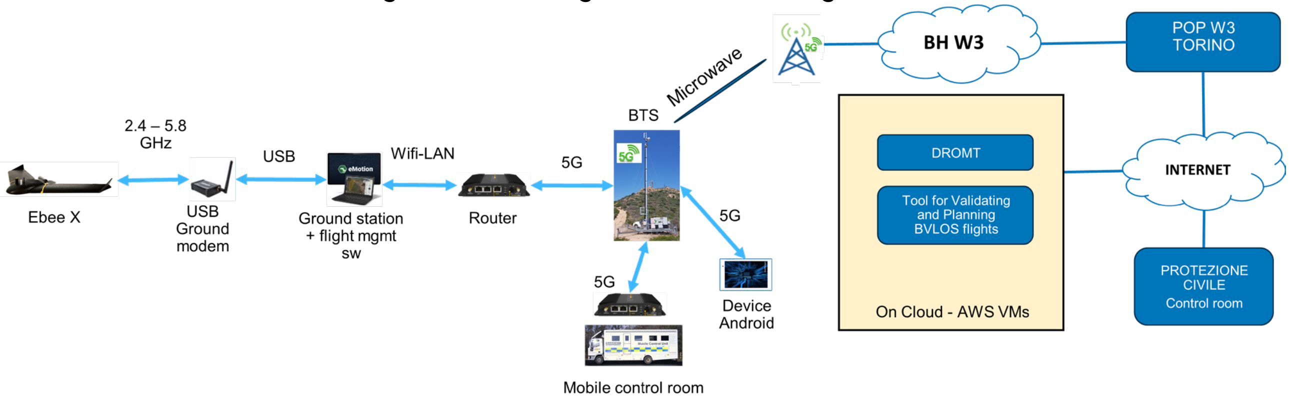

FIGURE 2. THE MAIN SYSTEM ARCHITECTURE ADOPTED WITHIN THE TORINO USE CASE 2

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The main change concerns the software components allocated on the Cloud for mission management. As already detailed in deliverable D3.1, the DROMThub application developed by DROMT will be used for the Turin Use Case. DROMThub offers several features aligned with the objectives of the 5G4LIVES project and has been specifically adapted to meet the needs and requirements of both the project and Civil Protection.

DROMThub is accessible through mobile applications (smartphones, tablets), an application installed on the Enterprise Remote Controller, or via a web app accessible from a browser. This ensures broad accessibility of the platform through devices connected to the 5G network. As shown in the figure, DROMThub runs on the Cloud using AWS virtual machines.

Consequently, the Politecnico di Torino team decided to allocate the software related to the web app implementing the BVLOS mission planning, validation, and monitoring tool in a similar way on the Cloud via AWS. This approach allows the tool to be accessed from any Internet-connected device and also enables potential integration with the DROMThub platform, such as retrieving the drone's position.

The rest of the architecture remains largely unchanged, with the various elements already introduced and described in previous deliverables: drone, remote controller, router, BTS, backhauling, and EPC (Evolved Packet Core).

We want to reiterate that the DJI Matrice M30T drone used in Use Case 1 will be connected to the mobile network via a dongle mounted on the drone. Currently, the dongle offered by DJI for the European market is only compatible with 4G networks. However, even with this configuration, it is possible to demonstrate and implement a drone connected to the mobile network and the associated infrastructure foreseen in the 5G4LIVES project. If 5G connectivity were available onboard the drone, the architecture would remain unchanged.

For more detailed descriptions, refer to Deliverable D.3.1, chapter 1, and Deliverable D.4.4, chapter 1.

2.2 Riga Use Case

The diagrams describe the connectivity of a 5G-enabled remote drone operation system for Riga Use-Case (Kisezers and Vecaki), considering infrastructure and data communication aspects for automated UAV missions. This system ensures centralised control, real-time monitoring, and data exchange/emergency decision support for search and rescue operations through 5G network architecture.

Figures illustrate the Remote Operation Control Centre, which serves as the main hub for UAV mission planning, scenario coordination, drone control, and real-time cross-platform monitoring. This centre is equipped with the Drone Control & Operations System, enabling operators to conduct UAV missions remotely via 5G connectivity. The control centre connects to field operations using a 5G network, supporting near-instantaneous communication, command execution, and data transmission.

This high-speed connectivity also links to various video-based monitoring systems, facilitating smooth integration with emergency responders, search and rescue teams, and municipal police. The advanced capabilities of the 5G network ensure that drone commands, telemetry, and high-definition video streams are transmitted with minimal delay, providing operators with real-time situational awareness for faster and more informed decision-making.

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For more detailed descriptions, refer to Deliverable D.3.1, Chapter 1

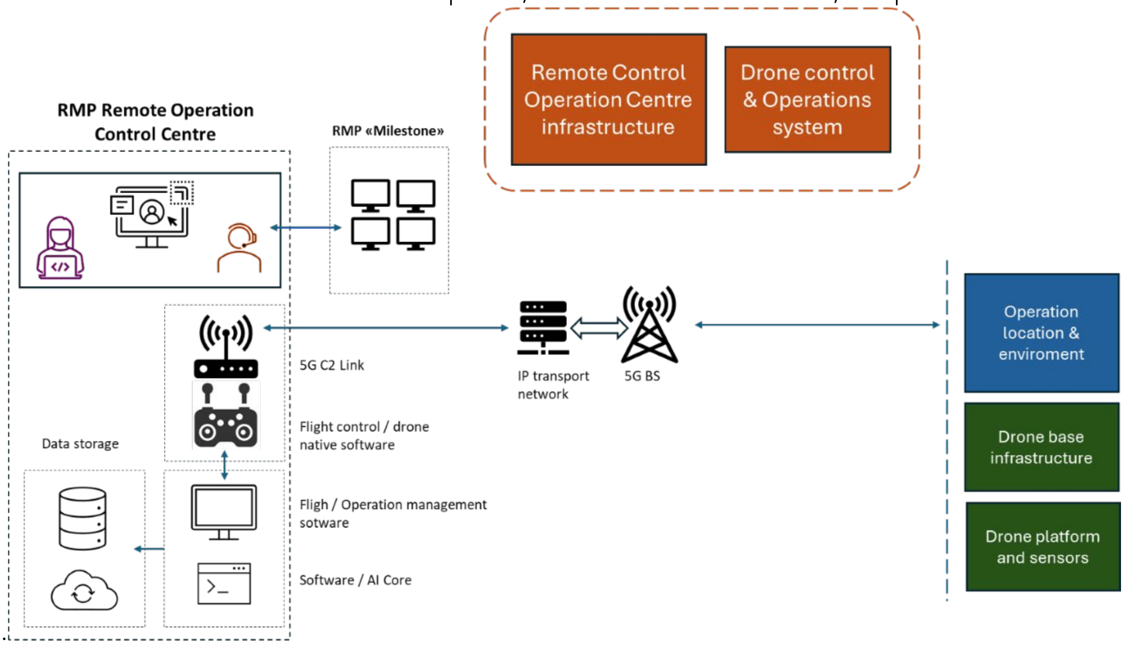

FIGURE 3. REMOTE OPERATION CONTROL CENTRE CONNECTIVITY ARCHITECTURE

Figure 3 shows the remote drone operations site, featuring a docking station that supports UAV recharging, maintenance, and automated mission deployment. Connected via 5G, it enables remote control, software updates, diagnostics, and real-time mission reassignment from the control centre.

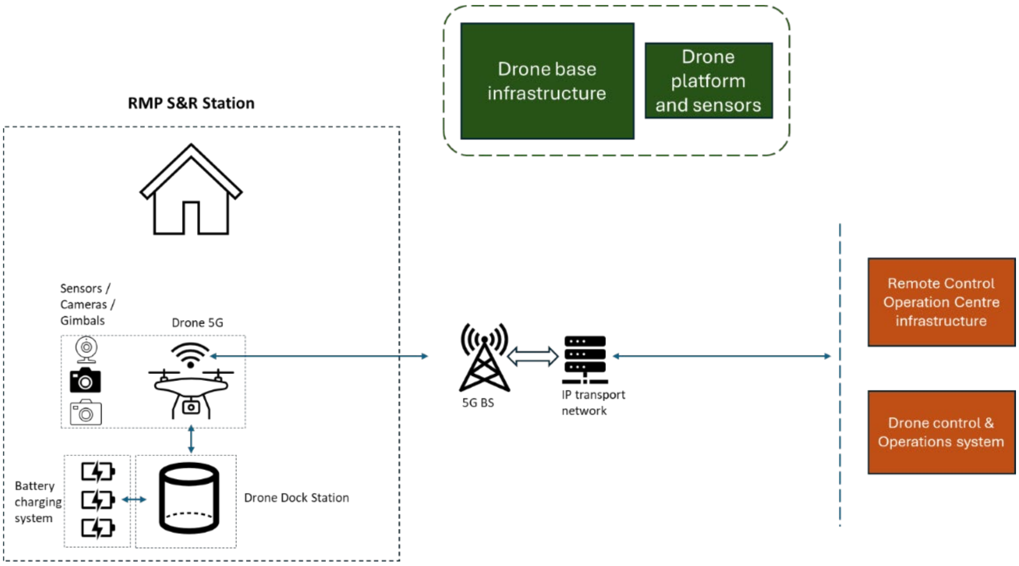

FIGURE 4. REMOTE OPERATION LOCATION/DRONE BASE INFRASTRUCTURE CONNECTIVITY ARCHITECTURE

Figure 4 illustrates the 5G-enabled operational connectivity between UAVs and the Remote Operation Control Centre, enabling real-time control, data streaming, and automated mission execution. Field personnel receive live drone feeds via 5G devices, enhancing situational awareness and response efficiency. The system supports multiple drones, offering scalable, automated, and adaptive operations for effective decision-making in dynamic environments.

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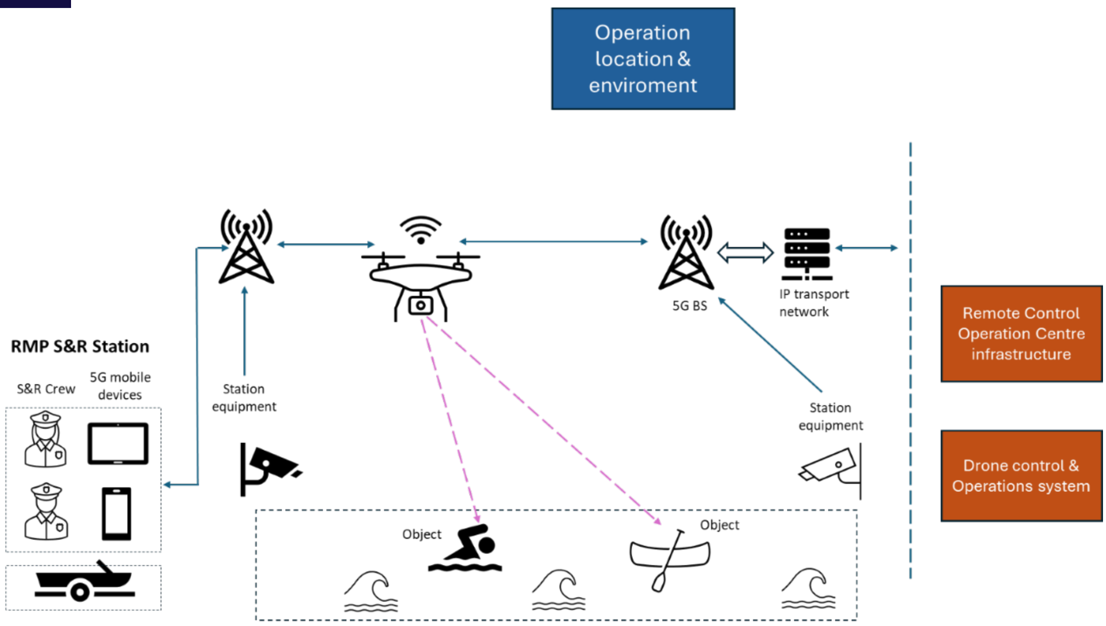

FIGURE 5. REMOTE OPERATION CONNECTIVITY ARCHITECTURE

2.3 Mobile Site Station Components

2.3.1 Riga Use-Case

The initial implementation phase of the 5G4Lives Riga Use-Case leverages the 5G NR n78 frequency band, operating both in Standalone (SA) and Non-Standalone (NSA) modes. The SA mode will provide full 5G benefits such as ultra-low latency and high data throughput. In contrast, the NSA mode will offer a smooth transition by using existing 4G infrastructure alongside 5G. While network slicing is not initially planned, its potential future implementation could significantly enhance the network's efficiency and reliability, prioritising critical drone operation communications.

The selected n78 band (FR1) operates between 3300–3800 MHz using Time Division Duplexing (TDD), enhancing spectrum efficiency and reducing latency, essential for UAV operation control and video streaming. LMT's 5G spectrum portfolio, specifically allocated for UAV usage, includes bandwidths of 40 MHz, 50 MHz, and 20 MHz. Each configuration delivers different theoretical throughput capacities and consistent low latency, crucial for UAV applications.

However, environmental factors such as distance, physical obstructions (e.g., buildings, terrain), electromagnetic interference, and equipment quality (antennas, cables, receivers) may affect actual performance.

TABLE 1. TECHNICAL/OPERATIONAL SPECIFICATION OF THE N78 BAND

Parameter	N78 (40 MHz)	n78 (50 MHz)	n78 (20 MHz)
Frequency Band	3400–3450 MHz	3650–3700 MHz	3750–3775 MHz
Bandwidth	40 MHz	50 MHz	20 MHz
ARFCN	628666	645000	650834
Central Frequency	3429.99 MHz	3675.00 MHz	3762.5 MHz
TDD Frame Structure	DDDSU (fixed)	DDDSU (fixed)	DDDSU (fixed)
Subcarrier Spacing	30 kHz	30 kHz	30 kHz
Theoretical DL Throughput	~506 Mbps	~634 Mbps	~243 Mbps
Theoretical UL Throughput	~166 Mbps	~209 Mbps	~80 Mbps
Latency	~10–20 ms	~10–20 ms	~10–20 ms
Mode	SA & NSA	SA & NSA	SA & NSA

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To ensure effective n78 5G coverage within the 5G4LIVES Riga Use-Case, existing LMT infrastructure will be enhanced through specific modifications. Existing base stations have been identified for upgrades and adjustments, including the addition of new antennas to ensure the necessary environment. Detailed explanation, specification, and architecture of the mobile network solution — refer to 5G4LIVES D3.1, Topic 1.1. network architecture, Section 1.1.1. Riga Use-Case: 5G Network Architecture and Solution.

2.3.2 Torino Use Case

The main components of the mobile BTS are:

- Van equipped with telescopic pole (up to 20 meters), power generator (if a wired power connection is not available)
- Baseband unit (BBU, Ericsson)
- Remote radio unit (RRU, Ericsson)
- Antennas 4G/5G, MIMO, 4T4R
- 2 sectors
- Band: LTE1800, LTE2100, LTE2600, 5GN38, 5GN78

The main components of the MW link are:

- Indoor Unit (IDU, Huawei)
- Outdoor Unit (ODU, Huawei)
- 2 parabolic antennas (Huawei)
- Splitter

Main configuration initial settings to be optimised after preliminary tests.

The values inside the Table 2 represent the default parametrization of a BTS deployed in Turin public mobile network, parameters like: azimuth, power, tilt, loss, gain, bands, sectors, RBS model, MIMO details, antenna model, antenna height, polarization and others that should be assigned to each new BTS in the network.

TABLE 2. INITIAL DEFAULT CONFIGURATION DATA THAT WILL BE USED FOR THE BTS ACTIVATION

Dati Generali	
Nome Sito	Area volo Progetto 5G4Lives - Torino
Codice Sito	XA780
Candidato	A
Localizzazione	
Comune	PIE - TO - TORINO - 001272
Indirizzo	Presso Cremaliera superga
Lat(WGS84)	45°04'53.4"
Long(WGS84)	07°45'58.3"
Y(Gauss-Boaga)	0.00
X(Gauss-Boaga)	0.00
Varie	
Progetto	5G
Struttura	Carrato
Note	Carrello provvisorio per Area volo Progetto 5G4Lives - Torino
Antenne Sito	4

Dati di Cella										
Num Settore	1	1	1	1	1	2	2	2	2	2
Banda	LTE1800	LTE2100	LTE2600	5GN38	5GN78	LTE1800	LTE2100	LTE2600	5GN38	5GN78
Num.Ramo	0	0	0	0	0	0	0	0	0	0
Dati Generali Bts										
Tipo Alloggiamento	Room	Room	Room	Room	Room	Room	Room	Room	Room	Room
Tipo Rbs	ERI_6150	ERI_6150	ERI_6150	ERI_6150	ERI_6150	ERI_6150	ERI_6150	ERI_6150	ERI_6150	ERI_6150
Numero Portanti Totale	1	1	1	1	1	1	1	1	1	1
Tipo CDU/RU	ERI_4466	ERI_4466	ERI_4466	no_CDU	no_CDU	ERI_4466	ERI_4466	ERI_4466	no_CDU	no_CDU
Note Cella	4T4R	-	4T4R	-	-	4T4R	-	4T4R	-	-
Tma/Cavi										
Utilizzo TMA/ASC/SBT	FALSO	FALSO	FALSO	FALSO	FALSO	FALSO	FALSO	FALSO	FALSO	FALSO
Tipo TMA/ASC/SBT	-	-	-	-	-	-	-	-	-	-
Posizione TMA/ASC/SBT	-	-	-	-	-	-	-	-	-	-
Diplexer	NO_DIPLEXER	NO_DIPLEXER	NO_DIPLEXER	NO_DIPLEXER	NO_DIPLEXER	NO_DIPLEXER	NO_DIPLEXER	NO_DIPLEXER	NO_DIPLEXER	NO_DIPLEXER
Lunghezza Cavi(m)	18.00	18.00	18.00	0.00	0.00	18.00	18.00	18.00	0.00	0.00
Diametro Cavi(")	1/2	1/2	1/2	-	-	1/2	1/2	1/2	-	-
Sistema d'Antenna										
N.Antenne	1	Multi-Band	Multi-Band	1	Multi-Band	1	Multi-Band	Multi-Band	1	Multi-Band
H.B.A. Tetto(m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H.B.A. Suolo(m)	18.12	18.12	18.12	16.78	16.78	18.12	18.12	18.12	16.78	16.78
H.C.E. Tetto(m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H.C.E. Suolo(m)	18.60	18.60	18.60	17.20	17.20	18.60	18.60	18.60	17.20	17.20
Azimuth(°)	240	240	240	240	240	320	320	320	320	320
Azimuth_Radio(°)	240	240	240	240	240	320	320	320	320	320
Posizione Antenna	-	-	-	-	-	-	-	-	-	-
Costr. Antenna	CellMax	CellMax	CellMax	Ericsson	Ericsson	CellMax	CellMax	CellMax	Ericsson	Ericsson
Modello Antenna	CMA-UBDHH/6518/E2-10	CMA-UBDHH/6518/E2-10	CMA-UBDHH/6518/E2-10	AIR3228_M2D	AIR3228_M2D	CMA-UBDHH/6518/E2-10	CMA-UBDHH/6518/E2-10	CMA-UBDHH/6518/E2-10	AIR3228_M2D	AIR3228_M2D
Guadagno(dBi)	17.50	17.90	18.50	21.50	24.20	17.50	17.90	18.50	21.50	24.20
Polarizzazione	XXPol	XXPol	XXPol	XPol	XPol	XXPol	XXPol	XXPol	XPol	XPol
Altezza(mm)	950.0	950.0	950.0	841.0	841.0	950.0	950.0	950.0	841.0	841.0
Larghezza(mm)	284.0	284.0	284.0	524.0	524.0	284.0	284.0	284.0	524.0	524.0
Profondità(mm)	135.0	135.0	135.0	222.0	222.0	135.0	135.0	135.0	222.0	222.0
Lobo 3dB Orizz.(°)	66.0	62.0	55.0	65.0	65.0	66.0	62.0	55.0	65.0	65.0
Lobo 3dB Vert.(°)	9.8	8.8	7.0	13.0	10.0	9.8	8.8	7.0	13.0	10.0
Range Tilt Elettrico	2 - 10	2 - 10	2 - 10	-2 - 5	-2 - 5	2 - 10	2 - 10	2 - 10	-2 - 5	-2 - 5
Tipo Downtilt Elettrico	RET_I	RET_I	RET_I	RET_I	RET_I	RET_I	RET_I	RET_I	RET_I	RET_I
Config.Connettori	-	-	-	-	-	-	-	-	-	-
Downtilt Elettrico(°)	8	8	8	2	2	8	8	8	2	2
Tilt El SubArray(°)	8	8	8	2	2	8	8	8	2	2
Downtilt Meccanico(°)	0	0	0	4	4	0	0	0	4	4
Separazione Antenne(m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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Dati di Cella										
Num Settore	1	1	1	1	1	2	2	2	2	2
Banda	LTE1800	LTE2100	LTE2600	5GN38	5GN78	LTE1800	LTE2100	LTE2600	5GN38	5GN78
Num.Ramo	0	0	0	0	0	0	0	0	0	0
Potenze										
Pot.Cpich/PRS/SSB(dBm)	10.40	15.20	8.20	12.20	17.20	15.20	15.20	12.20	12.20	17.20
Pot.Max(dBm)	52.00	52.00	52.00	46.00	50.00	52.00	52.00	52.00	46.00	50.00
Atten. Sw(dB)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potenza Impostata(dBm)	52.00	52.00	52.00	46.00	50.00	52.00	52.00	52.00	46.00	50.00
Perdita CDU(dB)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potenza Uscita da Bts(dBm)	52.00	52.00	52.00	46.00	50.00	52.00	52.00	52.00	46.00	50.00
Perdita Diplexer(dB)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perdite Cavi(dB)	1.82	1.98	2.27	0.00	0.00	1.82	1.98	2.27	0.00	0.00
Altre Perdite(dB)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potenza all'Antenna(dBm)	50.18	50.02	49.73	46.00	50.00	50.18	50.02	49.73	46.00	50.00
Eirp(dBm)	67.68	67.92	68.23	67.50	74.20	67.68	67.92	68.23	67.50	74.20
Tipo Copertura										
Copertura Outdoor	VERO	VERO	VERO	VERO	VERO	VERO	VERO	VERO	VERO	VERO
Richiesta Configurazione										
N. Trx - 1a serie	1	1	1	1	1	1	1	1	1	1
Pot. per Trx all'Antenna(W) - 1a serie	104.50	100.50	94.00	40.00	100.00	104.50	100.50	94.00	40.00	100.00
N. Trx - 2a serie	0	0	0	0	0	0	0	0	0	0
Pot. per Trx all'Antenna(W) - 2a serie	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potenza Totale all'Antenna(W)	104.50	100.50	94.00	40.00	100.00	104.50	100.50	94.00	40.00	100.00
Eirp(dBm)	67.69	67.92	68.23	67.52	74.20	67.69	67.92	68.23	67.52	74.20
Eirp Totale Settore(dBm)	77.05	77.05	77.05	77.05	77.05	77.05	77.05	77.05	77.05	77.05
Pot. Tot Antenna - DTX_PC(W)	-	-	-	-	-	-	-	-	-	-
Eirp-DTX_PC(dBm)	-	-	-	-	-	-	-	-	-	-
Eirp Tot Settore - DTX_PC(dBm)	-	-	-	-	-	-	-	-	-	-
Tilt Elettrico Richiesto(°)	8	8	8	2	2	8	8	8	2	2
Tilt Meccanico Richiesto(°)	0	0	0	4	4	0	0	0	4	4
MinTilt E. Rich.(°)	8	8	8	2	2	8	8	8	2	2
MaxTilt E. Rich.(°)	8	8	8	2	2	8	8	8	2	2
Min Tilt E SubArray(°)	8	8	8	2	2	8	8	8	2	2
Max Tilt E SubArray(°)	8	8	8	2	2	8	8	8	2	2
MinTilt M. Rich.(°)	0	0	0	4	4	0	0	0	4	4
MaxTilt M. Rich.(°)	0	0	0	4	4	0	0	0	4	4
Richiesta Configurazione - Fattori 5G										
K_TDD	-	-	-	0.750	0.750	-	-	-	0.750	0.750
K_PR	-	-	-	0.000	0.000	-	-	-	0.000	0.000
Actual Power(W)	-	-	-	30.00	75.00	-	-	-	30.00	75.00
Pwr_Lim_Esp(W)	-	-	-	30.00	75.00	-	-	-	30.00	75.00
Pwr_Val_Att(W)	-	-	-	30.00	75.00	-	-	-	30.00	75.00
Richiesta Configurazione - Dss										
DSS	VERO	FALSO	FALSO	FALSO	FALSO	VERO	FALSO	FALSO	FALSO	FALSO

2.4 5G USIMs Integration in Drones

As mentioned in the original proposal and the Grant Agreement (Tasks T2.6 and T3.6), the early architectural design included the deployment of drones fitted with integrated 5G USIM cards, backed by a local private core network and MEC (Multi-access Edge Computing) infrastructure. However, these assumptions were based on limited technical information and equipment limitations at the time.

Following in-depth technical alignment with all Italian partners, and particularly the Civil Protection Department, the following critical constraints and adaptations were identified:

The commercial drone models selected by Civil Protection for this project are currently not equipped with 5G modules, and therefore, integration of a 5G USIM into the drones is not feasible at this stage. Should the manufacturer release a 5G-compatible dongle during the project timeframe, the consortium is open to testing this feature. In the meantime, several 5G USIMs and modems have been supplied to Civil Protection to initiate connectivity testing between the ground control station and the Flight Control software hosted on the cloud.

All other equipment used in the Italian pilot is fully integrated with the public 5G network using USIMs and modems already provided to the Civil Protection authorities.

2.5 Local Private Core Network and Multi Access Edge Computing (MEC) Node

2.5.1 Torino Use Case

The real-world nature of the emergency monitoring use case entails substantial physical distance between drone operational zones (e.g., landslide- or fire-prone hills) and the control centre. This spatial separation makes a local private core network impractical, particularly given the rapid deployment required in emergencies.

Furthermore, given the project's goal to simulate real conditions as closely as possible, the geographical separation between the monitored area and the control room made the use of MEC (multi-access EDGE computing) servers ineffective. Their deployment times are too long to support the immediate response needed in natural disaster situations. It was found that installing the cloud-based Flight Control software selected by Civil Protection on an MEC server would involve additional effort and unforeseen costs.

Due to all these considerations, the local private core network and MEC (multi-access EDGE computing) server will not be used in this project. The decision was made to proceed using the existing commercial public 5G network. This solution ensures both technical reliability and rapid deployment, aligning with real-world constraints and emergency readiness requirements.

The main components of the system architecture for the 5G4LIVES project have undergone only minor updates, primarily involving the cloud-based allocation of mission management and monitoring software. Still, significant updates have been made to software allocation and connectivity strategies.

In the Turin use-cases, the DROMThub platform has been adopted for mission planning and monitoring, hosted on AWS cloud infrastructure and accessible via mobile, web, and enterprise devices. This ensures flexibility and broad accessibility for emergency operations. Similarly, the BVLOS mission planning tool has been deployed on the cloud, enabling integration with DROMThub and real-time data access.

Despite initial plans to equip UAVs with integrated 5G USIMs and support them with a local private core network and MEC infrastructure, practical constraints led to a revised approach. The selected commercial UAV lack 5G module compatibility, and the logistical challenges of deploying MEC servers in geographically dispersed emergency zones made their use impractical. Instead, the project now relies on the public 5G network, which offers the necessary speed, reliability, and rapid deployment capabilities aligned with real-world emergency response needs.

In the Riga use case, a centralised Remote Operation Control Centre enables real-time UAV mission execution and monitoring through 5G connectivity. This setup supports emergency response operations with high-speed data transmission, automated mission deployment, and integration with field personnel and emergency services.

Overall, the updated architecture reflects a pragmatic and scalable solution, leveraging cloud technologies and public 5G infrastructure to meet the operational demands of emergency response scenarios while maintaining alignment with the project's original goals.

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3. USE CASE FURTHER DESCRIPTION

In this chapter, an updated and detailed overview of the use cases within the 5G4LIVES project, focusing on the integration of UAV (Unmanned Aerial Vehicle) technologies with 5G infrastructure to support public safety and emergency response operations. It outlines the technical capabilities, network configurations, and operational workflows for both the Turin and Riga use cases built upon submission in WP2, as well as WP3 and WP4. The chapter also details the frequency bands, UAV specifications, control systems, and mission planning tools that enable safe, efficient, and scalable drone operations.

3.1 Technical capabilities of the technologies

3.1.1 Torino Use Case

Regarding the 5G mobile network, the main technical capabilities of this technology are:

- Increased Speed: 5G can achieve theoretical peak speeds of up to 20 Gbps, significantly faster than 4G
- Reduced Latency: Depending on the transport layer, 5G can offer much lower latency than 4G
- Enhanced Capacity: 5G networks can support a much larger number of connected devices simultaneously
- Improved Flexibility: 5G networks are highly flexible and can be customised (only in Stand Alone configuration) for different use cases through network slicing
- Advanced technologies: 5G utilises advanced technologies like massive MIMO (Multiple Input Multiple Output) and beamforming to enhance signal quality and coverage

In Italy, 5G frequencies cannot be used for connecting a drone directly to the ground station, as those frequencies are only authorised to be used for communication purposes; for this reason, the 5G network will instead be used to connect the ground station to the flight control platform and the remote-control room.

In the Turin use case, one will be conducted with a DJI Matrice M30T drone, while use case 2 will be conducted with an AgEagle Ebee X drone. For a more detailed technical description and the technological advantages they offer, please refer to Deliverable D.3.1, Chapter 2 – UAV Integration.

3.1.2 Riga Use Case

Frequency and network specification

To successfully deploy 5G-enabled remote drones and UAVs (Unmanned Aerial Vehicles) for the Riga Use-Case (Kisezers and Vecaki), a mobile network infrastructure must support near real-time communication, control, and data exchange. UAV drones have specific operational requirements that demand high-speed, low-latency, and reliable connectivity. 5G technology offers significant advantages, providing the necessary bandwidth, ultra-low latency, and high reliability to handle the continuous data stream that drones generate while operating in real-time. LMT (Latvian Mobile Telephone) has a broad frequency portfolio, enabling it to utilise various frequencies to support UAV operations. These frequencies span from low to high spectrum, allowing for diverse use cases based on coverage, data rate, and network demand. Here are the frequency bands that LMT can leverage to operate drones efficiently (frequencies are listed as whole bands):

n28 (700 MHz: 703-748 / 758-803). This low-band frequency provides extensive coverage with better signal penetration through obstacles such as buildings and trees. It is ideal for providing wide-area connectivity, ensuring reliable connections for drones operating over large, remote areas like Kisezers and Vecaki.

- n20 (800 MHz: 791-821 / 832-862). Like n28, this band is well-suited for providing coverage in rural or suburban areas, helping ensure that drones maintain a stable connection even in less populated regions.
- n8 (900 MHz: 880-915 / 925-960). This low-band frequency offers improved signal coverage and network reliability. It can support drone operations in urban environments and areas where interference from other wireless signals may be more prominent.
- n75 (1500 MHz: 1432-1517). This frequency band provides only downlink.

- n3 (1800 MHz: 1710-1785 / 1805-1880). This mid-frequency band offers high capacity, essential for handling dense communication traffic from multiple drones. It ensures that drones maintain a stable connection, even in high-density environments like cityscapes.
- n1 (2100 MHz: 1920-1980 / 2110-2170). This is a high-capacity band that supports large data transfers. It is particularly useful for high-speed data exchange applications, such as real-time video streaming or large data files sent from the drones to the control centre.
- n40 (2300 MHz: 2300-2400). This high-band spectrum offers excellent data throughput, enabling fast and responsive communication for data-heavy applications. It is ideal for supporting drone operations that involve large amounts of real-time data, such as drone fleet coordination and streaming from onboard cameras.
- n7, n38 (2600 MHz: 2500-2690). These bands offer high data rates and excellent capacity for handling multiple drones operating in the same area. They will provide fast communication between drones and control centres, especially in more densely populated regions.
- n78 (3500 MHz: 3300-3800). The n78 band, one of the most widely used for 5G, provides significant bandwidth for high-speed, low-latency communication. This band will be central in deploying the 5G4Lives Riga Use-Case project. It is especially suitable for environments with high-density drone activity, as it offers excellent data throughput and latency critical for UAV operations.

Currently, most of these frequency bands are still being utilised by legacy technologies like 2G and 4G, but plans are in place to re-farm these frequencies to accommodate 5G networks shortly. The transition from older technologies to 5G will unlock the full potential of these bands for drone operations, offering greater bandwidth, lower latency, and higher reliability. For the initial phase of the 5G4Lives Riga Use-Case project, the focus will be on using the n78 band, which will be deployed in both Standalone (SA) and Non-Standalone (NSA) modes. In SA mode, the 5G network will operate independently, providing the full benefits of 5G, including ultra-low latency and high throughput. On the other hand, NSA mode will leverage existing 4G infrastructure alongside 5G, enabling a smoother transition while offering some of the advantages of 5G. Initially, the project will not implement network slicing. This technology divides the network into virtual segments, each optimised for specific use cases (e.g., one slice for UAV control, another for video transmission). However, if slicing technology is introduced in the LMT network in the future, it will significantly enhance the network's ability to support the different needs of UAV operations, ensuring that high-priority communications, such as safety-critical signals, are given the necessary network resources.

Frequency specification of n78:

n78 is a FR1 (Frequency Range 1) 5G NR band operating in the 3300-3800 MHz range. It employs Time Division Duplexing (TDD), a mode that utilises the same frequency band for both uplink (UL) and downlink (DL), which helps improve spectrum efficiency and reduce latency.

LMT portfolio has different spectrums:

3400-3450 MHz, cells are configured with 40 MHz bandwidth,
ARFCN = 628666, central frequency is 3429.99 MHz;
3650-3700 MHz, cells are configured with 50 MHz bandwidth,
ARFCN = 645000, central frequency is 3675.00 MHz;
3750-3775 MHz, cells are configured with 20 MHz bandwidth,
ARFCN = 650834, central frequency is 3762.5 MHz.

These are strictly allocated for 5G network use, ensuring optimal performance for UAV applications.

Subcarrier spacing for n78 is 30 kHz, a standard for 5G FR1 (low and mid-range frequencies). The frame structure is defined as DDDSU and cannot be altered.

- For the n78 40 MHz TDD cell, the theoretical DL maximum throughput for the users is ~506 Mbps, and the theoretical UL maximum throughput for the users is ~166 Mbps. Latency is around ~10-20 ms.
- For the n78 50 MHz TDD cell, the theoretical DL maximum throughput for the users is ~634 Mbps, and the theoretical UL maximum throughput for the users is ~209 Mbps. Latency is around ~10-20 ms.

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- For the n78 20 MHz TDD cell, the theoretical DL maximum throughput for the users is ~243 Mbps, and the theoretical UL maximum throughput for the users is ~80 Mbps. Latency is around ~10-20 ms.

However, several factors can impact signal quality, throughput, and latency, including competing signals, electromagnetic interference, and environmental conditions. The distance between the transmitter and receiver can also affect signal strength, with longer distances leading to weaker signals. Physical obstacles such as buildings, terrain, and weather conditions can degrade signal quality. The type and quality of antennas, cables, and receivers are also critical in maintaining optimal performance, ensuring that drone operations remain reliable and secure. In summary, the 5G-enabled infrastructure for UAVs in Riga's Kisezers and Vecaki Use-Case will rely heavily on efficiently utilising frequency bands like n78 and others. This infrastructure will ensure that drones can operate safely and efficiently, with the flexibility to scale as more advanced 5G technologies, such as network slicing, are introduced.

UAV Solutions

The Riga-Case within the 5G4LIVES project represents a technologically advanced and highly integrated UAV solution, designed to ensure safe, autonomous, and efficient operations in both urban and remote environments. This solution is designed to meet the specific requirements of public safety, environmental monitoring, and crisis response scenarios, utilising the capabilities of 5G connectivity and intelligent automation.

Integrated UAV System

At the core of the Riga-Case drone solution is a robust quadcopter-type (multirotor) UAV, designed for high performance and reliability (also considering Latvian typical climatic conditions). The drone, with a compact diagonal size of 500 mm and a total weight not exceeding 3.6 kg (MTOW), can operate for 35 minutes of continuous flight in standard configuration, excluding additional payloads. Its structural design ensures durability in wind conditions up to 10 m/s and temperatures ranging from -10°C to +40°C, with an IP55 protection rating enabling operation in diverse weather conditions.

The UAV is equipped with a GNSS module supporting GPS, GLONASS, Galileo, and BEIDOU systems, ensuring precise geolocation. Vertical and horizontal accuracies are maintained at 0.5 m and 1.5 m, respectively, supporting safe navigation and reliable geofencing operations. Integrated obstacle detection capabilities extend up to 40 meters, ensuring situational awareness and operational safety. A key enabler of the solution is the integration of a 4G/5G modem supporting a wide range of 3GPP frequency bands, including n78, the primary band used in the project for the Riga Use-Case. This connectivity facilitates not only control of the UAV but also high-quality, real-time video transmission, ensuring robust command-and-control (C2) operations with low latency. The system's network capabilities are aligned with 5G deployment strategies in the Riga Use-Case, ensuring compatibility with existing and planned mobile infrastructure. For the identification of the drone during operations, the UAV is equipped with network remote ID functionality.

Payload and imaging system

The UAV features a dual video streaming capability with support for Full HD daylight and additionally thermal imaging, both encoded in H.264 and compliant with ONVIF standards. The imaging system includes a 12 MP CMOS camera for visual observation and a thermal sensor with 640x480 resolution. The camera configuration enables real-time fusion of thermal and RGB video, providing situational data during operations.

The gimbal-mounted payload features a 3-axis stabiliser supporting a full 90° range of motion, ensuring optimal image quality and steady footage across varying flight profiles. Real-time metadata, including GPS coordinates, altitude, camera angle, and zoom level, is embedded in the video stream, supporting mission documentation and operational analysis. The UAV is equipped with a 100 dB connectable siren at 1 meter and a loudspeaker for remote transmission of commands and voice messages directly from the operator.

Docking station

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Supporting the UAV is the special Docking Station solution—an automated, weather-resistant, and remotely monitored unit enabling high-level automated UAV operations. The station facilitates autonomous landing, take-off, battery charging, and secure storage. Integrated with lightning protection and anti-vandalism mechanisms, the docking station ensures continuous operation in public and semi-remote locations.

Critical environmental data is collected through an integrated VAISALA WXT530 weather station, which monitors wind, temperature, precipitation, and barometric pressure at the location. A CCTV camera system mounted on the station provides 360° visual surveillance, enhancing perimeter awareness and operational security. The entire system is powered by standard AC input and is supported by a 60-minute backup power supply for resilience during outages.

Control systems

The UAV system is operated using a professional-grade remote control unit with dual joysticks, a 7-inch high-brightness display, and a built-in battery supporting 4 hours of operation. The control system functionality offers both manual and automated flight modes, including special procedures such as return-to-home, scheduled flight plans, and live video feed management. The interface is designed for ease of use in field operations, with built-in 2TB memory for data storage.

Mission management software

The UAV solution is equipped with an integrated software suite that offers comprehensive mission planning, real-time UAV management, and post-flight analytics. Users are assigned role-based access with four levels: administrator, chief pilot, pilot, and observer. The software interface is map-based (OpenStreetMap or higher-resolution alternative) and provides real-time status of UAVs and docking stations, mission logs, environmental conditions, and live camera feeds.

Advanced warning systems are built into the platform, including alerts for battery level, deviation from flight path, nearby flying objects, video interruption, weather exceedances, and GPS interference. The system supports detailed ERP (Emergency Response Plan) records, full mission logging, and a digital checklist functionality for operational compliance. All audit logs are retained securely for at least 36 months to ensure regulatory and operational traceability.

Remote Operation Control Centre: architecture, processes, and operational workflow

The design of the Remote Operation Control Centre (ROCC) is built to support a highly automated workflow for managing drone-based operations within the 5G4LIVES ecosystem. This centre serves as the central hub for coordinating planning, mission execution, monitoring, and response for surveillance, emergency scenarios, and public safety missions.

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Remote Operation Control Centre organization design

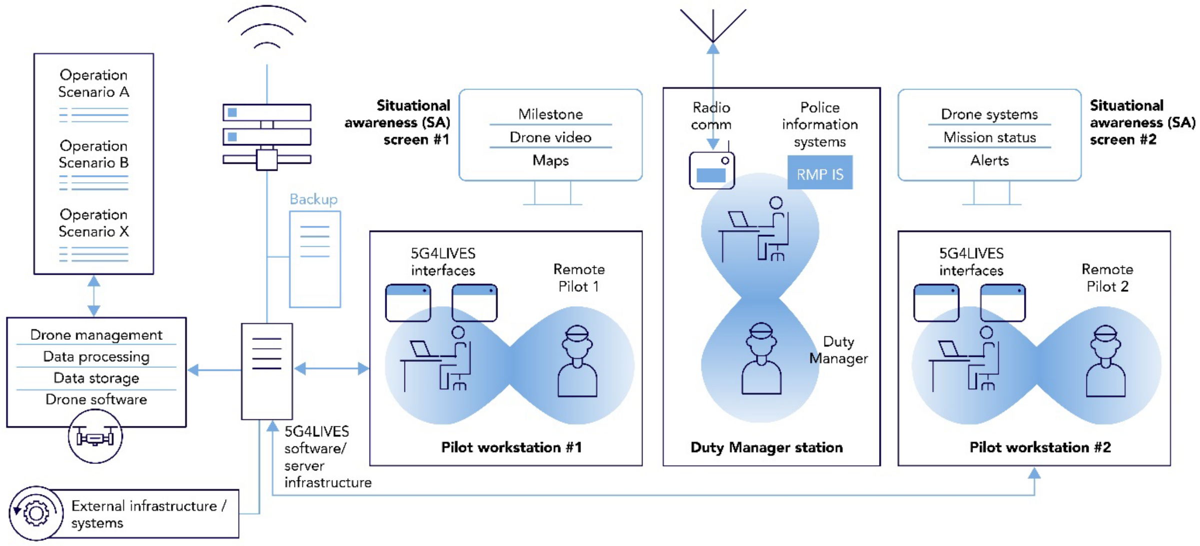

FIGURE 6. REMOTE OPERATION CONTROL CENTRE ORGANISATION DESIGN

The Figure illustrates how the 5G4LIVES system architecture supports distributed yet synchronised operations:

- Operational scenarios (A, B, X, etc.) are uploaded into the 5G4LIVES backend (drone management, data processing, storage).
- These scenarios are made available to pilot workstations via interfaces.
- Each Remote Pilot Station is equipped with situational awareness (SA) screens that display drone mission status and alerts.
- The Duty Manager station, connected to law enforcement information systems (RMP IS) and radio communication, oversees coordination and cross-agency integration.
- A backup server infrastructure ensures data reliability and fail-safe operations.

The result is a real-time, responsive, and automated control environment facilitating dynamic drone mission control.

Duty shift planning & activation workflow

The process includes duty planning and readiness verification:

- Duty shift planning is initiated with a briefing and task assignment.
- Environmental checks and equipment status evaluations determine compliance.
- If a system or environmental non-compliance is detected, a maintenance order or schedule reschedule is issued.

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Duty planning and preparation process diagram

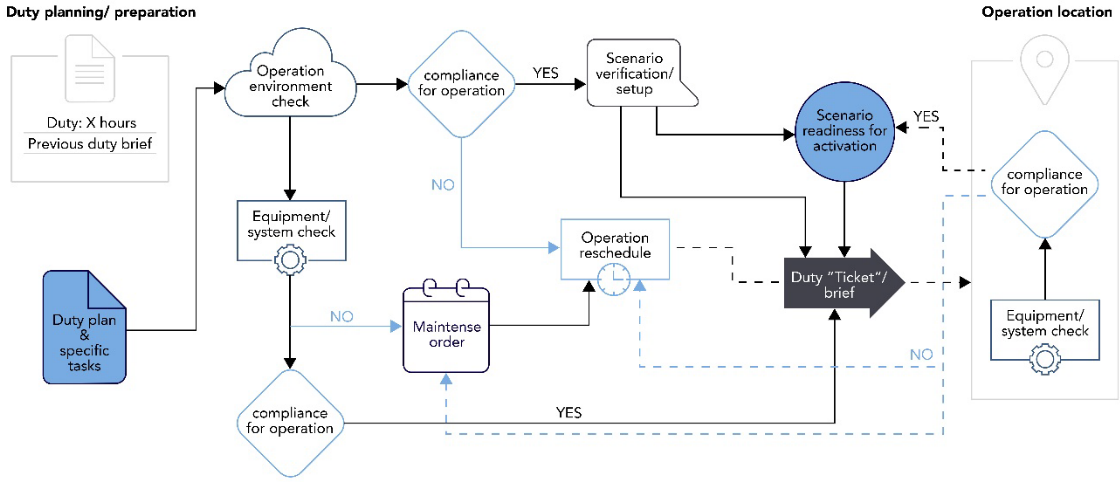

FIGURE 7. DUTY PLANNING AND PREPARATION PROCESS DIAGRAM

Pre-Operational check & system preparation

Operations begin with the Standard Operating Procedures (SOP) checklist. This step includes:

- Verifying and adjusting operational scenario parameters.
- Confirming the readiness of remote pilots and all system components.
- Once validation is complete, a take-off authorisation is issued.
- On-site system verification ensures that the drone is ready for launch, triggering the start of the operation.

This structured pre-check process ensures safety, procedural compliance, and readiness before mission execution.

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Pre-ops check/ fleet & system preparation

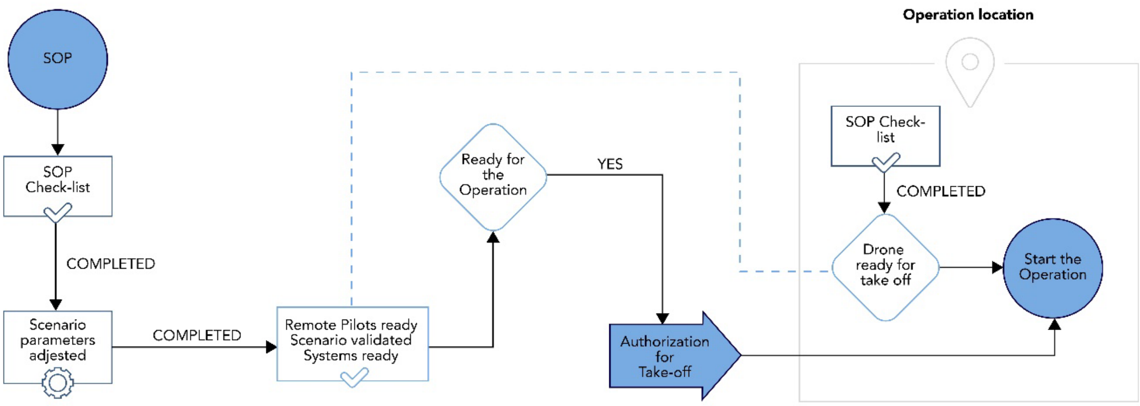

FIGURE 8. PRE-OPS CHECK/ FLEET & SYSTEM PREPARATION.

Active mission operations

Once a scenario is activated and validated using SOP protocols, the operational roles are distributed as follows:

- Remote Pilot #1 handles drone control, including mission management, flight tracking, and on-the-fly adjustments.
- Remote Pilot #2 focuses on observation, communication with stakeholders, and information management.
- The Duty Manager coordinates with on-site staff and police units, overseeing the flow of decisions and ensuring compliance with safety protocols.

This structure enables both flexible management and robust supervision of ongoing missions.

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Drone mission operation process diagram

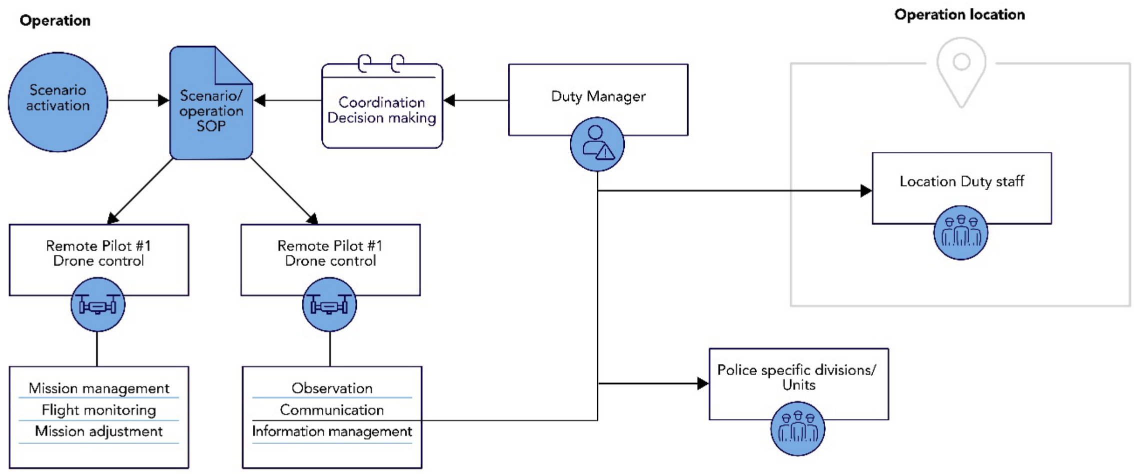

FIGURE 9. DRONE MISSION OPERATION PROCESS DIAGRAM

3.2 Analysis of existing and future single-use-case scenarios

The platform being developed for 5G4LIVES has the potential to be applied across a wide range of use cases, both in public and private domains.

Indeed, the platform enables the planning, execution, and monitoring of BVLOS missions, as well as post-processing of the acquired data. These features are essential for most drone operations, leveraging BVLOS capabilities and thus the full potential of remotely piloted aerial systems.

In general, it is well-suited for any aerial monitoring activity. For instance, in urban environments, it can be used for city surveillance, both for routine patrolling and large-scale events (concerts, sports events, fairs, etc.). A tool like this can therefore be used not only by Civil Protection authorities but also by other public safety and utility organisations such as the Police, Fire Brigade, and similar entities.

Beyond public institutions, the platform also has the potential to serve private stakeholders for infrastructure monitoring, facility surveillance, or the oversight of any private areas requiring security and monitoring.

In addition to surveillance and monitoring, the platform can also support BVLOS missions for logistics applications. A practical example is the INDOOR project, in which Politecnico di Torino is involved with the support of the City of Turin. The INDOOR project aims to use drones for the transport of organs, biological material (such as blood samples and biological specimens), and life-saving drugs between hospitals within both urban and suburban areas. A tool like the one under development within the 5G4LIVES project would enable the management and monitoring of such BVLOS missions. In this context, the BVLOS mission planning, validation, and monitoring tool is particularly relevant, as it allows routes to be planned in compliance with regulatory constraints while ensuring public safety.

Moreover, during natural disasters such as floods, wildfires, landslides, or earthquakes, the platform can be used to assess damage in real-time, identify blocked evacuation routes, and support situational awareness for first responders. Integration with geographic information systems (GIS) and emergency communication networks can allow drones to map affected zones and transmit actionable data to crisis management centres.

Beyond emergency services, the platform can also support environmental monitoring use cases. For example, it could be used to monitor deforestation, track wildlife populations, detect illegal fishing activities, or measure pollution levels in protected natural reserves. In agriculture, the technology could be adapted for

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crop monitoring, soil health assessment, or precision spraying, helping to increase yield while reducing environmental impact.

Looking to the future, the platform's compatibility with 5G network slicing and edge computing makes it ideal for supporting more complex, autonomous operations such as drone swarms. These could be used for tasks like perimeter surveillance of critical infrastructure (e.g. airports, power plants, and ports), wide-area pipeline inspections, or even the coordination of aerial fleets during mass events or crises.

Furthermore, its integration with AI-based analytics and real-time data sharing opens doors to predictive maintenance for infrastructure, such as early detection of faults in bridges, railways, or high-voltage lines. Such applications would be valuable not only for municipalities and utilities but also for private industries operating large-scale assets.

In summary, while initially focused on public safety and rescue operations near waterfronts and mountainous areas, the 5G4LIVES platform is a scalable and adaptable solution with the potential to drive innovation across diverse sectors ranging from healthcare logistics and emergency response to environmental protection, smart agriculture, and critical infrastructure management.

3.3 Scaling opportunities of the 5G4LIVES concept

Regarding the potential to scale the results of 5G4LIVES, the BVLOS mission planning, validation, and monitoring tool is of particular interest. As already discussed in Deliverable D2.1, the tool is being developed by the European Drone Regulation. The risk assessment methodology is compatible with SORA 2.0 (and SORA 2.5), the risk assessment methodology proposed by JARUS and adopted by EASA. This allows us to state that the tool is scalable to any European country where the European drone regulation is enforced.

Moreover, the tool (currently under development) makes specific reference to the updated SORA version (2.5), which has already been approved by EASA and is expected to be adopted in the coming months.

At present, the tool is being developed with the Turin Use Case. It therefore uses data compatible with the Italian scenario, specifically focusing on the urban area of Turin (particularly regarding population density data).

To scale the tool to other European countries, it is necessary to gather data consistent with the territory under analysis. It is important to note that the quality of the risk assessment provided by the tool developed by Politecnico di Torino is strongly dependent on the quality of the input data.

In conclusion, the main requirement to scale the BVLOS mission planning, validation, and monitoring tool is the availability and use of appropriate data aligned with the specific European country in which the tool is intended to be deployed.

Finally, it is worth highlighting that, although SORA-based risk assessment is mainly adopted in Europe, other non-European countries have either adopted SORA or are currently aligning with it, due to its effectiveness in assessing the risk of drone missions for professional activities, particularly in BVLOS operations.

Indeed, SORA has already been adopted by CASA (Civil Aviation Safety Authority) in Australia.

The FAA in the United States has not officially adopted SORA, despite being a JARUS member, but is discussing the possibility of adopting SORA (or an adapted version) for BVLOS operations and Urban Air Mobility contexts.

In Canada, on the other hand, an adapted version of SORA has been adopted.

This indicates that, potentially, the BVLOS mission planning, validation, and monitoring tool is scalable both within European countries and in other non-European states that are adopting SORA or adapted versions of it.

Another aspect worth mentioning, regarding the potential to scale the results of 5G4LIVES to different use cases and outside the determined pilot territories, is the active engagement of the city of Riga in the EU project CITYAM that focuses on preparing cities for sustainable mobility in urban airspace.

Through CITYAM, Riga city and the Baltic Sea region will strengthen their European frontrunner role in urban air mobility and lead the way for local authorities to shape a responsible and sustainable use of the air in cities. This project complements the efforts of 5G4LIVES very well. It will build a road to new scaling opportunities as the project with its 13 partners (out of which 6 are other EU cities) will provide the ingredients and tools for a solid UAM strategy, to adapt city planning practices about landing site and airspace

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management, and also to scale city-owned drone operations as part of a multimodal transport system. Increasing public officials' capabilities and measuring public acceptance are key to this work, as citizen acceptance of technology is a "make-or-break" factor in the development and scaling of Urban Air Mobility.

Drones are a green and smart mobility form, but the potential, volume and sustainability of these automated vehicles in the lower airspace of our cities need management and better planning. For this, strategy and policies, preparation, greater awareness, and more knowledge and tools are crucial.

In Europe, the number of people living in urban environments has been growing by approximately. 1 million annually. This trend will continue, and it is estimated that the population of European cities will be more than 340 million by 2030, which will have an ever-increasing impact on pollution and traffic congestion. Urban Air Mobility (UAM) could be one of the mitigation measures. Technology readiness is at the level where passenger and goods delivery could already be done with drones shortly. Although drones already have an impact on the city environment and are widely used, the potential they have in urban mobility is still, for the most part, unfulfilled. The main challenges holding back the wider usage brought out by the European Union Aviation Safety Agency (EASA) are a lack of infrastructure and concerns over safety and noise.

Therefore, as Riga develops drone mobility within the city, the focus is not only on practical application testing like the 5G4LIVES project but also simultaneously addressing urban planning issues and legislative measures to ensure that air mobility is safe, regulated, and socially acceptable.

The synergy between the 5G4LIVES and CITYAM projects is important because it enables a more cohesive and future-ready urban mobility and infrastructure ecosystem. 5G4LIVES focuses on deploying ultra-reliable, low-latency 5G networks to support critical applications such as autonomous emergency vehicles, including drones. When integrated with the work of the CITYAM project, Riga will develop urban air mobility guidelines and a geospatial data tool to plan and analyse safe drone routes within the city, as well as designated take-off and landing areas. The formulation of such a strategy and supporting legislation will enable the development of the necessary infrastructure and will make it possible to apply the autonomous drone technologies tested in the 5G4LIVES project more quickly and safely to broader urban use cases. It will create a favourable environment for new innovators in the urban air mobility sector to launch and grow their services, such as logistics, emergency response, infrastructure monitoring and others that can also be applied in the EU.

The 5G4LIVES project showcases the transformative potential of integrating UAVs with 5G networks for public safety and emergency response. Through the Turin and Riga use cases, the project demonstrates how advanced connectivity, automation, and mission management can enable real-time, reliable, and secure drone operations in diverse environments.

In Turin, the use of commercial drones connected via ground-based 5G infrastructure highlights a practical approach to overcoming regulatory and technical limitations. In Riga, a more comprehensive system is deployed, featuring autonomous UAVs, docking stations, and a centralised Remote Operation Control Centre, all supported by a high-performance 5G network.

The chapter underscored the importance of frequency planning, robust hardware, and intelligent software in achieving mission success. It also emphasises the need for structured operational workflows, including duty planning, pre-flight checks, and real-time mission coordination.

Overall, the 5G4LIVES project sets a strong foundation for future UAV applications in public service, offering a scalable and adaptable model for integrating next-generation communication technologies into critical infrastructure.

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4. BARRIERS FOR THE 5G4LIVES CONCEPT

Integrating cutting-edge technologies such as UAVs into 5G-enabled systems introduces not only technical advancements but also significant societal and regulatory challenges. The 5G4LIVES project aims to harness these technologies for public utility, particularly in emergency scenarios, by enabling UAV-based solutions supported by 5G connectivity.

In recent years, drones have been increasingly used for civil applications such as monitoring, mapping, surveillance, and delivery. However, these operations typically occur in rural or controlled environments and within VLOS, posing minimal risk to people and infrastructure. In contrast, deploying drones in urban and suburban areas, especially for BVLOS missions, raises critical concerns around public safety, privacy, and cybersecurity.

These societal concerns are compounded by cultural perceptions of UAVs in urban settings, where issues of trust, data security, and surveillance are particularly sensitive. Public acceptance of these technologies hinges on transparent communication, regulatory compliance, and demonstrable safety measures.

This chapter outlines the societal and regulatory issues influencing UAV integration in urban contexts. It also explores the current UAV application in Italy and Latvia.

4.1 Societal impact and constraints

The 5G4LIFE project pilots advanced UAV (Unmanned Aerial Vehicle) operations in urban and peri-urban environments, leveraging 5G connectivity to support critical societal applications. Its two primary use cases - in Riga and Turin - aim to improve public safety and environmental resilience. While the technological and economic dimensions of these use cases are well acknowledged, their societal impact and public acceptability are equally decisive for long-term deployment and scale-up.

In Riga, drones are being deployed to support rescue and monitoring operations in large recreational areas, including Vecāķi Beach and Ķīšezers Lake. These areas attract high numbers of visitors and can be difficult to access during emergencies. UAVs, equipped with high-definition video and thermal cameras, provide real-time situational awareness to first responders, helping to locate individuals in distress faster and more effectively. Public reception of such life-saving applications is generally positive—surveys and prior research confirm that citizens are more inclined to accept drones when they are used for risk management or health-related missions. However, concerns remain about flight safety, particularly in densely populated or crowded areas. Even when used for noble purposes, the potential for accidents (e.g., mid-air failures or crashes into bystanders) underscores the importance of visible safety assurances and strict operational compliance.

In Turin, UAVs are being tested in environmental and infrastructure monitoring, particularly in hilly or geologically vulnerable zones. The drones are equipped with infrared sensors and connected to satellite data for early detection of natural risks such as landslides or wildfires. These operations are valuable for long-term public safety and environmental health. Still, they may raise privacy and data governance questions, especially if citizens are unclear about what is being monitored or recorded. While environmental protection is a widely supported goal, ambiguity about data use can generate suspicion if not addressed proactively.

Beyond specific applications, general societal concerns about UAVs remain. One major issue is noise pollution: drones operating at low altitudes and high frequencies can disturb residents, particularly in quiet zones or during non-standard hours. Interim mitigation strategies such as noise profiling, flight route optimisation, and temporal restrictions can help maintain public goodwill. In the longer term, noise-abatement routing and next-generation low-noise propulsion systems may offer technical solutions.

Moreover, equity of service delivery is critical. If drone-based services are perceived as exclusive to wealthier districts or specific user groups, public trust may erode, and perceptions of elitism or technological overreach may emerge. Therefore, integrating UAVs into public and emergency services, especially in underserved areas, can improve perceived legitimacy and public benefit.

4.2 Regulatory barriers or challenges

One of the principal challenges in implementing the 5G4LIVES concept stems from the complex regulatory and technical conditions surrounding the use of radio frequency (RF) spectrum for Unmanned Aerial

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Vehicles (UAVs) operating within mobile networks. While multiple frequency bands have been harmonised at the European level for terrestrial International Mobile Telecommunications (IMT) services, their practical use for aerial user equipment (UE)—such as UAVs—is significantly constrained by regulatory gaps, national-level limitations, and interference risks with other critical services.

ECC Decision (22)07 defines harmonised technical and operational parameters for UAV operations in a set of Mobile/Fixed Communications Network (MFCN) bands, specifically:

703–733 MHz, 832–862 MHz, 880-915 MHz, 1710–1785 MHz, 1920-1980 MHz, 2500-2570 MHz and 2570–2620 MHz. Within these bands, different regulatory conditions apply:

- Out-of-band emission (OOBE) limits for RF bands: 1710-1785 MHz and 2500-2570 MHz/2570-2620 MHz.
- Operational technical conditions related to no-transmit zones (NTZ) for UAV operating in RF bands: 703-718 MHz, 832-835 MHz, 2500-2570 MHz or 2570-2620MHz.
- Operational technical conditions limiting the use of UAV operational RF band in space (not transmit when less than 30 m above ground level) for 703-733 MHz.
- No specific operational or technical conditions for RF bands like 880-915 MHz and 1920-1980 MHz.

The implementation of OOBE limits is supported through standards developed by relevant standardisation bodies, such as the European Telecommunications Standards Institute (ETSI), which provide technical guidelines to minimise interference. For the protection of the specific services, relevant standards may be implemented (e.g. introduction of the database). However, ECC/DEC/(22)07 explicitly emphasises that NTZ should be defined and implemented at the national level. It should be noted that CEPT develops recommendations or other deliverables to guide administrations in assisting the implementation of certain technical measures or other interference mitigation techniques for the protection of incumbent services. The lack of such recommendations may put a regulatory burden on the administration wishing to protect incumbent users, since the development of national regulation may take a significant effort. Another regulatory barrier is the practical implementation of operational requirements related to no transmission by the UAV in the 703-733 MHz band when less than 30 m above the ground level. It should be clearly distinguished whose responsibility is to ensure that UAVs operating in the 703-733 MHz band will not fly below 30 m above the ground level. All mentioned operational or technical conditions will only be effective if there is a mechanism to control the proper implementation of the measures effectively.

Other frequency bands—such as 1500 MHz, 2300 MHz, and 3400–3800 MHz — also may be used nationally if rights of use of the spectrum are assigned for the use of the public land mobile networks, subject to certain conditions for UAV operation. However, these bands should be approached with heightened caution, as they are not yet fully harmonised across Europe for UAV applications, or their use may require additional coordination and technical evaluation to ensure compatibility with existing services and to avoid potential interference.

Additionally, the 3500 MHz band presents a specific concern as it is adjacent to the frequency range used by aircraft altimeters, which are critical for aviation safety. This proximity raises the risk of interference, particularly near air corridors. In the case of Ķīšezers and Vecāķi in Riga, which lie along aircraft approach and departure routes, official coordination with the Civil Aviation Agency has been completed. However, flight operations in these zones must be conducted with exceptional caution, ensuring UAV activity does not interfere with manned aviation systems.

From a market readiness perspective, another significant barrier is the limited availability of UAV platforms with built-in 5G connectivity, especially those supporting the specific frequency bands recommended by ECC. This limits flexibility in hardware selection and often necessitates the use of custom or adapted solutions. Furthermore, although license-exempt bands such as 2.4 GHz and 5.8 GHz are commonly used for short-range UAV communications, their reliability in BVLOS (Beyond Visual Line of Sight) or high-throughput scenarios is constrained due to strict national regulations and the risk of interference from other users.

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Finally, while the 700 MHz and 3500 MHz bands are essential to Latvia's national 5G deployment and are heavily used by commercial operators, their integration into the 5G4LIVES project is technically feasible. However, due to the high density of existing traffic in these bands, dedicated interference mitigation strategies are essential. These may include dynamic spectrum management, traffic prioritisation, or geographic and altitude-based restrictions, to ensure that UAV and consumer mobile services can coexist without degrading each other's performance. Close collaboration with mobile operators and the national frequency administrations is crucial to guarantee network quality and flight safety across all test areas.

In conclusion, UAV deployment within mobile networks under the 5G4LIVES framework faces a complex landscape of regulatory, technical, and coordination challenges. Overcoming these barriers will require ongoing alignment with CEPT/ECC regulations, continuous engagement with national aviation and frequency authorities, and the authorisation must be requested in advance of a flight operation or, even when applying for a recurrent authorisation, consider the authorisation **and Consortium Actions.**

Recognising these challenges, the 5G4LIVES consortium has taken proactive steps to address spectrum-related issues and ensure robust, compliant UAV operations within the project.

1. A comprehensive technical specification has been developed for procurement, incorporating the full range of relevant frequency bands and reflecting the known limitations and regulatory landscape.
2. Based on early technical evaluations, the consortium has determined that relying on a single frequency band is not sufficient for safe and resilient UAV operation. Therefore, support for multiple bands is considered essential. In cases where issues arise with one band, alternative frequencies must be available to ensure continued mission performance.
3. Internal coordination among consortium partners has resulted in a classification of frequency bands—those suitable for use without major concern and those requiring increased caution due to either a lack of harmonisation or insufficient technical studies. As a result, the 5G4LIVES project is positioned as a "sandbox", allowing real-world experimentation to inform future policy and standardisation.
4. The issue of interference between UAVs operating in the 3500 MHz band and aircraft radio altimeters has been brought to the attention of relevant European bodies. This topic is currently under active consideration within ECC's Working Group Spectrum Engineering (WG SE) and Working Group Frequency Management (WG FM). Where feasible, the 5G4LIVES consortium will contribute practical findings and operational insights to these groups, supporting evidence-based improvements to UAV spectrum harmonisation and aviation safety protocols.

References:

- ECC Decision (22)07: Harmonised use of MFCN bands for aerial UE
- ECC Decision (20)01: Harmonisation of 3.4–3.8 GHz band for 5G
- National Radiofrequency Plan of Latvia (Electronic Communications Office of Latvia)

Drone regulatory barriers

A crucial aspect for the 5G4LIVES project, and one that represents a challenge for conducting demonstrations and experimental activities, concerns drone regulations.

Currently, all use cases in both Turin and Riga have been planned in compliance with the applicable drone regulations in Italy and Latvia, which are based on the European Regulatory framework. The considerations previously outlined in the previous deliverables were made by assessing the feasibility of flight missions during the experimental phases.

However, when it comes to the deployment of continuous services based on what is being developed within 5G4LIVES, regulation remains the main challenge and barrier.

In fact, as of today, conducting a BVLOS mission requires obtaining flight authorisation from the National Aviation Authority (e.g., ENAC in Italy). This authorisation must be requested in advance of a flight operation or, even when applying for a recurrent authorisation, each time the CONOPS of the mission changes. This aspect needs to be clarified with the National Aviation Authority. In any case, the process may require long waiting times, which are incompatible with the 5G4LIVES project's goals of responding to emergency scenarios.

One possible solution could be to involve an operator with a LUC (Light UAS Operator Certificate), a certification that grants the UAS operator certain privileges. According to EASA documentation, these privileges may include conducting a SORA and the related flight operation without needing prior authorisation from the National Aviation Authority (NAA). However, to date, LUCs granted in Europe are still very limited: for example, only one has been issued in Italy, according to (our) publicly available information.

Moreover, at present, performing medium-risk flight operations with SAIL > III remains a major challenge, if not impossible in some cases involving flights over densely populated areas. This limitation is mainly because there are no drones certified (or with an EU Label Class) that are suitable for operations in urban areas. Currently, there is no way to guarantee to the National Aviation Authority that a drone has a sufficiently low failure rate to meet the Level of Safety required for operations in populated environments with an acceptable risk level. The EU Label Classes published so far do not include such requirements.

However, EASA is moving in this direction and, for instance, in the past year has published initial documents concerning the design of UAS for medium-risk scenarios (e.g., Means of Compliance for the design of UAS operated under SAIL III conditions). This gives us confidence that drone types and models suitable for medium- to high-risk missions (SAIL > 3) will soon become available.

Another factor that limits the use of drones in populated areas is the difficulty of demonstrating to the NAA the real population density in each area. On this aspect, however, 5G4LIVES proposes the use of population density estimates derived from mobile phone data to infer how people are distributed in each (urban or non-urban) area. However, this data must be validated and accepted by the NAA.

The importance of using a population density database capable of estimating the time-varying distribution of people in space has been repeatedly emphasised by EASA.

Although regulatory aspects currently represent one of the main challenges and barriers to developing services based on the 5G4LIVES project, it appears that EASA is moving in a direction that supports the project's outcomes. The societal impact of the 5G4LIVES use cases is promising, especially when aligned with public safety and environmental stewardship. Yet, societal acceptance is not automatic. It must be earned through transparent communication, responsible data handling, visible risk management, and inclusive community engagement. These social dimensions are just as critical as the technical architecture in ensuring that drones become trusted actors in the urban landscape.

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5. CONCLUSIONS

This document, "5G4LIVES services co-creation, functional specifications and reference architecture (1st version)," serves as a foundational report for the 5G4LIVES project. It establishes the initial criteria and outlines the technological, regulatory, and societal challenges that need to be addressed in the subsequent phases of the project, particularly for the final Deliverable of the work package 2 - Deliverable 2.4.

Some of the challenges in the short term are related to technological issues.

Technologies, such as U-SIMS, were not technically viable when tested during the work package. The commercial drones used for this project are not equipped with appropriate modules, and therefore, the integration of USIM cards was not feasible at this stage.

Another of the identified technological challenges is the fact that there are not sufficient unmanned aerial vehicles on the market right now that have built-in 5G connectivity, especially those supporting specific frequency bands recommended by ECC for drone usage.

When it comes to the deployment of regular services based on solutions being developed within 5G4LIVES, regulation remains the main challenge and barrier.

As of today, conducting a BVLOS mission requires obtaining flight authorisation from the National Aviation Authority (e.g., ENAC in Italy). This authorisation must be requested in advance of a flight operation or, even when applying for a recurrent authorisation, each time the CONOPS of the mission changes, it needs to be clarified with the National Aviation Authority. In any case, the process may require long waiting times, which are incompatible with the 5G4LIVES project's goals of responding to emergency scenarios.

While regulatory aspects currently pose significant challenges and barriers to the development of services envisioned by the 5G4LIVES project, there is a positive indication that the European Union Aviation Safety Agency (EASA) is progressing in a direction that is supportive of the project's objectives and outcomes.

Careful attention should be paid to further radio frequency selection and securing for drone operations in all the EU countries. As the project has shown, based on Latvia's examples, existing bands can be very much utilised by other mobile devices and thus limit possibilities to ensure safe and undisturbed network coverage.

Both use cases within the 5G4LIVES project showcase a robust and adaptable system architecture for UAV-based emergency response. While the core infrastructure remains consistent, key enhancements have been updated. Particularly, the migration of mission management tools to cloud platforms like AWS in the Torino use case has significantly improved accessibility and operational flexibility. While in the Riga use-case, the system has enabled seamless mission planning, UAV control, and live data exchange through a centralised Remote Operation Control Centre. This architecture not only enhances situational awareness and decision-making but also demonstrates the scalability and adaptability of the 5G4LIVES concept for complex, multi-UAV operations in dynamic environments.

The document's approach aims to align diverse user needs with the specific technological capabilities and deployment conditions encountered in the distinct operational environments of Riga and Turin. The designation of D2.3 as the "1st version" and its explicit role in "laying the groundwork" for the final D2.4 underscores a structured, iterative project methodology. This approach acknowledges the dynamic nature of both technology integration and the evolving regulatory landscapes, allowing for necessary adaptations and refinements based on initial findings and real-world experimentation. Such a pragmatic strategy is characteristic of complex innovation projects, where initial assumptions are rigorously tested and adjusted to ensure practical viability.

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